TXR Tingle MEDICAL SYSTEMS

Technical Publication
M-2008-7-13

Installation Manual

STANDARD FREQUENCY SERIES GENERATORS

Contents: Models

TXR 325D

TXR 325M

TXR 425

TXR 525SFQ

¡ IMPORTANTE ! ... Protección ante los rayos-X

LOS EQUIPOS DE RAYOS-X SON PELIGROSOS PARA EL PACIENTE Y EL OPERADOR A MENOS QUE LAS MEDIDAS DE PROTECCION SEAN ESTRICTAMENTE OBSERVADAS

Si el equipo de rayos-X no se usa adecuadamente, puede causar lesiones. Por este motivo, las instrucciones aquí incluidas se deben leer y comprender en su totalidad antes de intentar poner el equipo en funcionamiento. Estaremos gustosos de asistir y cooperar en poner el equipo en marcha.

Aunque el equipo está construido según las normas de seguridad más estrictas y presenta un alto grado de protección contra las radiaciones-X, ningún diseño practico puede ofrecer una protección completa. Tampoco ningún diseño practico puede obligar al operador a tomar las precauciones adecuadas para prevenir la posibilidad de que cualquier persona de manera descuidada, poco sensata o ignorante, se exponga a radiaciones directas o indirectas.

Es importante que cualquier persona relacionada con radiaciones-X esté debidamente entrenada y tome las medidas adecuadas para asegurar la protección contra posibles lesiones.

El fabricante asume que todo operador y personal de servicio autorizado para manejar, instalar, calibrar o mantener este equipo, es consciente del peligro que conlleva la exposición excesiva a las radiaciones-X, está suficientemente entrenado y posee los conocimiento necesarios para ello. Por lo tanto, el equipo aquí descrito se vende entendiendo que el fabricante, sus agentes y representantes no tienen ninguna responsabilidad en caso de lesiones o daños que puedan resultar de la exposición a dichas radiaciones.

Existen diversos materiales y dispositivos protectores, cuyo uso es recomendable.

IMPORTANT ! ... X-ray Protection

X-RAY EQUIPMENT IS DANGEROUS TO BOTH PATIENT AND OPERATOR UNLESS MEASURES OF PROTECTION ARE STRICTLY OBSERVED

X-ray equipment if not properly used may cause injury. Accordingly, the instructions herein should be thoroughly read and understood before attempting to place this equipment in operation. We will be glad to assist and cooperate in placing this equipment in use.

Although this apparatus is built to the highest safety standards and incorporates a high degree of protection against X-radiation other than the useful beam, no practical design of equipment can provide complete protection. Nor can any practical design compel the operator to take adequate precautions to prevent the possibility of any persons carelessly, unwisely, or unknowingly exposing themselves or others to X-radiation.

It is important that everyone working with X-radiation be properly trained and take adequate steps to insure protection against injury.

The manufacturer assumes that all operator and service personnel authorized to use, install, calibrate and maintain this equipment is cognizant of the danger of excessive exposure to X-radiation, is sufficiently trained and has the required knowledges for it. The equipment herein described is sold with the understanding that the manufacturer, its agents, and representatives are not liable for injury or damage which may result from exposure to X-radiation.

Various protective material and devices are available. It is recommended that such materials and devices be used.

IMPORTANT ! ... Protection contre les rayons-X

L'EQUIPEMENT RAYONS-X EST DANGEREUX A LA FOIS POUR LE PATIENT ET POUR L'OPERATEUR A MOINS D'OBSERVER STRICTEMENT LES CONSIGNES DE PROTECTION

L'équipement à rayons-X peut provoquer des blessures s'il n'est pas correctement utilisé. En conséquence, les instructions de ce manuel doivent être lues attentivement et bien assimilées avant de tenter de mettre en route ce matériel. Nous serons heureux de vous assister et de coopérer à l'installation de ce matériel.

Bien que cet équipement soit construit selon les normes de construction les plus sévères et qu'il comporte un haut degré de protection contre le rayonnement-X en dehors du rayon utile, aucune conception n'apporte une protection totale. De même qu'aucune conception ne peut obliger l'opérateur à prendre les précautions adéquates afin d'éviter que toute personne ne s'expose ou n'expose les autres au rayonnement sans précaution, de façon imprudente et inconsciente.

Il est important que toutes les personnes travaillant avec le rayonnement-X soit correctement formées et prennent les mesures adéquates afin de se protéger contre toute blessure.

Le constructeur suppose que tous les utilisateurs et le personnel d'entretien autorisé à utiliser, installer, calibrer et entretenir cet équipement est conscient du danger de l'exposition excessive au rayonnement-X, est suffisamment formé et possède les connaissances nécessaires pour cela. L'équipement décrit dans le présent manuel est vendu sous réserve que le fabricant, ses agents et représentants ne soient pas tenus pour responsables des blessures ou dommages qui pourraient résulter d'une exposition aux rayons-X.

Plusieurs matériels de protection et systèmes sont disponibles. L'utilisation de ces matériels et systèmes de protection est recommandée.

DECLARACION AMBIENTAL
SOBRE LA VIDA UTIL DEL EQUIPO O SISTEMA

Este equipo o sistema contiene componentes y materiales peligrosos para el medioambiente (tales como tarjetas de circuito impreso, componentes electrónicos, aceite dieléctrico usado, plomo, baterías, etc), los cuales se consideran y son residuos peligrosos al finalizar la vida útil del equipo o sistema, según establecen las normas internacionales, nacionales y locales.

El fabricante recomienda que al finalizar la vida útil de equipo o sistema, se contacte con un representante autorizado del fabricante o con un gestor autorizado de residuos para la retirada de este equipo o sistema.

ENVIRONMENTAL STATEMENT
ON THE LIFE CYCLE OF THE EQUIPMENT OR SYSTEM

This equipment or system contains environmentally dangerous components and materials (such as PCB‘s, electronic components, used dielectric oil, lead, batteries etc.) which, once the life-cycle of the equipment or system comes to an end, becomes dangerous and need to be considered as harmful waste according to the international, domestic and local regulations.

The manufacturer recommends to contact an authorized representative of the manufacturer or an authorized waste management company once the life-cycle of the equipment or system comes to an end to remove this equipment or system.

DECLARATION D’ENVIRONNEMENT
SUR LA VIE UTILE DE L’EQUIPEMENT OU SYSTEME

Cet équipement ou système contient des composants et matériaux dangereux pour l’environnement (ex: électroniques cartes, composants électroniques, huile diélectrique usée, plomb, batteries, etc.), lesquels sont considérés comme résidus dangereux en cycle terminal de vie d’un équipement ou système, en accord avec les normes internationales, nationales et locales en vigueur.

Le fabricant recommande une fois le cycle terminal de l’équipement ou système atteint, de contacter un représentant autorisé du fabricant ou les autorités compétentes en la matière afin d’organiser et de gérer le recyclage adéquat de cet équipement ou appareil.

REVISION HISTORY

REVISION	DATE	REASON FOR CHANGE
0	January 1, 2003	New Edition
1	August 25, 2003	Advisory Symbols
2	March 5, 2005	Tube Limit Selection Tables
3	April 5, 2006	General Revision
4	July 13, 2008	Added TXR 425 Model Designation

This document is the English original version, edited and supplied by the manufacturer.
All Copy including Advisory Symbols: Type Style Aerial.

The state of revision of this Document is indicated in the code number shown at the bottom of this page.

ADVISORY SYMBOLS

DANGER! ***DANGER ADVISES OF CONDITIONS OR SITUATIONS THAT IF NOT HEEDED OR AVOIDED WILL CAUSE SERIOUS PERSONAL INJURY OR DEATH.***

WARNING **WARNING ADVISES OF CONDITIONS OR SITUATIONS THAT IF NOT HEEDED OR AVOIDED COULD CAUSE SERIOUS PERSONAL INJURY OR DAMAGE OF EQUIPMENT.**

CAUTION ***Caution advises of conditions or situations that if not heeded or avoided could cause personal injury or damage to equipment.***

Note *Alerts readers to pertinent facts and conditions. Notes represent information that is important to know but which do not necessarily relate to possible injury or damage to equipment.*

SAFETY SYMBOLS

The following safety symbols will be used in the equipment.
Their meaning are described below.

Attention, consult accompanying documents.

Ionizing radiation.

Type B equipment.

Dangerous voltage.

Ground.

This symbol indicates that the waste of electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized representative of the manufacturer or an authorized waste management company for information concerning the decommissioning of your equipment.

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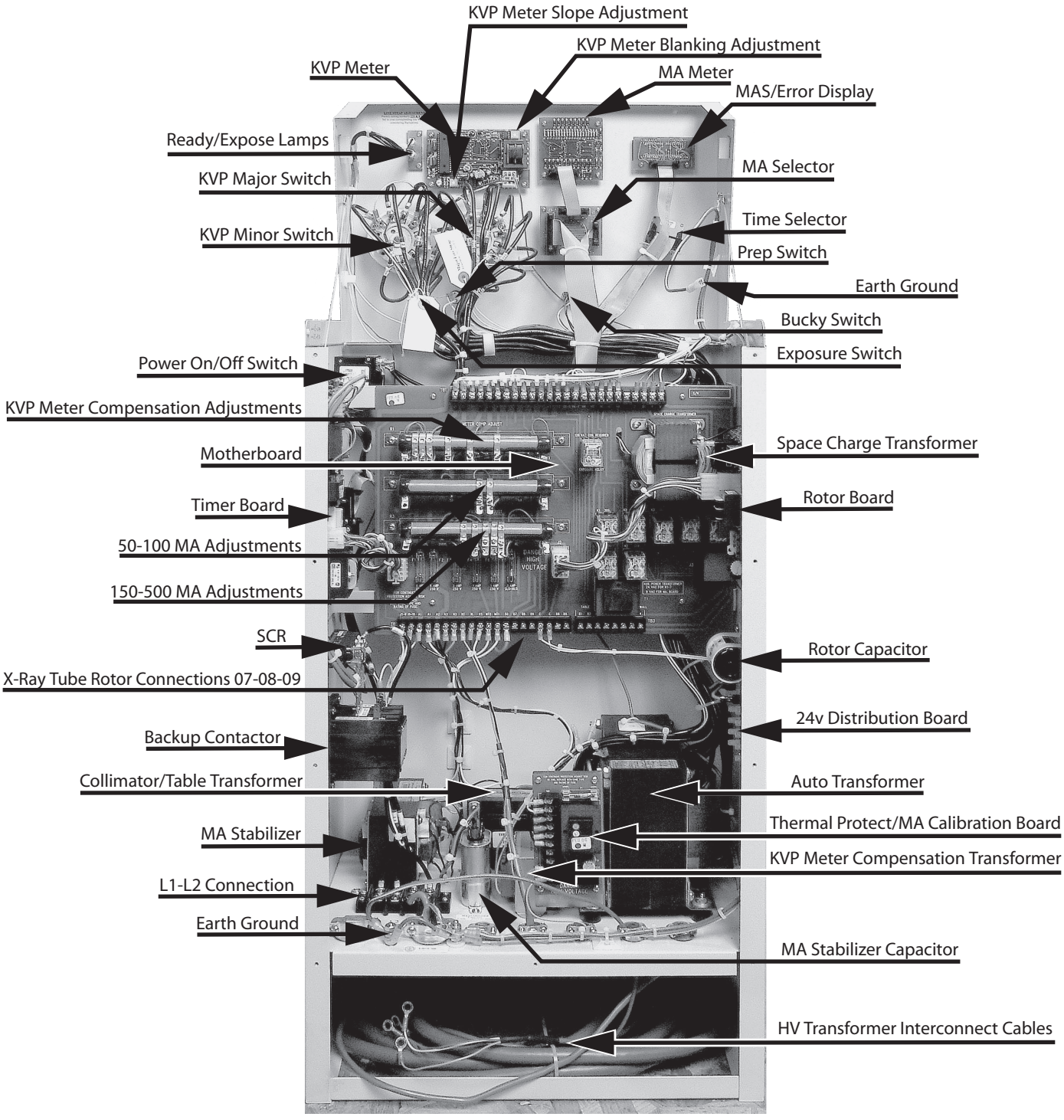
COMPONENT LOCATION



Calibration and interconnection points are identified above.

SECTION 1
INTRODUCTION

The installation process depends on generator and system configuration. Installation must be performed in the following order. Perform only the sections required to install the unit. **Section 6-8 has been provided with minimal changes from Progeny. Progeny and Eureka are registered trademarks owned by Progeny.**

1.1 TOOLS AND TEST EQUIPMENT

The following hand tools and products are required for the installation.

- Standard service engineers tool kit.
- Drill and assorted bits.
- Silicone Insulating Grease (proofing compound).
- Alcohol cleaning agent.

The following test equipment is required for Calibration and Service.

- Digital Multimeter.
- Non-invasive kVp Meter.
- Digital mAs Meter.
- Non-invasive Digital mR Meter
- Calculator.
- Stands or Test Instruments called for in sections of this manual.

Only for AEC purposes:

- Sensitometer.
- Densitometer.

Copper Plates for the Collimator Filter Holder (recommended for AEC calibration):

- 2 units of 1.0 mm thickness,
- 1 unit of 0.5 mm thickness,
- 2 units of 0.2 mm thickness,
- 1 unit of 0.1 mm thickness.
- Instead of Copper Plates it can be used Acrylic Plastic Plates:
- 6 units of 5 cm. thickness
- 5 units of 1 cm. Thickness

Only for Tomo purposes:

- Tomophantom tool.

1.2 PRE-INSTALLATION CHECK

Prior to beginning installation, it is recommended to inspect the site and verify that the x-ray room complies with Pre-Installation requirements, such as:

- Incoming Line
- Main Switch and Safety Devices
- Conduits
- Space Requirements

(Refer to “Pre-Installation” document)

SECTION 2

UNPACKING AND INSTALLATION

The generator and operators console is placed in individual padded wrap and corrugated boxes. Both corrugated boxes are placed into wooden crates and shipped.

Upon receipt of the X-ray unit and associated equipment, inspect all shipping containers for signs of damage. If damage is found, notify the carrier or his agent immediately.

After this device or complete system is picked up by the carrier, Tingle X-Ray, LLC is relieved of any responsibility for damage during shipment.

2.1 STANDARD FREQENCY – LINE POWERED

1. Open the shipping container and remove both corrugated boxes, which contain the X-ray Control Console and the High Voltage Transformer. To prevent damage to circuit breaker, when corrugated boxes are being moved, make sure arrows are pointed up.
2. Carefully remove X-Ray Control and High Voltage Transformer from the corrugated boxes and unwrap protective bubble wrap or oil proof shipping bag. Do not discard any packing material such as envelopes, boxes, or bags until all parts are accounted for as listed on the packing list.

Illustration 2-1
Standard Frequency Series Generators

Lay box on it's side, arrows up	Remove staples from bottom, fold flaps back.	Stand upright and remove crate.
		
CAUTION – MAY DAMAGE CIRCUIT BREAKER Do not move control with the circuit breaker side down.		

3. If damage is found to the above, have driver write a bad order note on all copies of the freight bill and sign all copies. (Do not forget to obtain a clear copy with his signature for your records).
4. If concealed damage is discovered, notify the transportation agent at once and ask for an inspection Report of Damage. (This report must be filed within 15 days).
5. Move the High Voltage Transformer to its assigned floor space. At least two people are required for this operation.
6. Move the X-ray Control Console to its assigned floor space. One person and a hand truck are required for this operation.

7. Remove the shipping platform (plywood) from the bottom of the X-ray Console and verify that all internal wiring is secure.
8. Check the part numbers and serial numbers of each component with its identification labels, and inspect all pieces for visible damage. If any damaged parts are found, repair or order replacements to prevent unnecessary delay in installation.
9. Usually the Control and Transformer are freestanding. Seismic areas and other conditions require fastening the Generator Cabinet to the floor. Mounting holes are provided on the bottom of the Console. Use fasteners required by local Code.
10. Leave a working area around the equipment until its final assembly.

THE HIGH VOLTAGE TRANSFORMER IS VERY HEAVY. AT LEAST TWO / THREE PEOPLE ARE REQUIRED TO REMOVE THE UNIT FROM THE PALLET AND MOVE IT INTO ITS PREPARED PLACE.

DO NOT SUPPLY THE MAIN POWER UNTIL SPECIFICALLY INSTRUCTED TO DO SO IN THIS SERVICE MANUAL. LEAVE A WORKING AREA AROUND THE EQUIPMENT UNTIL ITS FINAL ASSEMBLY.

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SECTION 3
CABLE CONNECTIONS

This section provides the information necessary to connect the generator cables with the system and options.

WARNING

FOR MORE INFORMATION ABOUT ELECTRICAL REQUIREMENTS AND CABLE CONNECTIONS, REFER TO "PRE-INSTALLATION" DOCUMENT AND BECOME FAMILIAR WITH THIS SECTION 3.

Some safety devices such as Safety / Emergency Switch, Warning Light, and Door Interlock Switch are supplied and installed by the customer. Verify that safety devices have been properly installed and routed during the Pre-Installation procedure.

3.1 CABLE ROUTING INSIDE CONTROL CONSOLE

Previous to cable connections being made from inside the x-ray control console, route and secure the cables in the following way.

3.1.1 Stator and Interconnection Cables with or without conduit have to be routed along the rear bottom of the cabinet and through the strain relief connectors at the rear floor of the electrical cabinet. See Table 3-1 and Illustration 3-2.

3.2 POWER LINE CONNECTIONS

With Safety Disconnect Switch OFF, connect Line Power to the X-ray control Terminals marked L1, L2, and Earth Ground. When Local Codes require other interconnect techniques or hardware, comply with those Codes.

3.2.1 STANDARD FREQUENCY GENERATORS – LINE POWERED

DANGER!

THIS X-RAY CONTROL IS PERMANENTLY CONNECTED TO THE POWER LINE, AND POWER REMAINS ON PARTS OF THE ELECTRICAL SYSTEM UNLESS THE SAFETY SWITCH INSTALLED IN THE ROOM ELECTRICAL CABINET IS OFF. WHEN THE CONTROL AND HIGH VOLTAGE GENERATOR IS POWERED, LEDS AND INDICATORS OUTSIDE AND INSIDE THE CONSOLE DISPLAY ALL RELEVANT FUNCTIONS. DO NOT POWER ON THE X-RAY CONTROL UNTIL SPECIFICALLY INSTRUCTED IN THIS MANUAL.

1. Verify that the power supply line is “OFF” in the Room Electrical Cabinet.

2. The power supply line should be according to the generator model defined in the “Pre-Installation” document. Also, feeder wire sizes are indicated in the same document relative to the power supply line and the wire length. Verify that power line voltage and phase of the Generator coincides with the one in Room Electrical Cabinet.

3. Cut the cable to the appropriate length and remove insulation from both ends of the power and ground wires.

4. For Single Phase Generator, connect the power wires L1 and L2 to Console Terminals L1 and L2 (remove back cover, Terminals located on the left side of the cabinet), and the ground wire to the Ground terminal in the cabinet (to the right of the power terminal strip).

DANGER!

SINGLE PHASE GENERATORS ARE FACTORY DELIVERED TO OPERATE ON SINGLE PHASE (L1 AND L2). IF CONNECTING TO PHASE AND NEUTRAL LINE CONFIRM THAT VOLTAGE DOES NOT EXCEED 260 VAC. IF THIS IS THE CASE RE STRAP THE AUTOTRANSFORMER WHERE IT MATCHES THE INPUT LINE.

5. The whole system (X-ray Table, Tube Stand, Wall Stand, Collimator, etc.) can be switched ON/OFF when the Console is switched ON/OFF. For that power, the System Devices through the output terminals on the Distribution Board, is switched when the POWER ON/OFF SWITCH is operated. The Male Connectors on the PC Board connect to .250 Faston Connectors. This PC Board is located on the right side, underneath the Rotor Board.

6. Route these wires and connect them to the respective terminals in the Console Cabinet.
7. Verify that the Emergency Switch has been connected to the Room Electrical Cabinet so that it cuts the power to the generator console when it is switched off.

8. Verify that when the console is energized, voltage between A1 and A2 is 120 VAC $\pm$ 2 VAC. If the voltage between A1 and A2 is outside these limits re-strap the autotransformer so that it corrects this voltage.

3.3 HV TRANSFORMER CONNECTIONS

With Safety Disconnect Switch OFF, Route Leads P1, P2, Ground, XC, XS, XL and MI through the Strain Relief Connectors into the High Voltage Transformer junction box, located on top of the transformer. Follow connection instructions provided inside the junction box.

3.4 HV X-RAY TUBE CONNECTIONS

3.4.1 HIGH VOLTAGE CABLES

CAUTION

The Terminal Pins of the High Voltage cables are extremely delicate and easily damaged. Take particular care to handle them carefully. Make sure that they are straight and that the splits in the pins are open (parallel to sides). The arc suppression gaskets shipped with the high voltage cable may not make good contact with the receptacles. We advise not to use the suppression gasket. Use ring seals, vapor proof compound for the tube and insulating oil in the transformer receptacles. Hand tighten several times.

Anode and Cathode cables are furnished according to the room layout (length of the high voltage cables).

1. Assemble the mounting accessories of each Termination Plug following the Cable manufacturer's **instructions.**
2. Prepare the High Voltage terminals that will be installed in the X-ray Tube(s) receptacles. Apply Silicone Paste over the entire surface of the Plug including the Pins.
3. Carefully connect the Anode and Cathode cables from the HV Transformer into the respective X-ray Tube(s) receptacles. Ensure that all connections are made correctly, maintaining correct Anode and Cathode orientation.
4. Put approximately 1 cm (0.5") of HV Oil in the HV Transformer receptacles.
5. Carefully connect the Anode and Cathode cable from the X-ray Tube into the respective HV Transformer receptacles. Insure that all connections are made correctly, maintaining correct Anode and Cathode orientation. With ring seals in place, tighten the cable nuts securely.

DANGER!

TO PREVENT ELECTRICAL SHOCK
PERMANENTLY SECURE HIGH VOLTAGE CABLES

HV CABLE ENDS ARE PROVIDED WITH LOCKING ALLEN SCREWS. ALL FOUR HV MALE CONNECTORS MUST BE TIGHTENED TO PREVENT REMOVAL OF HV CABLES BY HAND OR ACCIDENT FROM THE X-RAY TUBE OR HV TRANSFORMER.

3.4.2 STATOR CABLE

X-ray Tubes are equipped with the Stator cable installed.

X-RAY TUBE STATOR INTERCONNECT Leads from x-ray tube	**X-RAY CONTROL TERMINALS** Connect to Control Mother Board Terminal Strip
07 (Black)	07
08 (Eureka and Toshiba leads - Red) (Machlett lead - Green)	08
09 (White)	09
Earth Ground	Earth Ground
Shielding	Earth Ground

FANS

Wires from fans should be routed with the Stator Cable and connected to the indicated terminal of the control cabinet. Depending on the x-ray tube, the fans are powered at 115 VAC or 220 VAC. Make the following connections to select the fan voltage. You are required to add two in line fuses rated 3A 250 VAC for this addition.

FAN INTERCONNECT FROM STATOR Leads from x-ray tube Fan	**X-RAY CONTROL** Fuse Connect to Major and Minor Tap Switch
120 or 240 VAC	Fuse Connect to either 120 or 240 on Major Tap Switch
Common Side	Fuse Connect to “0” on the Minor Tap Switch
Earth Ground	Earth Ground
Shielding	Earth Ground

WARNING

PROTECT THE CONTROL WIRING: BEFORE ENERGIZING THE FAN, YOU ARE REQUIRED TO ADD TWO 3A 250 VAC INLINE FUSES.

THERMOSTAT OR PRESSURE SWITCH SIGNAL

If the X-ray Tube is provided with a Safety Thermostat (approx. 65 degree C or Pressure Switch - must be NC Contact), the two wires should be routed to the Terminals on the Mother Board in the X-ray Console.

THERMOSTAT WIRES **(From X-ray tube)**	**MOTHER BOARD TOP TERMINALS** **(Located inside the Console)**
Connect thermal switch in series with the Safety and PBL interlock circuit.	P and # 4 (See Table 3-1)

3.5 ANODE STARTER (ROTOR CONTROL)

The anode starter voltage and capacitor is factory set to 220VAC, 30-35 mfd. After a .5 second time delay 220VAC is removed and 50VAC is applied to maintain the anode speed. Other tubes may require other voltages and capacitor values. In all cases, refer to X-ray Tube Product Data furnished with the tube.

Two Step Operation: Upon depressing the Prep Pushbutton, a command is sent to the rotor control board initiating a 220vac starting voltage to the x-ray tube stator. When sensing functions are confirmed (During the time delay) the rotor control board automatically switches, removing the 220vac start voltage and connects 50vac run voltage to the stator to maintain anode speed. To allow filament stabilization, an adjustable time delay is factory set at 2.2 seconds. If the x-ray tube stator circuit is connected and the anode is rotating in the counterclockwise direction, a ready signal causes the green lamp to illuminate next to the word “READY”.

One Step Operation: Upon depressing the Exposure Pushbutton, the rotor circuit automatically cycles as above with an Exposure beginning immediately after the 2.2 second delay.

3.6 INTERCONNECTION CABLES

This section identifies the cables and runs needed for Console, Generator and System Interconnection. Route and connect the interconnection cables from each component installed in the system to the Generator Cabinet as indicated in Table 3-1 and Illustration 3-2 below.

Table 3-1
INTERCONNECT WIRING CHART

CONTROL	LINE BOX	POWER REQUIRED	CIRCUIT BREAKER SIZE
L1	**L1**	***TXR 325D & M**, TXR 425 240 VAC nominal*	*80 amp single phase*
L2	**L2**	***TXR 525 SFQ** 240 VAC nominal*	*100 amp single phase*
Earth Ground	**Earth Ground**		

CONTROL	HIGH VOLTAGE TRANSFORMER	BUCKY CONNECTIONS	
P1	P1	**Eureka True Speed Bucky UL Listed**	
P2 Earth Ground	P2 Earth Ground	**X-Ray Control** **Earth Ground**	**Bucky** **Earth Ground**
XC	XC	B1	B1
XS	XS	B2	B2
XL	XL	B3	B3
M1	M1	B4	B4
		B8	B8

ROTOR CIRCUIT	X-RAY TUBE	TUBE THERMAL SWITCH
07	07 *(Black)*	Connect thermal switch in series with the Safety and PBL interlock circuit.
08	08 *(Eureka and Toshiba leads – Red)* *(Machlett lead - Green)*	
09	09 *(Lead – White)*	P and # 4 (See PBL Interlock Circuit)
Earth Ground	Earth Ground	

COLLIMATOR POWER SUPPLY- DOUBLE INSULATED, 175 VA

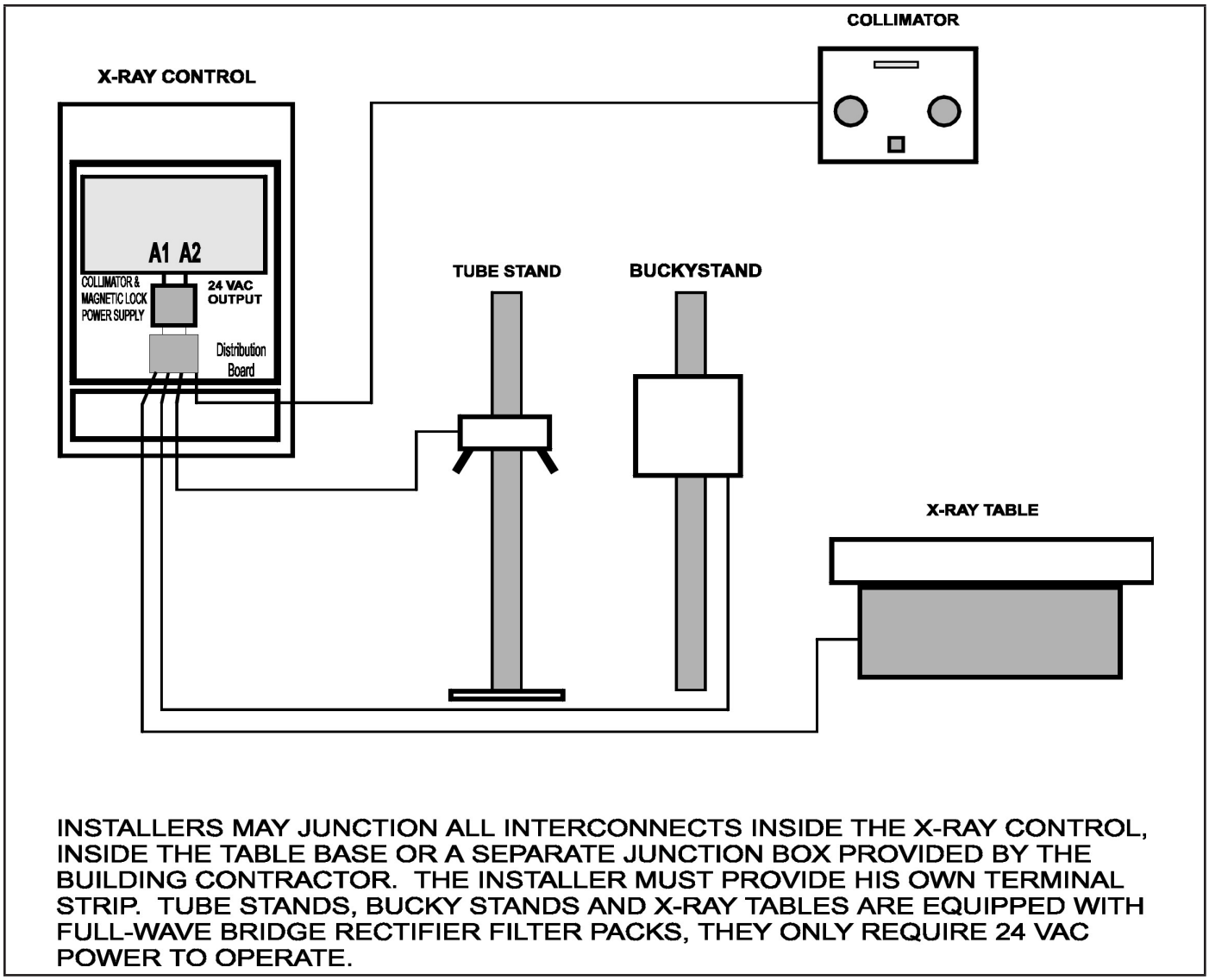
Connects to 24 VAC Distribution Board inside X-ray Console.

SAFETY AND COLLIMATOR PBL INTERLOCK CIRCUIT

P is jumped to 4 on top of the Mother Board Terminal Strip. For connecting PBL, SID or other interlocks into the circuit, remove the jumper and connect the isolated contacts or switches into those terminal points (P & 6). (Notice): The rotor will not run nor will the ***ready lamp light*** if PBL, SID or other interlocks (switches) have not been aligned properly. (See schematics in Pre-Installation document).

Illustration 3-2
Interconnection Wiring

ADD EARTH GROUNDING BETWEEN ALL DEVICES: MINIMUM WIRE SIZE 10 AWG.
WIRE COLOR: GREEN WITH YELLOW STRIPE.



CAUTION

(Pinch Point)
Use Care: When Opening And Closing The Hinged Console.
Keep Hands And Fingers Clear From The Sides And Rear.

3.6.1 COLLIMATOR ERROR SIGNAL (OPTIONAL)

This option can be wired into the x-ray console. For systems using an Automatic Collimator, the x-ray exposure can be inhibited due to a collimator error. This signal can be used only for one Automatic Collimator in the System. For connecting information: Refer to Table 3-1.

3.6.2 DOOR INTERLOCK SIGNAL

Connect two wires from the Room Door Interlock Switch(s) to the Console Mother Board Terminal as instructed in the Pre-Installation Manual Section 3.6. If the room is not provided with a Door signal no changes are required.

3.6.3 WARNING LIGHT SIGNAL

Room lamp(s) can be externally powered through a combination of relays and interconnecting wire. When installed per instructions in the Pre-Installation Manual Section 3.6, the lamps will energize during prep and exposure indicating the room is under power and x-ray is imminent and radiation exposure is activated.

When the x-ray control Power Switch is off, no control is to the lamps and they are extinguished, which are powered externally.

3.6.4 AUDIBLE SIGNAL

At the end of x-ray exposures a sonalert sounds indicating that radiation has terminated and that you may proceed to the next task.

3.6.5 COLLIMATOR LAMP AND SYSTEM LOCKS

The generator is equipped with a Double Insulated 175W Transformer to supply power to the Manual Collimator Lamp and System Locks (X-ray Table, Tube Stand, Wall Stand, etc.).

A Dedicated Printed Wire Board (24VAC Distribution Board) is located in the Control Console that allows clean, unobstructed connections for all 24V Faston Interconnects. Refer to Table 3-1.

3.6.6 BUCKYS

For systems with 1 or 2 Buckys: Cables from Buckys can be connected to the lower right hand Terminals on the Console Mother Board. The terminals are clearly marked Table and Wall Bucky. Connect the Buckys as indicated in Table 3-1.

Test and verify X-Ray Control Operation before connecting Buckys.

SECTION 4

FINAL INSTALLATION AND CHECKS

4.1 HV TRANSFORMER

Place High Voltage Transformer into its designated place as indicated in the floor plan. The HV Transformer contains “Shell Diala” or equivalent insulating oil which expands or contracts per elevation or temperature change. After final leveling, check that there is not oil leakage or overfill. If there is, check that the oil level is approximately 20 mm (3/4”) of the top surface of the HV Transformer. If there is overfill, use a syringe to remove the excess oil. If oil is needed use the above type oil or equivalent type oil to bring the oil level up to the approximate level indicated above.

Do Not Allow Insulating Oil To Get Into Eyes Or On The Body. Follow Information And Indications And Wash Thoroughly

4.2 CABLING FASTENING AND COVERS

Before re-installing cabinet or device covers, perform the rest of the Check Out and Calibration Procedures.

Check that all electrical connections are firm and secure, and all cables are correctly routed. If cabling has to be shortened, lengthened or re-routed make sure all connections are proper to meet local electrical Codes.

4.3 CHECKS FOR INSTALLING X-RAY SYSTEMS

Previous instructions included all relevant information for interconnecting the X-ray Control with devices such as: The HV Transformer, Tube Stand, X-ray Tube, Collimator, X-ray Table, Wall Stands and Buckys. Installation and Testing Procedures in this section establishes and ensures orderly installations and Insures Radiation Safety for the assembler, operator and patient.

This section organizes the installation process into progressive steps and emphasizes tests required and procedures given. Some sections provide Data Sheets so that you can document relevant information.

1. Remove line Fuses or Circuit Breaker from the Disconnect Box. Measure Line Voltage and Adjust both Line Straps.
2. Connect L1, L2 and Earth Ground to Control (line wiring and conduit are supplied by the customer).
3. Place High Voltage Transformer into its designated place as indicated in the floor plan. The HV Transformer contains “Shell Diala” or equivalent insulating oil which expands or extracts per elevation or temperature change. After final leveling, check that there is not oil leakage or overfill. If there is, check that the oil level is approximately 20 mm (3/4”) of the top surface of the HV Transformer.
4. If there is overfill, use a syringe to remove the excess oil. If oil is needed use the above type oil or equivalent to bring the oil level up to the approximate level indicated above. Do not allow oil to get into eyes or on the body. Follow indications and wash thoroughly.
5. Connect X-ray Control to High Voltage Transformer. Use interconnects provided making sure all wires are marked correctly.
6. Install the Tube Stand, X-ray Tube, and Collimator. Connect Rotor leads to Control.
7. Install High Voltage Cables between High Tension Transformer and X-ray Tube.
8. Connect Collimator and Tube Stand supply cord to 24 VAC Distribution Board inside the X-ray control.
9. Install Fuses or Circuit Breaker. Switch Line on. Switch Control on. Switch Bucky OFF.
10. Calibrate the X-ray Control in this manner. First: Adjust each MA or MAS Station with KVP set at 80.
11. Align light to X-ray field, adjusting as needed. Adjust Tube Stand Beam Alignment, Floor and Wall.
12. Align and Center X-ray Table to the X-ray Field. Connect table to 24 VAC Distribution Board inside X-ray control.
13. Assemble, center to x-ray field and install Buckystand. Connect Buckystand 24 VAC to 24 VAC Distribution Board inside control.
14. Re-check x-ray alignment and fasten Table Base to the Floor. Re-check Buckystand Alignment and fasten.
15. Ensuring x-ray control is operating properly, if applicable, connect Reciprocating Buckys: Check Bucky operation.
16. Connect PBL lockout or other interlocks and switches required.
17. Using # 10 AWG EARTH GROUND Green with Yellow Stripe wire, Ground all devices together.

4.3.1 INSTALL X-RAY TUBESTAND

Proper Tubestand installation is vital to final X-Ray Beam and Light Field Alignment to Wall Stand and X-ray Table. Assemble, erect, level, align and fasten the Tube Stand to comply with the manufacturer’s instructions. (For information on aligning the x-ray and light field go to Sections 6, 7 and 8 in the Collimator Section).

4.3.2 FASTENING THE X-RAY TUBE TO THE TUBEMOUNT

Using appropriate collimator spacers, mounting plate and bolts, fasten the x-ray tube to the tubemount. (First time installers see complete information provided in the collimator section.)

WARNING

MAKE SURE THAT STATOR WIRES ARE PROPERLY CONNECTED. IF LEADS ARE NOT PROPERLY CONNECTED STATOR WILL INCORRECTLY ROTATE CLOCKWISE AND THE ROTOR CONTROL ROTATION SENSING CIRCUITS WILL NOT ALLOW A READY SIGNAL. BEFORE MAKING ANY EXPOSURE ENSURE THAT ANODE ROTATES COUNTERCLOCKWISE.

4.3.3 COLLIMATOR INSTALLATION

Note

Shutter Mechanisms for Certified Collimators have been precisely aligned with respect to the mounting flanges at the factory. Therefore, the necessity of field alignment of the central ray has been virtually eliminated.

For Beam Limiting Testing and Alignment Instructions
See Sections 6, 7 and 8.

Determine the collimator mounting surface to focal spot distance from the data supplied with the X-ray tube (do not rely on an inscribed mark on the tube housing).

Note: The collimator will not perform properly unless the focal spot to upper swivel ring distance is 2-7/16" (2.44 inches, 62 mm) +/- 1/32" (.031 inches, 1 mm). Be sure to include any permanent mounting plates in the focal spot to port boss distance stated in the tube manufacturer's data.

Note: The Linear MC150 is designed to be used with a lead diaphragm or cone in the plastic port of the X-ray tube.

If it is found that lead diaphragms or cones require removal or modification, consult the factory.

4.3.4 SKIN GUARD INSTALLATION (OPTIONAL)

NOTE: Refer to Figure 2.2

Note *Skin Guard Kits are optional and must be purchased separately from the collimator.*

1. Remove the Front Cover Bezel, then the Left and Right Side Covers by removing the six (6) 6-32 screws which keep them in place.
2. Mount the two (2) Skin Guard Rails to the Left and Right Side Covers using the four (4) screws provided in the Skin Guard Kit.
3. Reattach the Left and Right Side Covers, then the Front Cover Bezel. After assembly, test the field lamp timer for proper operation.

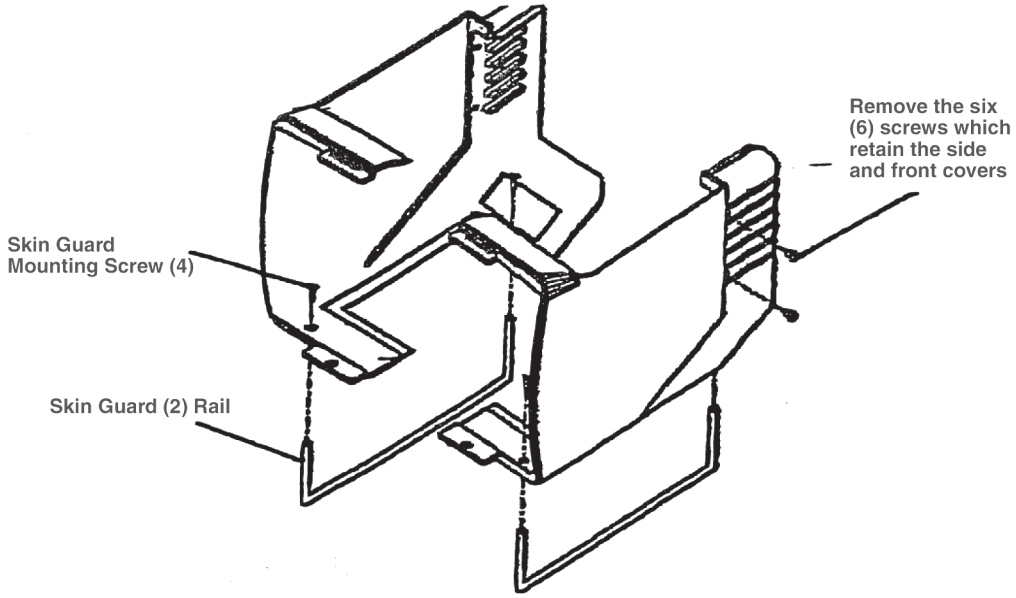


FIGURE 2.2 – SKIN GUARD INSTALLATION

4.3.5 SETTING THE LINE STRAPS

Matching the autotransformer to the incoming line is accomplished with two line straps, one on the Major KVP Selector Switch and one on the Minor KVP Selector Switch. All nine major voltages, 100 through 260, from the autotransformer are considered positive numbers. All eight minor voltages, 0 through 18, from the autotransformer are considered negative numbers. For line matching at installation, measure your line supply voltage. Example: The installation Line Supply voltage is **234**. Connect the Major line strap to **240**-then connect the Minor line strap to **-5. 240-5 = 235**. After line straps have been set, connect a digital voltmeter between A1 and A2. If line is matched properly, **118-122V** should appear between A1 and A2.

See calibration Data Sheet Part 1.

Line Supply Voltage	Connect Major Line Strap To Match nearest Line Voltage + Numbers	Connect Minor Line Strap To Deduct the Difference -Numbers	Line/Autotransformer Match	Measure Voltage Between A1 - A2
Example 234VAC	Connect Major Line Strap to 240 on the Major KVP Switch	Connect Minor Line Strap to minus (- 5) on the KVP Switch 240-5= 235 VAC	235VAC. The Auto is matched within 1 volt of the actual line.	118-122VAC
Your Voltage				

4.3.6 X-RAY CONTROL CHECK OUT PROCEDURE

NOTICE:

1. Check dials and knobs for looseness and whether they are indicating the correct function. Register and tighten as needed. Turn Line Power ON, turn Breaker on X-ray Control. Turn Bucky Switch to OFF.
2. Vary Major and Minor KVP switches and observe the KVP Meter Display .
3. Vary the MA Switch and observe MA and MAS Meter Displays.
4. Vary the Time Select Switch and observe the MAS Displays.
5. DISREGARD KVP METER READOUT AT THIS TIME. Depress rotor button (After 2.2-second delay, the **green ready lamp** should light), then depress the exposure push-button.
   A. You should hear the back-up contacts close and the console **amber exposure lamp** light.
   B. At the end of the exposure, the exposure lamp should extinguish.
   C. An audible signal sounding termination should be observed.
   D. If the above conditions are met, the Control is ready for Calibration. Proceed to Section 5.
   E. Should an ERROR CODE be displayed, (See ERROR CODE CHART in section 12.6.5).
6. Turn control OFF and connect all test instruments needed for calibrating the X-ray Control.

4.3.7 X-RAY BEAM QUALITY AND ALIGNMENT PROCEDURES

X-ray Beam Quality depends on many factors which cannot be explained in such a short space. For this reason a complete section has been included which explains all facets of testing, adjustments and verification for X-ray Beam Quality. **See Sections 6, 7 and 8.**

SECTION 5

CALIBRATING THE X-RAY CONTROL

Before being shipped, every Standard Frequency X-Ray Control and High Voltage Generator is fully calibrated with certified documents and must pass a 100% Quality Assurance Testing Program. However, calibration is dependent on the age and quality of the x-ray tube and high voltage cables being used. For the purposes of this manual and especially this Section, Tingle X-Ray, LLC has assumed that a new x-ray tube and high voltage cables are being used.

5.1 ADJUSTING THE TIMER

Microprocessor timers do not require adjustment. Inputs: There are basically four main components to the timer section inputs. A timer selector switch, ribbon cable connecting the switch to the timer board, the input power plug harness, and the timer board itself. Outputs: There are three basic components to the timer output. A MAS/ERROR / Tube Limit / Overload display with ribbon cable, a SCR and Safety Backup Contactor Harness, and SCR Pack. For timing Reproducibility refer to Calibration Data Sheet Part 6. If you suspect a problem with the timer or its associated components, refer to Section 4.1.4 X-Ray Control Check Out Procedure.

5.2 ADJUSTING THE MILLIAMPERE STATIONS

Model TXR 325 D, TXR 325M, TXR 425 or 525 SFQ X-Ray Control with High Voltage Generator is shipped from the factory tested and calibrated. However, since Line Voltages, which affects KVP, and High Tension Cable lengths, which affects MA/MAS varies, the assembler must recalibrate all x-ray controls that are installed. First Procedure: Adjust MA/MAS Stations.

5.2.1 MA/MAS CALIBRATION PROCEDURE

1. Copy the page titled **Calibration Data Sheet**.
2. Connect an Accurate mA or mAs meter to + and – on the Thermal Board. NOTE POLARITY. Select S1 switch to Test and run all calibrations and tests.
3. Using Part 2 of the Calibration Data Sheet, follow its direction. **DURING THIS PROCEDURE ADJUST ONLY THE FILAMENT LIMITING RESISTORS: DO NOT ADJUST THE KVP METER COMPENSATION CIRCUITS OR THE KVP METER.**
4. After MA calibration has been completed, continue using the Calibration Data Sheet to calibrate KVP. If mA is too high or low caused by too long or too short high voltage cables see 5.2.2.

5.2.2 MA STABILIZER ADJUSTMENT

Long or short high voltage cables and some 50 hertz applications require adjusting the mA Stabilizer. The mA stabilizer can be field adjusted. See instructions in the Maintenance Manual M-2008-7-14.

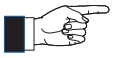
5.3 TESTING AND CALIBRATING KVP

Now that you know all MA stations are calibrated properly, you must insure that the KVP appearing at the x-ray tube selected by both major and minor tap switches match the Console KVP Meter Readout, within accurate limits.

5.3.1 KVP CALIBRATION PROCEDURE

1. Using Part 3 of the Calibration Data Sheet, continue. (mAs has already been calibrated and verified)
2. Select 50 mA at 80 kVp. Take an exposure. Measure kVp at the tube. Adjust the kVp Meter Slope Pot so that the Console kVp Display matches the actual output at the x-ray tube.
3. Select 100 mA at 80 kVp. Take an exposure. Measure kVp at the tube. Adjust the 100 band on the KVP Meter Compensation Resistor until the Console KVP Display matches the output at the tube.

4. Select 150 mA at 80 kVp. Take an exposure. Measure kVp at the tube. Adjust the 150 band on the KVP Meter Compensation Resistor until the Console KVP Display matches the output at the tube.
5. Select 200 mA at 80 kVp. Take an exposure. Measure kVp at the tube. Adjust the 200 band on the KVP Meter Compensation Resistor until the Console KVP Display matches the output at the tube.
6. Select 300 mA at 80 kVp. Take an exposure. Measure kVp at the tube. Adjust the 300 band on the KVP Meter Compensation Resistor until the Console KVP Display matches the output at the tube.
7. Select 400 mA at 80 kVp. Take an exposure. Measure kVp at the tube. Adjust the 400 band on the KVP Meter Compensation Resistor until the Console KVP Display matches the output at the tube.
8. Select 500 mA at 80 kVp. Take an exposure. Measure kVp at the tube. Adjust the 500 band on the KVP Meter Compensation Resistor until the Console KVP Display matches the output at the tube.

Note 

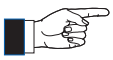
Automatic Line Compensation: The line compensating kVp circuitry will track up and down scale and will internally adjust the KVP Meter Display for fluctuating line voltages. To verify, complete all Calibration Data Sheet Tests.

5.4 SPACE CHARGE

As the kVp is increased from anode to cathode across an X-ray tube, you have a space charge affect. We use a space charge compensation network in our controls that will offset the effect to kVp causing the selected current to track across the entire kV range. Using standard and fine focal x-ray tubes, the space charge has already been set at the factory and no adjustment should be necessary. The mA will be maintained at 10% (plus or minus) of full scale. The rotor circuit works with the mA circuit as when the rotor is initiated the filament is boosted reducing the time that the filament has to be at full mA production. Completing and documenting MA and KVP Calibration verifies space charge circuits are working properly.

5.4.1 SPACE CHARGE CALIBRATION PROCEDURE

1. TO TEST SPACE CHARGE: Cover X-Ray Tube port with lead sheeting or make sure collimator shutters are closed. (Arrange for operation where beam limiting lockout devices are incorporated in equipment).
2. Locate test switch on the Thermal Board. Switch to TEST mode (on).
   Connect MA or MAS meter between +/- terminals located underneath the test switch.
   NOTE POLARITY.
3. Copy the page titled Calibration Data Sheet. Complete the fourth and fifth section.
4. If a Dynalyzer or similar test equipment is not used, use a Digital MAS Meter.

Note 

Space Charge Characteristics of x-ray tubes are linear only above and about 55 to 60 kVp, so complete compensation cannot be obtained from that kVp and below.

SECTION 6

RADIATION SAFETY

6.0 REQUIREMENTS.

Before attempting activities that require observation, testing, validating and documenting the results of such testing, become thoroughly informed to the danger of being exposed to x-radiation. You are to comply with all Safety Statements issued throughout this Manual. They may be in the form of **DANGER, WARNING, CAUTION OR NOTE** signs and any statement in BOLD type. The terms on this page are explained and used throughout section 6.

FOCAL SPOT TO SKIN DISTANCE

TO KEEP THE ABSORBED DOSE TO THE PATIENT AS LOW AS POSSIBLE, MAINTAIN 45 cm (17.6 INCHES) OR GREATER FOCAL SPOT TO SKIN DISTANCE in Normal Use.

Reference IEC 60601-1-3 CL 29.205.2

REFERENCE AXIS

THE X-RAY TUBE FOCAL SPOT MOVEMENT IS ARTICULATED ABOUT ITS REFERENCE AXIS, ROTARY, VERTICAL AND HORIZONTAL MOVEMENT WITH MEASURMENT SCALES, MARKERS AND POINTERS TO IDENTIFY DISTANCE FROM FOCAL SPOT TO IMAGE RECEPTORS. See XR8/2.20.

Reference IEC 60601-1-3 CL 29.203.1

FOCAL SPOT to IMAGE RECEPTOR DISTANCE

COLLIMATORS PROVIDE INDICATED SCALES TO IDENTIFY FIELD DIMENSIONS AT SELECTED SOURCE TO IMAGE DISTANCES. ALL INDICATOR MEASUREMENT FOR SCALES AND MARKERS ARE PROVIDED IN CENTIMETER, MILLIMETER AND INCHES. FOR ADDED PROTECTION LESS THAN 40 INCH FFD WE SUGGEST INSTALLING THE SKIN GUARD. See Section 4.3.4.

Reference IEC 60601-1-3 CL 29.203.2

ATTENUATION OF THE X-RAY BEAM

Avoid Excessive Attenuation to the X-ray Beam from material interposed between the patient and the X-ray Image Receptor, which can cause unnecessarily high levels of Absorbed Dose and Stray Radiation.

The Attenuation Equivalent of the items listed in Table 1, when forming part of an X-ray Equipment System and located in the path of the X-ray Beam between the Patient and the X-ray Image Receptor, shall not exceed the applicable maximum values given in the table 1.
Inspect table -tops and cradles for any physical damage or deviations, which might alter the attenuation characteristics.

Reference IEC 60601-1-3 CL 29.206 ands 21 CFR 1020.30n

Table 1

Item	Maximum ATTENUATION EQUIVALENT
PANEL FRONTS (Total of all layers)	1.0 mm Al
CRADLE	2.0 mm Al
PATIENT SUPPORT, stationary, without articulated joints.	1.0 mm Al
PATIENT SUPPORT, movable, without articulated joints.	1.5 mm Al

NOTES:
1. Devices such as Radiation Detectors are not included in the items listed in this table.
2. Requirements are given concerning the Attenuation properties of Radiographic Cassettes in IEC 406, of Intensifying Screens in Appendix A of IEC 658 and of Anti Scatter Grids in IEC 627.

6.1 COLLIMATOR OPERATIONAL CHECK OUT PROCEDURE

After the Collimator, Power Chassis and cabling have been installed, apply 24 VAC power and observe the face plate of the collimator.

6.1.1 Push the LAMP button and check that the light field lamp remains on for approximately 25 seconds.

6.1.2 While the field lamp is on, be sure the light field can be collimated to required size with the control knobs.

6.2 LIGHT FIELD / X-RAY FIELD CONGRUENCE TEST

The following operational check is performed with the collimator located in a single fixed position above a test pattern located on the table top.

Any required adjustments are made while observing the light-field edges, therefore it is necessary to confirm that the light-field is representing the X-ray field. By establishing a defined light-field and exposing a film to a density of 1.0, the X-ray field (image) can be compared to the light-field.

The X-ray field should be determined by exposing film to a density of 1.0 on the developed image, and observing the point at which the density is just visibly increased above the fog background of the film.

In a similar manner, the light-field edges should be determined by observing the light-field on a white background. By observing the point at which the lightfield is just visibly increased over the background illumination, and comparing this to the X-ray field (and to the tolerance marks on the pattern), congruence comparisons may be made.

Note ☞

The Performance Standards 1020.30 (b) (22) and (45) define the edges of the lightfield where the illumination is one-fourth of the maximum and the edges of the X-ray field where the exposure rate is one-fourth of the maximum.

EQUIPMENT REQUIRED:

A. LINEAR collimator test pattern (contained with the collimator manual)
B. Measuring tape (ruler)
C. 14” x 17” (35 cm x 43 cm) X-ray film cassette
D. Densitometer (or a 1.0 density neutral density filter for a density comparison).

6.2.1 Remove the LINEAR collimator table-top TEST PATTERN #1 from the manual and position it on the table-top with the edges parallel to the table-top edges. Flatten the creases and tap it into position at the corners in a manner that will not damage it upon removal.

6.2.2 Angulate the collimator to 0° horizontal. Position the collimator at a focal spot to TEST PATTERN distance of 40” or 100 cm $\pm$ 0.2 cm by measuring from the center of the exit window to the center of the light-field; this distance should be 30.38” or 75.6 cm.

LIGHT FIELD / X-RAY CONGRUENCE TEST

6.2.3 Place the X-ray source to table distance at 40 inches or 100 cm SID.

6.2.4 Locate a cassette on the table-top and accurately center the cassette to the light-field.

6.2.5 Manually reduce the size of the X-ray field to the next smaller film size.

6.2.6 Identify the light-field edges and carefully mark the edges by placing the metal markers as illustrated in Figure 6.1.

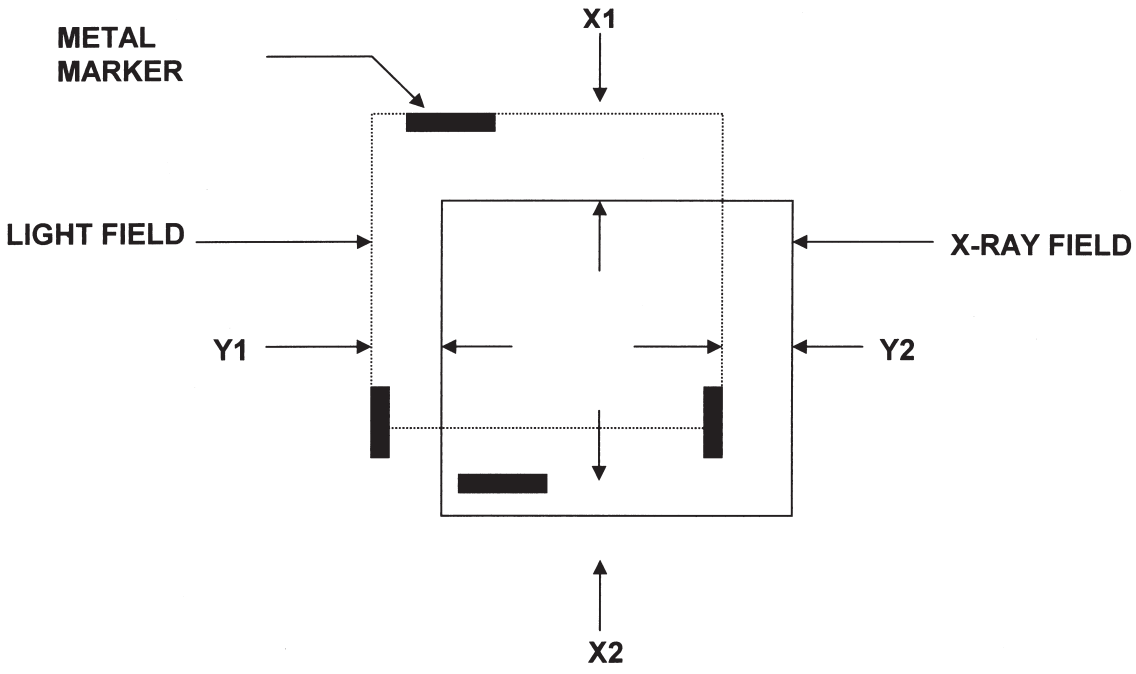
6.2.7 Expose the film to a density of 1.0 and develop.

6.2.8 Carefully identify the X-ray field edges and measure the difference between the X-ray field edges and light-field edges.

6.2.9 The sum of the long axis difference (X1 + X2) shall not exceed 2% of the SID, and the sum of the cross axis difference shall not exceed 2% of the SID.

6.2.10 If errors exceed those shown in Figure 6.1 below, refer to Section 7.0, ADJUSTMENT AND ALIGNMENT PROCEDURES.

LIGHT FIELD / X-RAY FIELD CONGRUENCE TEST



X1 + X2 MUST BE LESS THAN 2% OF THE SID

Y1 + Y2 MUST BE LESS THAN 2% OF THE SID

FIGURE 6.1

SECTION 7

X-RAY LIGHT FIELD / X-RAY BEAM ADJUSTMENTS

CROSS-HAIR WINDOW ADJUSTMENT

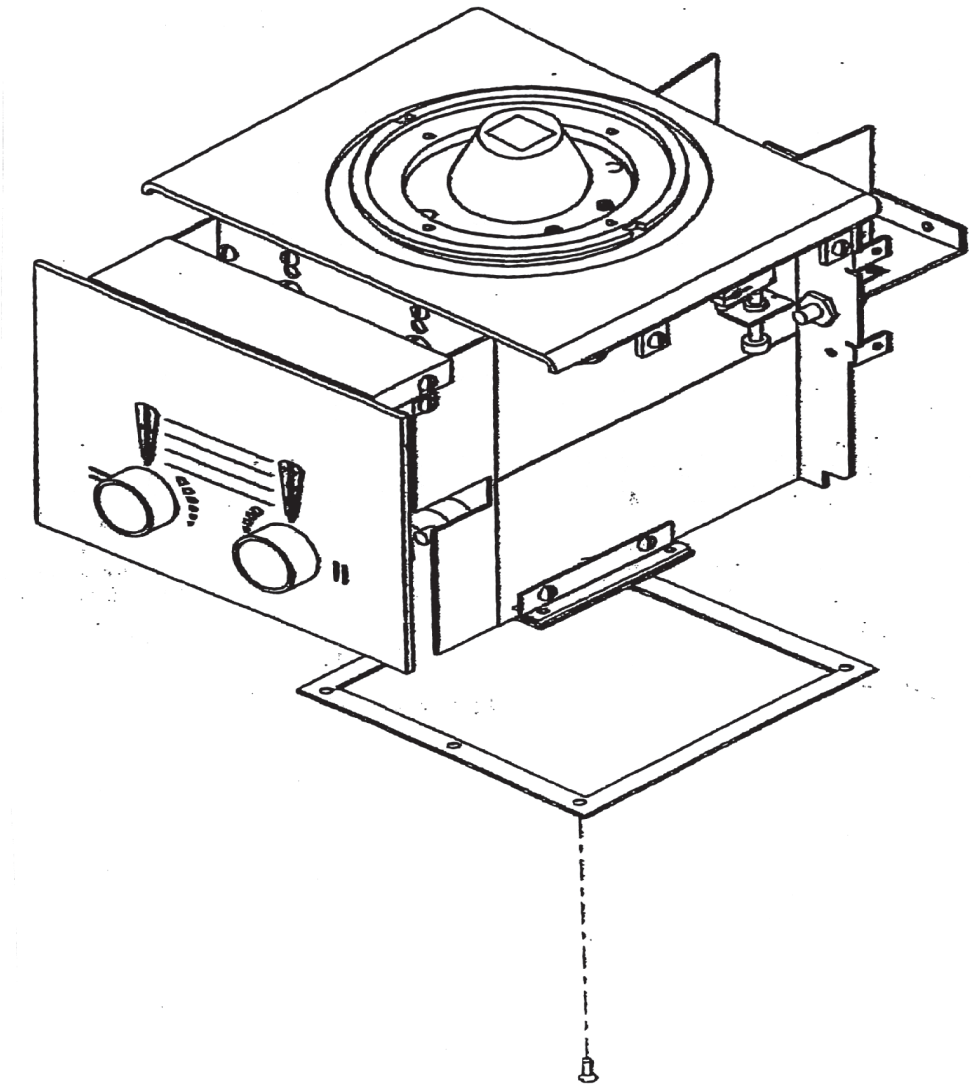


FIGURE 2.1

7.0 ADJUSTMENT AND ALIGNMENT PROCEDURES

7.1 FIELD PROJECTION LAMP AND MIRROR ADJUSTMENT

This procedure must be performed when the field projection lamp is altered from it's original position or replaced. This test must also be performed if the original mirror angle has been altered and if any edge of the developed X-ray image is outside of the 30.5 cm x 30.5 cm @ 100 cm tolerance marks as defined in Step 6.2.

7.1.1 Steps 3.1 through 3.2 should be carefully reviewed or repeated prior to a lamp or mirror adjustment attempt. This is particularly important if only a single testing indicates a failure to meet the requirements defined in Step 6.2.

7.1.2 The collimator position, and the developed X-ray film, must remain undisturbed from the position defined in Steps 6.1 through 6.2.

7.1.3 Remove the rear cover and the lamp housing heat shield.

WARNING! THE LAMP AND HEAT DEFLECTORS MAY BE HOT ENOUGH TO CAUSE SEVERE BURNS. DO NOT TOUCH ANY OBJECT IN THE LAMP AREA WITH BARE SKIN.

THE INTENSITY OF THE LIGHT OUTPUT IS SUFFICIENT TO TEMPORARILY IMPAIR YOUR VISION IF ALLOWED TO ENTER THE EYES DIRECTLY. MAINTAIN A POSITION IN WHICH YOU CAN SEE NEITHER THE FILAMENT WHEN IT IS OFF, NOR ALLOW LIGHT TO DIRECTLY ENTER YOUR FIELD OF VISION WHEN IT IS ON.

7.1.4 If the developed X-ray image (steps 1 through 9 in section 6.2) is off-center in the longitudinal direction, loosen the two screws securing the lamp housing.

7.1.5 Use a pair of long nose pliers to move the lamp housing slightly until ***the light field has shifted*** to a position that is centered to the developed X-ray image in the longitudinal direction. Tighten the two screws securing the lamp bracket.

7.1.6 If the developed X-ray image (steps 1 through 9 in section 6.2) is in error in the cross-table direction, adjust the angle of the mirror (using the adjustment screw) until ***the light field has shifted*** to a position that is centered to the developed X-ray image.

7.1.7 If the X-ray image is smaller than the light field, loosen the screws securing the lamp socket and use a pair of long nose pliers to move the socket further away from the center of the collimator until light field/x-ray field congruency has been achieved.

7.1.8 If the X-ray image is larger than the light field, loosen the screws securing the lamp socket and use a pair of long nose pliers to move the socket closer to the center of the collimator until light field/x-ray field congruency has been achieved.

7.1.9 Repeat steps 1 through 9 in section 6.2 to confirm the results of the above adjustment.

7.1.10 Tighten the lamp bracket screws and replace the rear cover.

7.2 CROSS HAIR WINDOW ADJUSTMENT

This procedure is to be performed if the cross hair shadows are not centered to the light field (Reference Figure 2.1).

7.2.1 Remove the spacer and the entire collimator enclosure.
7.2.2 Loosen the screws securing the plastic window.
7.2.3 Move the plastic window to align and center the cross hair pattern to the light field (center lines on the test pattern).
7.2.4 Tighten the screws and reassemble the collimator covers.

7.3 BUCKY CENTERING LIGHT- LINE ADJUSTMENT

If the collimator is equipped with a Bucky Light-Line Prism:

7.3.1 This procedure is to be performed if the centering light-line is not centered to the ***correctly adjusted light-field.*** If it is centered, replace the collimator enclosure and skip to section 5.0.
7.3.2 Remove the rear cover.

WARNING

THE LAMP AND HEAT DETECTORS MAY BE HOT ENOUGH TO CAUSE SEVERE BURNS. DO NOT TOUCH ANY OBJECT IN THE LAMP AREA WITH BARE SKIN.

WARNING

THE INTENSITY OF THE LIGHT OUTPUT IS SUFFICIENT TO TEMPORARILY IMPAIR YOUR VISION IF ALLOWED TO ENTER THE EYES DIRECTLY. MAINTAIN A POSITION IN WHICH YOU CAN SEE NEITHER THE FILAMENT WHEN IT IS OFF, NOR ALLOW LIGHT TO DIRECTLY ENTER YOUR FIELD OF VISION WHEN IT IS ON.

7.3.3 If the centering light-line is off-center to the correctly centered light-field or exhibits a rainbow of colors along one edge, loosen the two screws securing the prism/slit bracket See Figure 4.3.
7.3.4 Use a pair of long-nose pliers to move the bracket as required to center the light-line to the correctly adjusted light-field.

Note

IN ORDER TO AVOID THE RAINBOW OF COLORS ALONG THE EDGES, MAINTAIN THE PRISM IN A POSITION THAT IS CENTERED TO THE BRIGHT LIGHT-LINE THAT IS OBSERVED ON THE BRACKET AT THE BASE OF THE PRISM WHILE ADJUSTING THE BRACKET.

7.3.5 Tighten the screws and replace the collimator covers.

If the collimator is equipped with a Bucky Light-Line Laser:

THE LAMP AND HEAT DEFLECTORS MAY BE HOT ENOUGH TO CAUSE SEVERE BURNS. DO NOT TOUCH ANY OBJECT IN THE LAMP AREA WITH BARE SKIN

THE INTENSITY OF LIGHT OUTPUT IS SUFFICIENT TO TEMPORARILY IMPAIR YOUR VISION IF ALLOWED TO ENTER THE EYES DIRECTLY. MAINTAIN A POSITION IN WHICH YOU CAN SEE NEITHER THE FILAMENT WHEN IT IS OFF, NOR ALLOW LIGHT TO DIRECTLY ENTER YOUR FIELD OF VISION WHEN IT IS ON.

This unit utilizes a low power (2.5 x 10^{-3} W 650 nm) Class II laser to produce an alignment beam. DO NOT STARE DIRECTLY INTO BEAM OR VIEW WITH OPTICAL INSTRUMENTS.

Laser Adjustment

1.) Verify alignment of the field light to the X-ray beam.

2.) Remove the covers from the collimator.

3.) Open the long shutters to the maximum setting.

4.) Close the long shutter to project a .25 to .50 wide beam onto the work surface.

5.) Use a “rigid projection board” (piece of cardboard ~ 12” x 18”) to sweep the activated laser/field light beam from the work surface up to the bottom of the collimator.

6.) Note the laser line to field light position and alignment at the extremes of the projection board movement.

7.) Axial angular adjustment: Indicated by an angular mis-alignment of the laser line to the field light projection. Loosen the 4-40 rotation stop screw and rotate the laser module until the laser line is parallel and in alignment with the field light projection.

8.) Lateral (side to side) adjustment: Loosen the bracket laser mounting screws and adjust the laser side to side in the slots provided. Tighten the mounting screws.

9.) Longitudinal angular adjustment: Indicated by the laser line projection moving from one side to the other of the field light projection. Loosen the module mount screws.
Move laser module to appropriate direction.

10.) Reinstall the covers on the collimator.

Laser Bucky line Projections

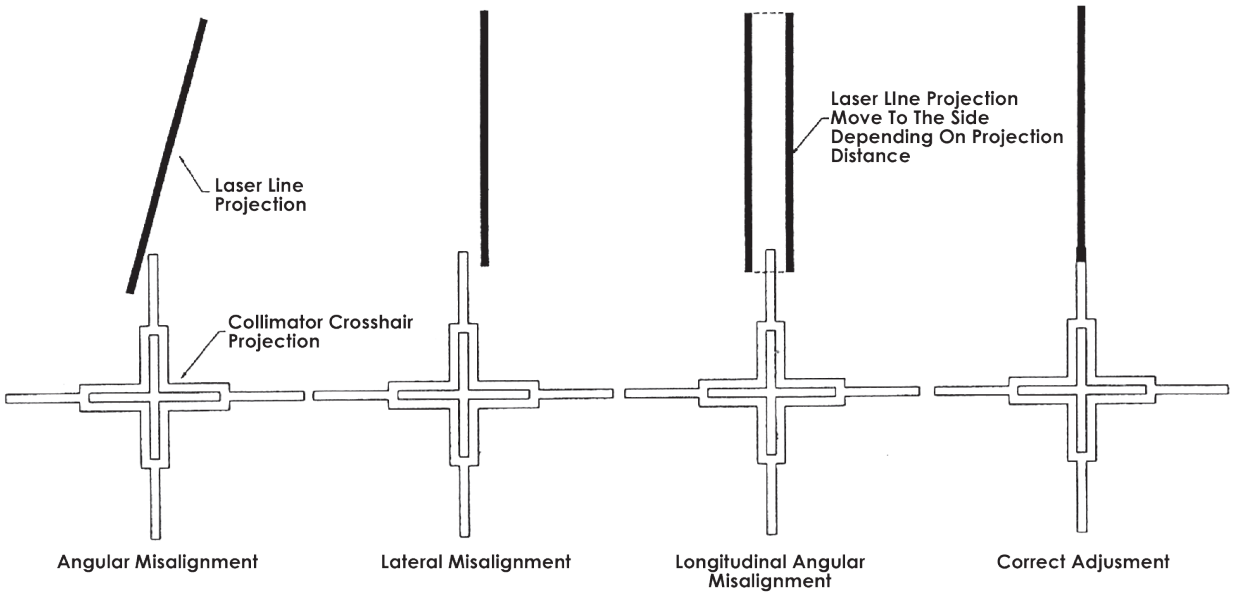
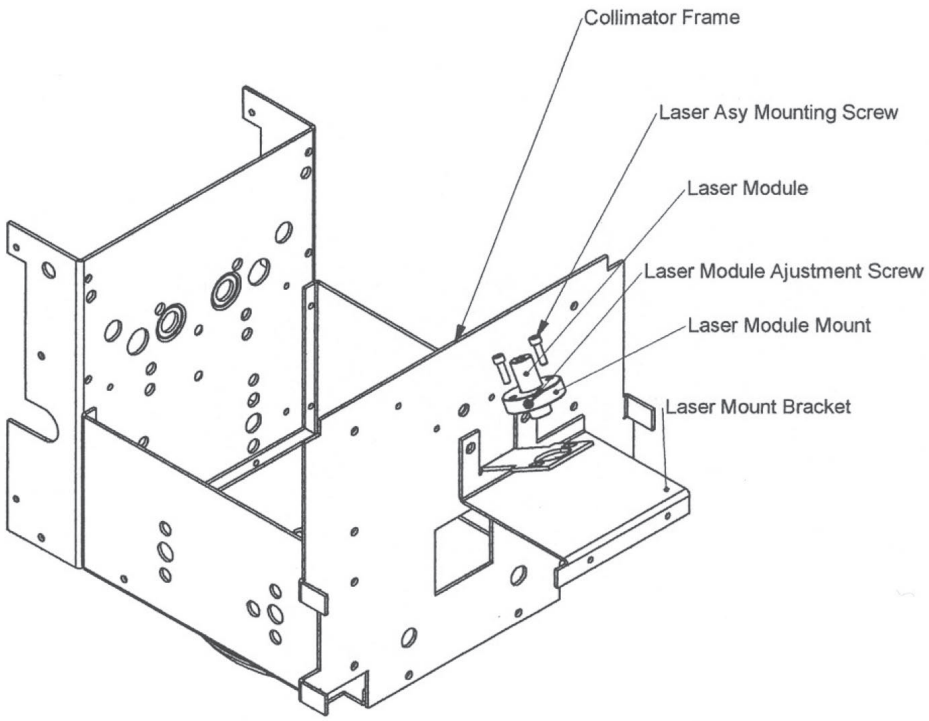


Figure 2.2
Reference View of Laser Parts



7.4 LONG AND CROSS SHUTTER FIELD SIZE INDICATOR ADJUSTMENT

The field size indicator dials are factory calibrated and should not require adjustment. If it becomes necessary to readjust, follow the procedure below:

7.4.1 Disconnect the collimator power. Remove the knobs by loosening the set screws holding them in place. Using a long allen wrench, the set screws on the hubs of the two dial indicators can be loosened, making adjustment possible.

7.4.2 Tape test pattern 70-09021 supplied in manual to the table top and set the SID to 40” to the table top (or using test pattern 70-09023 also supplied in the manual, set the SID to 100 cm to the table top). Turn on the collimator, light the field lamp and adjust the shutters to project a 17” x 17” light field on the test pattern (or 43 cm x 43 cm if using the 70-09023 test pattern).

7.4.3 Loosen the set screws in the dial hub and rotate the dial to indicate exactly 17” at the 40” SID index line (or 43 cm at them 100 cm SID index line). Lock the set screw without disturbing the shutter setting. Repeat for the other axis.

7.4.4 Replace knobs. Check the unit for proper tracking of light-field verses indicated field size at 40”, 100 cm, 72” and 180 cm SID.

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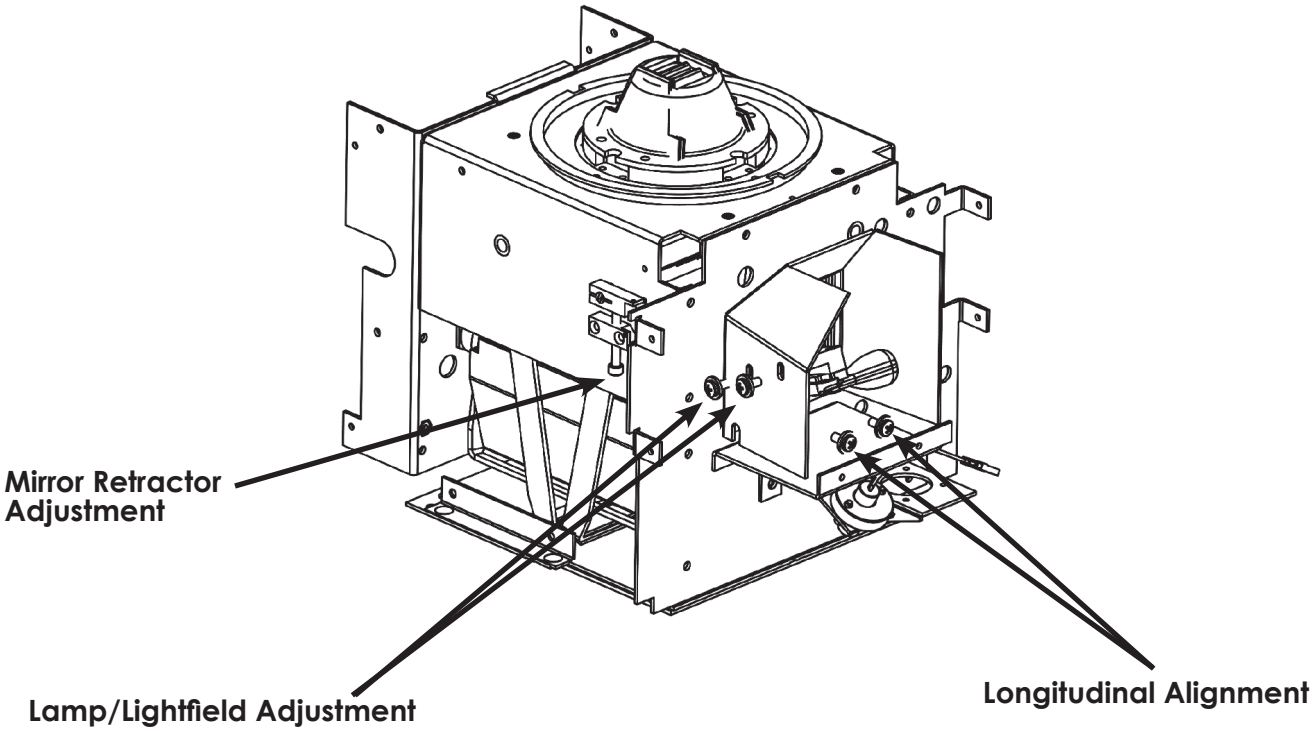

CROSS ALIGNMENT	LONGITUDINAL ALIGNMENT
1. Adjust two #6-32 screws for Light-field alignment.	1. Slightly loosen the two #6-32 screws
2. (Option) Add Loctite to set in position.	2. Position lamp bracket laterally for light-field alignment, left to right.
	3. Tighten the two #6-32 screws.

FIGURE 2.3 - LIGHT-FIELD ADJUSTMENT

WARNING

THE LAMP AND HEAT DEFLECTORS MAY BE HOT ENOUGH TO CAUSE SEVERE BURNS. DO NOT TOUCH ANY OBJECT IN THE LAMP AREA WITH BARE SKIN.

WARNING

THE INTENSITY OF LIGHT OUTPUT IS SUFFICIENT TO TEMPORARILY IMPAIR YOUR VISION IF ALLOWED TO ENTER THE EYES DIRECTLY. MAINTAIN A POSITION IN WHICH YOU CAN SEE NEITHER THE FILAMENT WHEN IT IS OFF, NOR ALLOW LIGHT TO DIRECTLY ENTER YOUR FIELD OF VISION WHEN IT IS ON.

CAUTION

Both Cross And Long Shutters Must Be Fully Open For Any Mirror Retraction - Forcing The Mirror Will Miscalibrate The Light-field!

SECTION 8

COMPLIANCE VERIFICATION

8.1 VERIFICATION TESTS TO BE PERFORMED

8.1.1 BEAM QUALITY (HALF-VALUE LAYER [HVL])

REQUIREMENT- The minimum beam quality requirements listed in Tables 204 and 5-1 shall be met. (See 21 CFR 1020.30 (m). **(See IEC 60601-1-3 Clause 29.201.5)**

.01 METHOD I - VISUAL DETERMINATION OF HALF-VALUE LAYER (HVL)

A. General

The above HVL requirement will be considered to have been met if it can be demonstrated that the aluminum equivalent of the total filtration in the primary beam is not less than that shown in Table. 5-2.

B. Equipment

None is required.

Table 204 — MINIMUM BEAM QUALITY REQUIREMENTS (IEC 60601-1-3.CL 29.201.2 Table 204)

X-Ray Tube Voltage			
Application	**Operating range for Normal Use kV**	**Selected value (See NOTE 1) kV**	**Minimum permissible first HALF-LAYER mm AL**
Other Applications	**From 30 upwards**	**Less than 50**	**See NOTE 2**
		50	**1.5**
		60	**1.8**
		70	**2.1**
		80	**2.3**
		90	**2.5**
		100	**2.7**
		110	**3.0**
		120	**3.2**
		130	**3.5**
		140	**3.8**
		150	**4.1**
		Greater than 150	**See NOTE 2**

*Type 1100 aluminum alloy as given in Aluminum Association Publication No. ASD-1, Aluminum Standards and Data.

Table 5-1 MINIMUM BEAM QUALITY REQUIREMENTS (21 CFR 1020.30 (m).

Kvp Range	Measured kVp	HVL (mmAl*)
Below 50	**30**	**0.3**
	40	**0.4**
	49	**0.5**
50 to 70	**50**	**1.2**
	60	**1.3**
	70	**1.5**
Above 70	**71**	**2.1**
	80	**2.3**
	90	**2.5**
	100	**2.7**
	110	**3.0**
	120	**3.2**
	130	**3.5**
	140	**3.8**
	150	**4.1**

*Type 1100 aluminum alloy as given in Aluminum Association Publication No. ASD-1, Aluminum Standards and Data.

Table 5-2 ALUMINUM EQUIVALENT OF PRIMARY BEAM TOTAL FILTRATION

Operating Voltage (kVp)	Total Filtration (mm Al Equivalent)
Below 50	0.5
50-70	1.5
Above 70	2.5

C. PROCEDURE

Visually inspect the system and determine the aluminum equivalence of the total filtration in the primary beam. This includes the inherent filtration of the X-Ray tube, X-ray tube housing, beam-limiting device, and any additional filtration that may have been added in the useful beam (in fluoroscopic systems the tabletop is included as part of the added filtration).

D. VERIFICATION OF COMPLIANCE

The aluminum equivalence of the total filtration must be equal to or greater than the amount specified in Table 5-1.

NEMA Standard 5-15-1979

.02 METHOD II - STANDARD ABSORBER METHOD

A. GENERAL

This test is to be used when the surveyor cannot remove or see the total filtration equivalence.

The HVL determinations obtained from the following procedures are to be compared with those illustrated in Table 5-1. The HVL in millimeters of aluminum of the system being tested must be greater than or equal to the values shown in Table 5-1.

B. EQUIPMENT

1. Radiation detector
2. Standard absorber with equivalent filtration of 2.5 millimeters of aluminum.

C. PROCEDURE

1. With the detection device positioned horizontally, an exposure is made at a pre-selected technique factor of 80 kVp and appropriate mA and time. The reading of the radiation output is recorded.

2. Position a total of 2.5 millimeters of aluminum at the port of the beam-limiting device and repeat the exposure using the same technique factors. Record the radiation output.

D. VERIFICATION OF COMPLIANCE

Verify that the radiation output in step 2 is greater than or equal to 50 percent of the radiation output in step 1.

NEMA Standard 5-15-79

.03 METHOD III - BRH/FDA COMPLIANCE TEST

A. GENERAL

The HVL determinations obtained from the following procedures are to be compared with those illustrated in Table 5-1. The HVL in millimeters of aluminum of the system being tested must be greater than or equal to the values shown in Table 5-1.

B. EQUIPMENT

1. BRH/FDA compliance test standard with accessories.
2. Survey meter adapted for use with stand with an ion chamber.
3. Several sheets of aluminum, each having a thickness of 0.5 or 1.0 millimeter.

C. PROCEDURE

1. Attach the spacer, positioned out of the primary beam, to the test stand. Center the stand on the table. Center the source over the stand and bring the beam-limiting device down into firm contact with the spacer. Select the MANUAL mode of operation (there must not be a cassette in the cassette tray). Insert the beam-defining assembly in slot 1 of the stand with the leaded side up (See Figure 5-1). Adjust the beam-limiting device so that the X-ray field slightly exceeds the aperture of the beam-defining assembly. Mount the ion chamber at position B with the chamber facing upward. Connect the chamber and meter with the cable provided. Select a tube potential that is commonly used and is in the highest kVp range of the X-ray system.
2. With no added filtration in the beam, make an exposure and record the reading. For all diagnostic X-ray equipment, use Table 5-3 to determine increments of filtration required to perform the half-value layer procedure. Make an exposure and record the reading for each total thickness.

TABLE 5-3 HIGHEST DESIGN OPERATING RANGE

Total Added Filtration, mm Al		
Below 50 kVp	**50 - 70 kVp**	**Above 70 kVp**
0.5	1.0	1.5
1.0	1.5	2.5
1.5	2.5	3.5
2.0	3.5	4.5

The recorded data is plotted on semi-log graph paper (Examples A and B, Fig. 5-6) and the half-value is read directly from the graph.

D. VERIFICATION OF COMPLIANCE

Verify that the half-value layer of the useful beam for a given X-ray tube potential is not less than the values shown in table 5-1.

NEMA Standard 5-15-1979

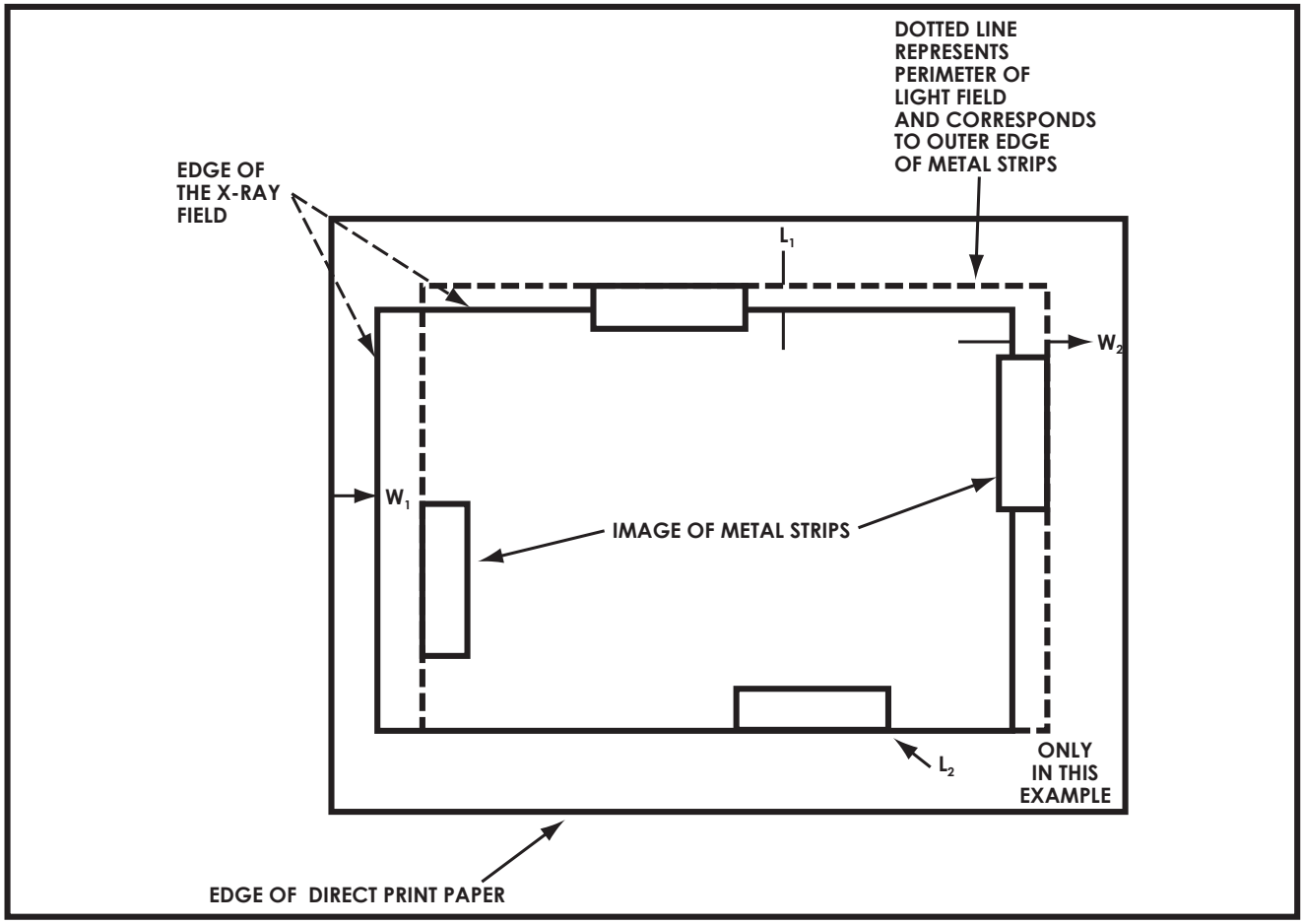

FIGURE 5.3 LIGHT FIELD vs. X-RAY FIELD ERROR MEASUREMENTS

TABLE 5-4 HALF VALUE LAYERS AS A FUNCTION OF FILTRATION AND TUBE POTENTIAL FOR DIAGNOSTIC UNITS*

Peak Potential (kVp)										
Total Filtration Mm Al	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Typical Half-Value Layers (mm Al)										
0.5	0.36†	0.47†	0.58	0.67	0.76	0.84	0.92	1.00	1.08	1.16
1.0	0.55	0.78	0.95	1.08	1.21	1.33	1.46	1.58	1.70	1.82
1.5	0.78	1.04	1.25†	1.42†	1.59†	1.75	1.90	2.08	2.25	2.42
2.0	0.92	1.22	1.49	1.70	1.90	2.10	2.28	2.48	2.70	2.90
2.5	1.02	1.38	1.69	1.95	2.16	2.37†‡	2.58†‡	2.82†‡	3.06†‡	3.30†‡
3.0	...	1.49	1.87	2.16	2.40	2.62	2.86	3.12	3.38	3.65
3.5	...	1.58	2.00	2.34	2.60	2.86	3.12	3.40	3.68	3.95

*For full-wave rectified potential
† Recommended minimum HVL for radiographic units.
‡ Recommended minimum HVL for fluoroscopes

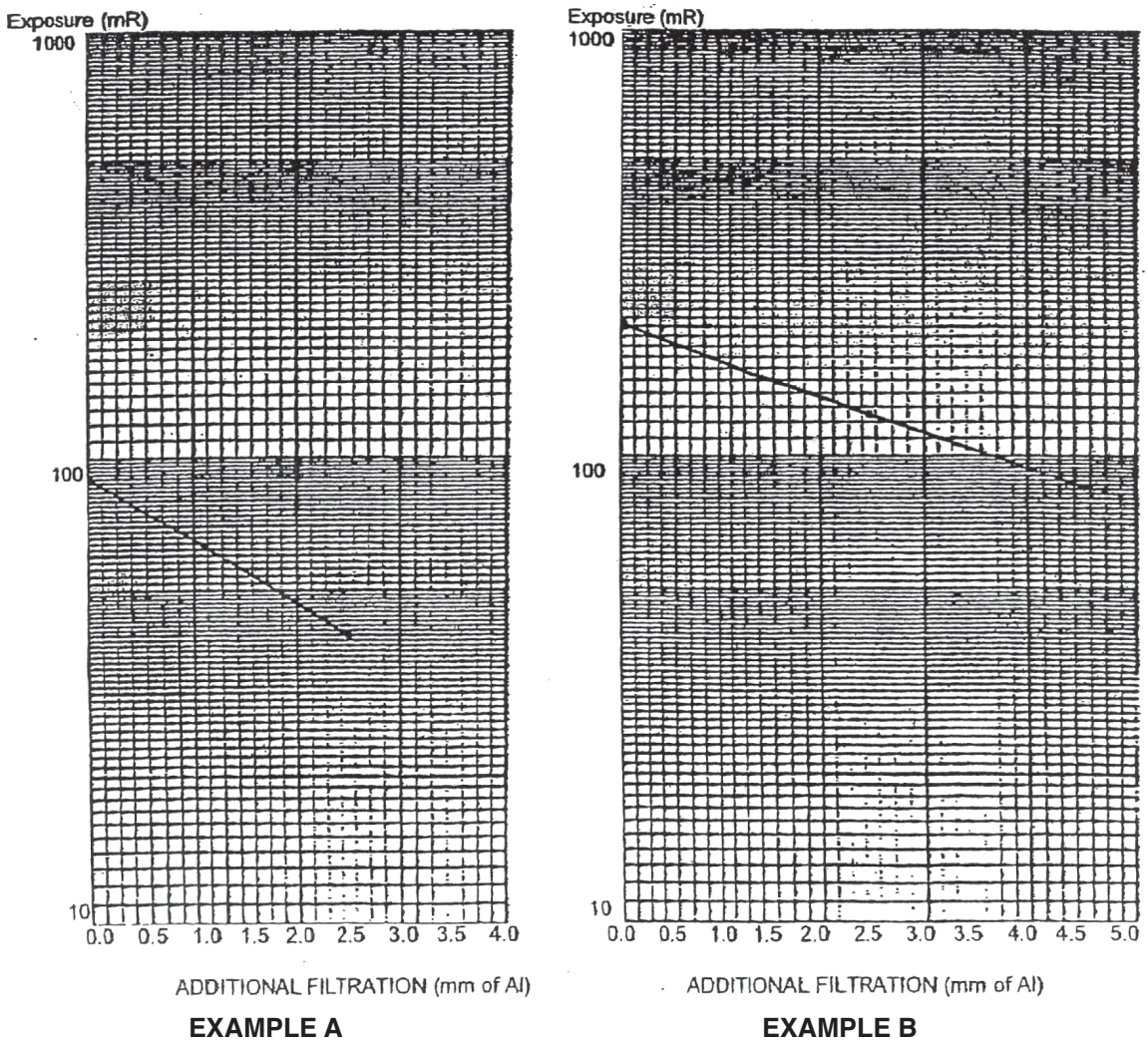

FIGURE 5-6
HALF-VALUE LAYER DETERMINATION GRAPHS

XR 8-2.14 VISUAL DEFINITION

(RADIOGRAPHIC) OF X-RAY LIGHT FIELD

REQUIREMENT - Means shall be provided for visually defining the perimeter of the X-ray field. The total misalignment of the edges of the visually defined field with the respective edges of the X-ray field along either the length or width of the visually defined field shall not exceed 2 percent of the distance from the source to the center of the visually defined field when the surface upon which it appears is perpendicular to the **Reference Axis** of the X-ray beam (see 21 CFR 1020.31 (d) (2)).

.01 METHOD 1 - BRH-FDA COMPLIANCE TEST METHOD

A. EQUIPMENT REQUIRED

1. BRH/FDA compliance test stand (including slide assembly)
2. Four metal marker strips
3. Plastic cassette, loaded with direct print paper or film

B. PROCEDURE

1. Attach the spacer, positioned out of the primary beam to the test stand. Center the stand on the table. Center the source over the stand, assure by the means provided that the axis of the X-ray beam is perpendicular to the plane of the image receptor, and bring the beam-limiting device down into firm contact with the spacer. Select the MANUAL mode of operation (there must not be a cassette in the cassette holder).
2. Insert the slide assembly, grid side up, into slot 6 of the test stand and the focal spot assembly into slot 1 (Figure 5-2). Place a cassette loaded with direct print paper or film into the slide assembly.
3. Adjust the collimator so that no part of the light-field intersects any portion of the top of the test stand. (Further collimation to a light field of less than 15 by 20 centimeters (6 by 8 in) on the side assembly grid may be desirable to assure that the X-ray field will be fully contained on the direct print paper for film in the slide assembly).
4. Position the outer edge of each metal strip to correspond with each side of the light-field. One end of the metal strip shall extend to the center line of the respective grid arm.
5. Select proper technique factors and make an exposure (may require several exposures to obtain 1 R to the direct print paper).
6. Develop the direct print paper or film.

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C. VERIFICATION OF COMPLIANCE

For determination of misalignment, compare the edges of the X-ray field to the edges of the light-field as defined by the outer edges of the metal strips. On each side of the rectangular fields, measure the separation between the X-ray field and the outside edge on the image of the respective metal strip. Sum these measured separations for opposite sides of the X-ray field to yield a total misalignment in the length and width dimensions. Record the length misalignment and width misalignment, both without regard to sign (see Paragraph D and Figure 5.3).

D. CALCULATIONS

Calculate the source to image distance (SID) per the following formula (to slot 6) as the indicated source-to-table top distance minus 4.7 centimeters (1.85 in) and record. Calculate 2 percent of this SID and record. Both the length and width misalignment must be less than 2 percent of SID (to slot 6).

$$\frac{2.5}{S} = \frac{X}{X + 13.95}$$

$$2.5X + (2.5)\ 13.95 = XS$$

$$(2.5)\ 13.95 = XS - 2.5X$$

$$34.875 = X\ (S - 2.5)$$

$$X = \frac{34.875}{S - 2.5}$$

The misalignments are calculated as follows:

Length misalignment = $L_1 + L_2 \leq 2\%$ SID
Width misalignment = $W_1 + W_2 \leq 2\%$ SID

Calculate 2% of the measured SID. Each of the misalignments, length or width, must be less than or equal to 2% of the measured SID for compliance.

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.02 METHOD II - METAL MARKER METHOD

A. GENERAL

The actual versus indicated source-to-image receptor distance (SID) test must be performed prior to attempting this test.

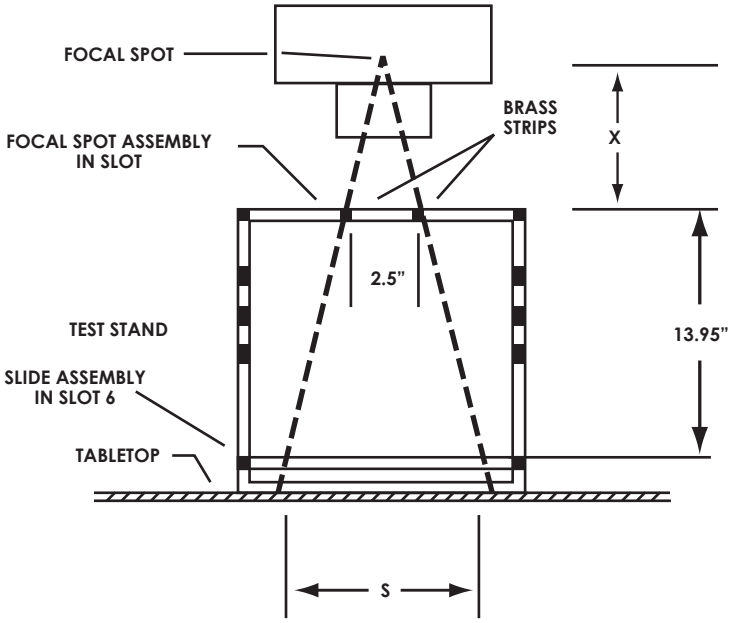

FIGURE 5-4 CALCULATION EXAMPLE

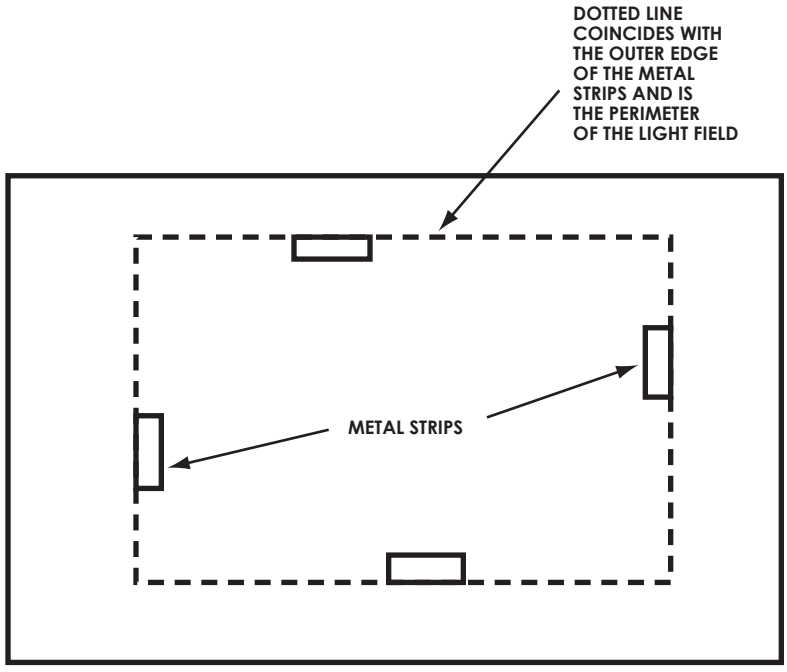

FIGURE 5-5 METAL MARKER METHOD

B. EQUIPMENT

1. Plastic cassette with direct printer paper or film.
2. Radio-opaque markers*

   * Each marker is approximately .080 cm galvanized sheet metal having the dimensions of 4 by 4 cm.

C. PROCEDURE

1. Adjust the source assembly and the beam-limiting device so that they are approximately centered over the table and perpendicular to the table top. Then position the beam-limiting device to the SID previously determined and record the indicated value.
2. Insert the cassette and turn on the light-field.** Adjust the beam-limiting device to the next size smaller than the cassette size being used.

   **** Make a note to record the field size indicated on the dial of the beam-limiting device for the SID being used.**
3. Position the outer edge of each metal marker on the table top to correspond with each side of the light-field (Figure 5-5).
4. Select the appropriate technique factors and make an exposure.
5. Develop film or direct-print paper.

D. VERIFICATION OF COMPLIANCE

For determination of misalignment, compare the edges of the X-ray field to the edges of the light field as defined by the outer edges of the metal strips. On each side of the rectangular fields, measure the separation between the X-ray field and the outside edge of the image of the respective metal strip. Sum these measured separations for opposite sides of the X-ray field to yield a total misalignment in the length and width dimensions. Record the length misalignment and width misalignment, both without regard to sign (see Par. E and Figure 5-3).

E. CALCULATIONS

$$\frac{2.5}{S} = \frac{X}{X + 13.95}$$

$$2.5X + (2.5)\,13.95 = XS$$

$$(2.5)\,13.95 = XS - 2.5X$$

$$34.875 = X\,(S - 2.5)$$

$$\frac{X}{} = \frac{34.875}{S - 2.5}$$

The misalignments are calculated as follows:

Length misalignment = $L_1 + L_2 \leq 2\%$ SID

Width misalignment = $W_1 + W2 \leq 2\%$ SID

Calculate 2% of the measured SID. Each of the misalignments, length or width, must be less than or equal to 2% of the measured SID for compliance.

NEMA Standards 5-15-79

.03 METHOD III - ALTERNATE TEST STAND METHOD

A. GENERAL

1. The image of the radiation field on the film must be of uniform density with sharply defined edges.
2. The graduated template is utilized to minimize the amount of error introduced into the measurement of the X-ray field size.
3. The actual versus indicated SID must be determined prior to performing this test.

B. EQUIPMENT

1. Manufacturer's recommended test stand.
2. Cassettes and film.
3. Graduated template.

C. PROCEDURE

1. Align the tube unit and image receptor and set the SID with the normal operating aids (detents, scales, lights, etc.)
2. Load cassette and insert into image receptor.
3. Close shutters to a size smaller than that of the cassette placed into the image receptor.
4. Position the test stand in accordance with the manufacturer's instructions.
5. Energize the field light and record or define the position of the four light field edges as shown on the graduated template or position four metal markers so that the outer edge of each metal marker corresponds to an edge on each side of the light-field or both.
6. Select proper technique factors, make an exposure, and develop film.

D. VERIFICATION OF COMPLIANCE

1. Calculate 2 percent of the actual SID and record.
2. Compare the edges of the X-ray field to the edges of the light field as defined by the outer edges of the metal markers or by the graduated scale.

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4. Measure the distance between the edges of the two fields for each side of the rectangular fields (see Figure 5-3).

5. Arithmetically sum the misalignment of opposite sides, regardless of sign, of the rectangles, to yield misalignment in each of the two directions.

$$\text{Length misalignment} = L_1 + L_2 \leq 2\% \text{ SID}$$
$$\text{Width misalignment} = W_1 + W_2 \leq 2\% \text{ SID}$$

Both the length and width misalignment must be less than 2 percent SID as calculated in Step 1.

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XR 8-2.15 INTENSITY OF LIGHT FIELD ILLUMINATION

.01 METHOD I – DIRECT TEST

A. GENERAL

1. The image of the radiation field on the film must be of uniform density with sharply defined edges.
2. The graduated template is utilized to minimize the amount of error introduced into the measurement of the X-ray field size.
3. The actual versus indicated source-to-image distance (SID) must be determined prior to performing this test.

B. EQUIPMENT

1. Manufacturer's recommended test stand.
2. Cassettes and film.
3. Graduated template.

C. PROCEDURE

1. Align the tube unit and image receptor and set the SID with the normal operating aids (detents, scales, lights, etc.)
2. Load cassette and insert into image receptor.
3. Close shutters to a size smaller than that of the cassette placed into the image receptor.
4. Turn on the light localizer.
5. At or near the center of a light field quadrant, determine the illuminance by subtracting the ambient light level from the corresponding light level as measured when the light localizer is energized. Do not move the photometer between measurements.
6. Repeat the procedure for the remaining three quadrants.
7. Determine the average illuminance of the four light field quadrants.
8. Record the model number, serial number, and the date of calibration of test instrument.

D. VERIFICATION OF COMPLIANCE

Verify that the average illumination is not less than 160 lux (15 footcandles).

NEMA 5-15-79

.02 METHOD II - INDIRECT TEST

A. GENERAL

1. This indirect test is feasible after the correlation between light output and voltage is made; the manufacturer then specifies a voltage to be measured or adjusted, or both.

2. Make certain that all surfaces in the light path are clean and unobstructed.

B. EQUIPMENT

Digital voltmeter

C. PROCEDURE

1. Remove trim covers to gain access to the lamp socket.

2. Verify that the specified lamp is in the socket.

3. With the light-field energized, measure the voltage across the lamp socket terminals.
4. Record the voltage measured.

5. Record the model number, serial number and calibration date of the digital voltmeter.

D. VERIFICATION OF COMPLIANCE

The voltage recorded shall be within the tolerances specified by the manufacturer.

NEMA Standard 5-15-1979

NOTE: THE AC VOLTAGE AT THE LAMP SOCKET MUST NOT BE LESS THAN 19.5 VAC RMS

XR 8-2.17 X-RAY FIELD/RECEPTOR CENTER ALIGNMENT

REQUIREMENT - Means shall be provided to align the center of the X-ray field with respect to the image receptor to within 2 percent of the SID (See 21 CFR 1020.31 (e) (1).

A. GENERAL

1. All exposures taken during this test must have a uniform film density of approximately 1.0.
2. Actual versus indicated SID must be determined prior to performing this test.

B. EQUIPMENT

Radiographic cassette loaded with film (20 by 25 cm).

C. PROCEDURE

1. Load cassette with film and place into the bucky tray.
2. Assure the X-ray beam is perpendicular to the image receptor and centered over the bucky tray.
3. Set the SID to the value determined in the actual versus indicated SID test.
4. Reduce the X-ray field to approximately 15 by 20 cm.
5. Make an exposure and develop the film.
6. To determine as accurately as possible the corners of the image recorded on the film, locate two points on each of the four sides of the image. Through the two points on each side draw a straight line. These four lines, when extended, intersect making a rectangle which is a close approximation of the actual X-ray field. Draw a diagonal across the image to determine the center of the X-ray image.
7. To determine the center of the X-ray film draw diagonals across the film (the point where these two lines cross is the center of the film), or fold the film into quarters (the point where the two folds cross is the center of the film).
8. The distance from the film center mark to the image center mark is measured and recorded as the linear displacement or misalignment of the centers of the X-ray field and the image receptor.

D. VERIFICATION OF COMPLIANCE

Verify that this distance is less than or equal to 2 percent of the SID.

NEMA Standard 5-15-79

XR 8-2.18 INDICATION OF X-RAY FIELD SIZE

REQUIREMENT - Means shall be provided on the beam-limiting device to indicate field size in the image receptor plane to within 2 percent of the SID (see 21 CFR 1020.31 (e) (1).

A. GENERAL

The actual versus indicated SID test must be performed prior to beginning this test.

B. EQUIPMENT

A 24 by 30 centimeter or a 20 by 25 cm cassette with film.

C. PROCEDURE

1. Set the SID to the value determined in the actual versus indicated SID test.

2. Center the film cassette in the cassette tray and insert into position.

3. Adjust the field size to 15 by 15 centimeters or 8 by 8 inches by means of the numerical indicators on the beam-limiting device.

4. Make an exposure and develop film.

5. Measure and record the length and width dimensions of the image.

D. VERIFICATION OF COMPLIANCE

The deviation of any of the recorded dimensions must not exceed 2 percent of the SID in Step 1.

NEMA 5-15-79

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XR 8-2.20 X-RAY FIELD LIMITATION AND ALIGNMENT

REQUIREMENT

The X-ray field size in the plane of the image receptor, whether automatically or manually adjusted, shall be such that neither the length nor the width of the X-ray field differs from that of the image receptor by greater than 3 percent of the SID and that the sum of the length and width differences without regard to sign be no greater than 4 percent of the SID, when the equipment indicates that the **Beam Axis** is perpendicular to the plane of the image receptor (see 21 CFR 1020.31 (e) (2) (ii)). **Reference Axis. (IEC 60601-1-3 CL 29.203.1)**

.01 METHOD 1 - BRH/FDA TEST STAND METHOD

A. EQUIPMENT

1. BRH/FDA compliance test stand with accessories
2. Slide assembly
3. Plastic cassette containing a sheet of direct print paper or X-ray film
4. Ruler
5. Cassette (preferably 20 to 25 cm or smaller).

B. PROCEDURE

1. Using the means provided, align the source assembly so that the beam axis is perpendicular to the image receptor.
2. Place the test stand on the table.
3. Position the spacer so that it does not intersect the primary beam and secure with the pushbutton connectors.
4. Center the source assembly over the test stand using the means provided, e.g. bucky light.
5. Bring the source assembly down into firm contact with the spacer.
6. Center the cassette tray with the source assembly using the means provided, e.g. bucky light.
7. Insert the plastic cassette into the slide assembly. Then insert the slide assembly into slot 5 (see Figure 5-2).
8. Center the film cassette in the cassette tray and insert into position. If the positive beam limitation will not operate at this SID, raise the source assembly and lock in position at the first operable SID.
9. Make an exposure. Develop the image. Measure and record and length and with dimensions of the image.
10. Calculate the field size correction factor as the SID/A where:
    a. SID is the indicated source-to-image receptor distance, and

b. A is the indicated source-to-tabletop distance less 19.5 cm.

Multiply each of the measured dimensions by the correction factor.

$$\text{X-ray field length at undertable image receptor} = \frac{\text{SID}}{\text{A}} \times (\text{X-ray field length at slot 5})$$

$$\text{X-ray field width at undertable image receptor} = \frac{\text{SID}}{\text{A}} \times (\text{X-ray field width at slot 5})$$

Determine the difference without regard to sign between the corrected length and width dimensions and the corresponding cassette film size dimensions (20 by 25, 13 by 18, etc.). Each of these differences must be less than 3 percent of the SID, and the sum of these differences must be less than 4 percent of the SID.

NEMA Standards 5-15-79

.02 METHOD II - ALTERNATE TEST STAND METHOD

A. GENERAL

Prior to performing this test, the magnification factor must be determined in accordance with the X-ray/light field alignment test - Method III.

B. EQUIPMENT

1. Manufacturer's recommended test stand
2. Cassette with film

C. PROCEDURE

1. Align the tube unit and image receptor and set SID to the value determined in the actual versus indicated SID test.
2. Insert empty 20 by 25 cm cassette into bucky tray.
3. Position test stand in accordance with manufacturer's instructions.
4. Load a second cassette and place in the designated position.
5. Select the proper technique factors, make an exposure, and develop film.
6. Measure the length and width of the X-ray image on the film.
7. Multiply each measurement by the magnification factor previously determined.

D. VERIFICATION OF COMPLIANCE

Verify that the X-Ray field size in the plane of the image receptor does not differ from that of the image receptor by greater than 3 percent of the SID and that the sum of the length and width differences without regard to sign is not greater than 4 percent of the SID.

(IEC 60601-1-3 CL 29.203.1) NEMA Standards 5-15-79

8.2 RECORD OF COMPLIANCE - RECORD

This sheet is to be used by the assembler to assure that all points of compliance are covered. It will also serve as a maintenance log.

HOSPITAL _____ ROOM # _____

DATE OF INSTALLATION _____ ASSEMBLER _____

_____ _____

Requirement	Applicable Paragraph	Installation Date	S E R V I C E Date	Date	Date	Date
1. Determination of Half-Value Layer	XR8/2.09					
2. Visual definition of X-Ray light field	XR8/2.14					
3. Intensity of light-field	XR8/2.15					
4. X-Ray field/receptor Center alignment	XR8/2.17					
5. Indication of field size	XR8/2.18					
6. X-Ray field Limitation & Alignment	XR8/2.20					
7. Cassette Tray/ Inspection Cleaning						
8. Electrical Cable Inspection						
INITIALS:						
NOTES:						

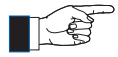
SECTION 9

OPERATING INSTRUCTIONS FOR INSTALLERS

9.1 PRODUCT SIMILARITY

The Model TXR-325 D is similar to the Model TXR-325 M, TXR-425 and the TXR-525 SFQ X-Ray Controls. All have digital MAS, ERROR CODE, MA, and KVP Displays and SCR controlled output. The Model TXR-325 D is the basic machine having limited time per exposure. Additional Timing and Control Logic are added to the Model TXR 325-M, TXR-425 and TXR-525 SFQ X-Ray Controls. This section is dedicated to the installer and service engineer.

The information contained in this section explains the way the selectors, indicators and displays work.

Note 

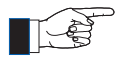
Refer to Operation Manual for instructions on identifying all console selectors and indicators.

9.1.1 MILLIAMPERE SELECTOR

The Millampere Selector accomplishes several tasks. It connects to the tube limit sensing on the timer board. It selects, K1, 2, 3, 4 and 5 Mother Board Relay Coils on the TXR 325 D & M and TXR-425 plus Relays K6 and 7 on the 525 SFQ. Each Relay has four functions: 1. One contact selects the mA and its predetermined focal spot, 2. One contact selects proper space charge compensation. 3. Another contact selects kVp Meter Adjustment Compensation - so that the kVp meter will read correctly for each mA station selected. 4. The remaining contact selects the mA meter display. The selector is connected by ribbon cable to plugs on the Mother, Timer, and mA Meter Boards.

9.1.2 FOCAL SPOT SELECTOR

You should select the desired milliamperes before choosing kVp or a time station because a change in the mA station will also change the kVp meter reading, which in turn will also change the actual kVp potential at the X-Ray Tube. When the mA is selected for a view the focal spot is automatically selected.

Note 

The focal spot is automatically selected according to the mA Station.

At milliampere settings below three hundred, the kVp meter may indicate higher than 125 kVp. The kVp at this point may exceed the kVp rating of the x-ray tube, cables and high voltage transformer. Observe the tube rating charts and the tube limits programmed into the timer.

9.1.3 MILLIAMMETER DISPLAY

The mA meter is a digital meter which reads preset milliamperes. It indicates the preset readings before and during the exposure. For calibrating or testing the unit, refer back to “ADJUSTING THE MILLIAMPERE SETTINGS”. For additional information, see Trouble Shooting Section.

9.1.4 KILOVOLT DISPLAY AND KILOVOLT SELECTORS

The kilovolt meter is an AC digital voltmeter, calibrated in kilovolts, and is compensated to read the actual kilovolts at the mA selected. The meter features slope adjustment and adjustable kVp Blanking Max/Min Limits. KVP selection is accomplished by a nine-step major and an eight-step minor tap switch, furnishing steps of kVp within the range. Accuracy is plus or minus 10% of full scale. Turning kVp selectors clockwise increases kVp and counter clockwise will decrease kVp. Setup: Because of the space charge and kVp compensation effect: first select the milliampere station, then select the desired kVp.

CAUTION ***Never change kVp during an Exposure.***

9.1.5 TIMER AND TIME SELECTOR

The timer is a digital timing circuit that has a range of .008s to 6.0s (1/120 second to 6 seconds) in 23 approximate geometric progressive steps. Depending on the model, the timer is programmed for specific X-ray Tube Limits. **CAUTION:** If the mA Test meter or exposure indicator should read past normal time of selected time, quickly throw the “EMERGENCY OFF SWITCH” and notify qualified X-Ray Service Personnel.

9.1.6 MAS AND ERROR CODE DISPLAY

The digital MAS meter is a digital meter, which reads four conditions.

1. Pre-Set MAS
2. Actual computed MAS output during and at the end of exposures.
3. Error Codes, preceded by the letter “E” that may be used for troubleshooting the x-ray control.
4. Error Code “OL” which indicates Generator Power Limit Exceeded. Exposure is Inhibited.

9.1.7 BUCKY SWITCH

1. For equipment with Gridcabinets, select Bucky OFF. (Jumper Motherboard Terminals B1 to B2).
2. If one or more Bucky is installed, select Bucky Table or Bucky Wall.
3. For x-rays where a Bucky is not needed, switch the Bucky to the OFF position.
4. If a Bucky is installed and when selected will not run or runs and the x-ray control will not make an exposure: Condition: Switch the Bucky Switch Off. If x-rays are possible call service personnel and have them service Bucky(s). Possible Cause: B2 jumper to B3 on the Mother Board or B2 jumper to B3 on the Bucky is open or missing. NOTICE: For the Bucky to work properly, jumpers are required on the Mother Board and Bucky.

9.2 EXPOSURE CONTROLS AND INDICATORS

Radiographic exposures from the Control Console are made with the “Prep” (preparation) and “Expose” x-ray exposure) push-buttons or with an optional handswitch. The status of the exposure is indicated by the “Ready” and “X-ray On” indicators for the duration of the exposure. The complete sequence of events are explained.

9.2.1 PREP PUSHBUTTON

Two Step Operation: Upon depressing the Prep Pushbutton, a command is sent to the rotor control board initiating a 220vac starting voltage to the x-ray tube stator. When sensing functions are confirmed, provided there are no interlock failure or system faults, (During a non-adjustable .5 second delay) the rotor automatically switches, removing the 220vac start voltage and connects 50vac run voltage to the stator to maintain rotating anode speed. To allow filament stabilization, an adjustable time delay is factory set at 2.2 seconds.

9.2.2 READY INDICATOR

If the x-ray tube stator circuit is connected and the anode is rotating in the counterclockwise direction, a ready signal causes the ***green lamp*** to illuminate next to the word "***READY***". One Step Operation: Depress Exposure Pushbutton, the rotor circuit automatically cycles as above and Exposure begins immediately after the 2.2 second delay. Ready indicates that the technique selected is proper and there are no interlock failures or system faults. The x-ray tube is ready for exposure.

9.2.3 EXPOSE PUSHBUTTON

After the "Ready" Indicator is illuminated, press this push-button to start X-ray exposure. If the push-button is released before the generator completes the selected time, the exposure will be prematurely terminated. During Exposure, the amber lamp illuminates next to the word *"EXPOSURE."* An audible sonalert signal will sound in the control to indicate the termination of an exposure.

9.2.4 EXPOSURE INDICATOR (X-RAY ON)

This **amber colored lamp** illuminates next to the word ***"EXPOSURE"*** and indicates that the X-ray exposure is in progress. At the same time that radiographic exposures are being made, an audible signal sounds.

X-RAY HANDSWITCH (OPTIONAL)

Radiographic exposures can also be initiated with an X-ray hand switch which can be attached to the x-ray console.

The X-ray hand switch button has three positions: "Off", "Preparation" and "X-ray Exposure", which operates in the same way that "Prep" and "Exp" pushbuttons operate on the control console.

Press the hand switch half-way for "Prep" and fully for "Exp".

9.2.5 SIMPLE GENERATOR TEST PROCEDURE

1. Switch Control Power ON and turn Line Switch ON to X-Ray Control.
2. LED Display should light displaying MAS, MA and KVP. (LED's indicates Unit is in operation).
3. Select 200 MA, 80 kVp, 1 Second. (LED Display should indicate 200 MAS-200MA-80 KVP).
4. Depress Rotor push-button (after a 2.2 second delay the green Ready lamp should energize. If the ready lamp does not energize, the problem is in the rotor circuit or before). See Control Schematic.
5. When the green ready lamp energizes, depress the Exposure push-button and record the mA or mAs test meter reading. The recorded mA or mAs should be in the range of *+/- 10% of the mA or mAs selected*.
6. With Bucky Installed. If there is no exposure and the unit is switched to table or wall Bucky, change the switch to Bucky OFF and retest. *(If exposure meets condition of 5 above, trouble is in the bucky circuit).*
7. If there is still no exposure initiated under condition *6*, the problem is most likely in the *Timer*, *Timer Switch*, the *Ribbon Cable* connecting the timer to the timer switch, or the back-up contactor.

SECTION 10

TUBE RATINGS AND CHARTS

10.1 X-RAY TUBE AND FOCAL SPOT RATINGS

Most of the electrical energy delivered to the X-Ray tube is converted into waste heat; only a small fraction of the energy is converted into x-rays. There are three considerations involving this waste heat:

1. If too much energy is supplied to the X-Ray Tube, the focal area of the target may melt away and destroy the X-Ray Tube. Ratings, which tell you how to avoid this are called FOCAL SPOT RATINGS, and tell you how much energy you can apply in a single exposure to a cold tube.
2. If energy is applied to the X-Ray Tube at a faster rate than the anode can dissipate the heat produced, the anode may melt or liberate gas, and thus destroy the X-Ray Tube. Ratings which tell you how to avoid this trouble are called ANODE HEAT STORAGE RATINGS, or perhaps just anode ratings.
3. If energy is applied to the X-Ray Tube at a faster rate than can be dissipated by the tube housing, eventually the oil will expand so much that the expansion chambers will compress beyond capacity and the tube housing will begin to leak oil. Ratings that tell you how to avoid this **trouble are called** *HOUSING THERMAL CHARACTERISTICS* **and include the** *HOUSING HEAT STORAGE CAPACITY*, **and** *HOUSING COOLING CHARACTERISTICS*.

10.2 ANODE HEAT STORAGE RATINGS

Heat storage and dissipate rating are based on HEAT UNITS. To determine the number of HEAT UNITS, which you will apply to the X-Ray tube anode, multiply the exposure factors: **kVp X mA X seconds = HEAT UNITS**. Thus a technique which calls for **80 kVp, 200 mA**, and **1/2** second, produces 80 **X** 200 **X 1/2** = ***8000 HEAT UNITS.***

10.2.1 SEASONING X-RAY TUBE

An X-Ray Tube that is put into service for the first time should be seasoned before bringing up to full kilovoltage use. See x-ray tube seasoning instructions included with the x-ray tube.

1. Select 100 mA small focus.
2. Starting at about 50 or 60 kVp make 3 exposures at 1/10 second each, waiting approximately 30 seconds between exposures.

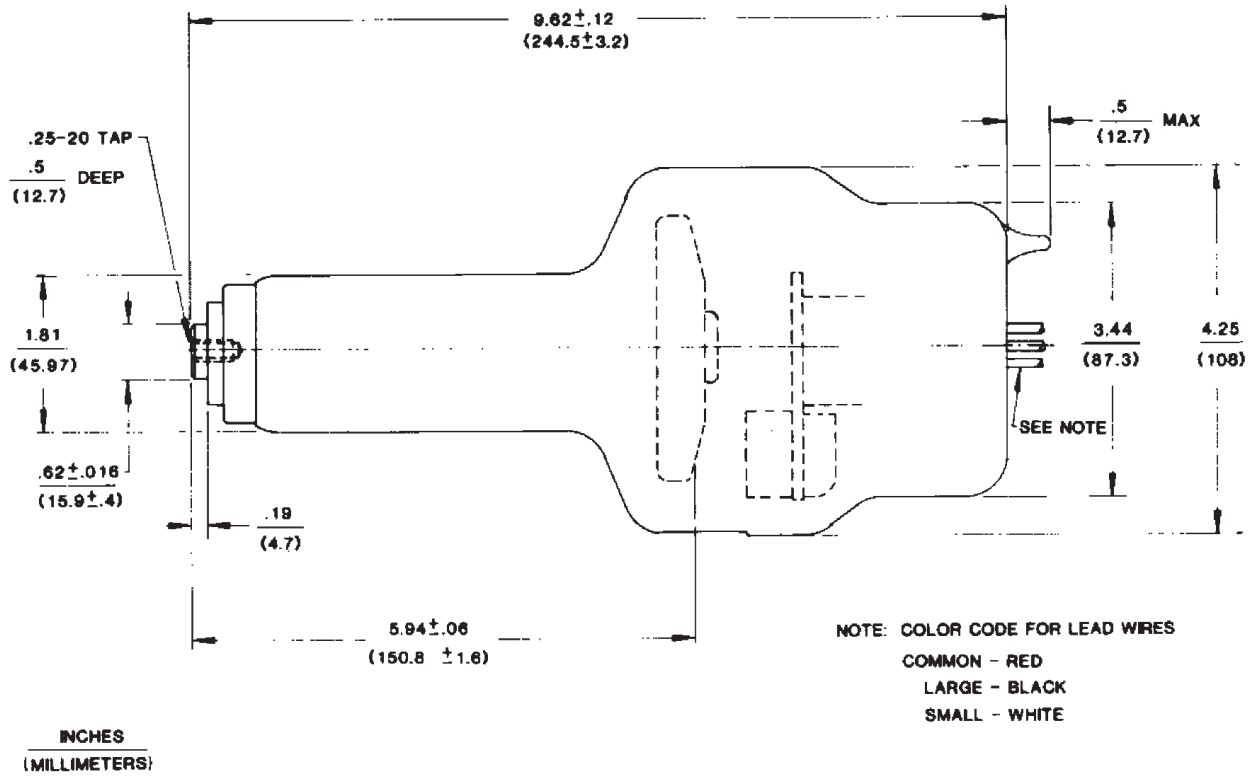
WARNING **DURING X-RAY EXPOSURES TUBE HOUSINGS MAY BECOME HOT. WHEN HANDLING AND INSTALLING X-RAY TUBES COMPLY WITH ALL INFORMATION PROVIDED WITH THE X-RAY TUBE.**

Be sure the tube collimator shutters is closed and that the operator or anyone else is not exposed to any radiation. Make similar exposures increasing the kVp in 10 kVp steps up to 90% of the maximum ratings. Should any instability appear while breaking in, reduce the kVp until the instability disappears.

10.3 TUBE CHARTS

Note *Familiarize yourself with x-ray tube insert and rating charts provided on the following pages. Rating charts are provided with the x-ray tube that is furnished with your system. Those should be used with your equipment.*

Insert Outline Drawing



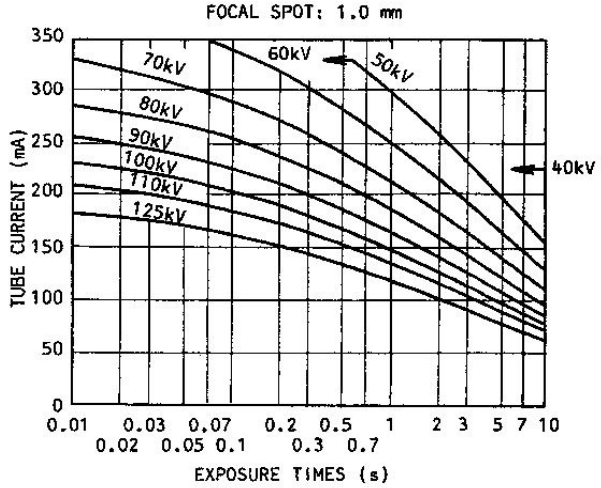
Typical Insert Construction
Target: Rhenium-Tungsten-faced Molubdenum

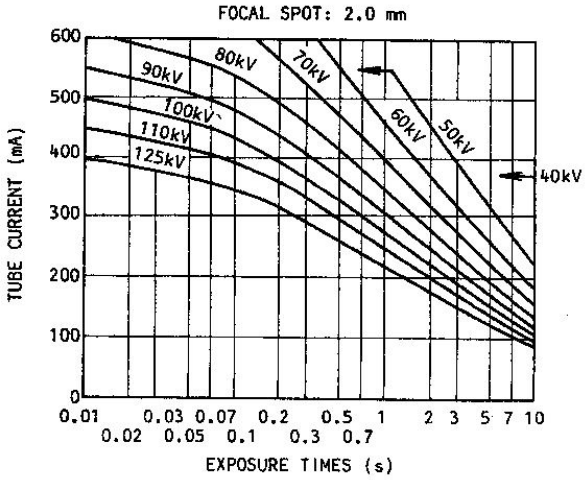
TOSHIBA X-RAY TUBE RATING CHARTS

Model E7239X - E7239FX - E7239GX
Listing UL/CE 0197

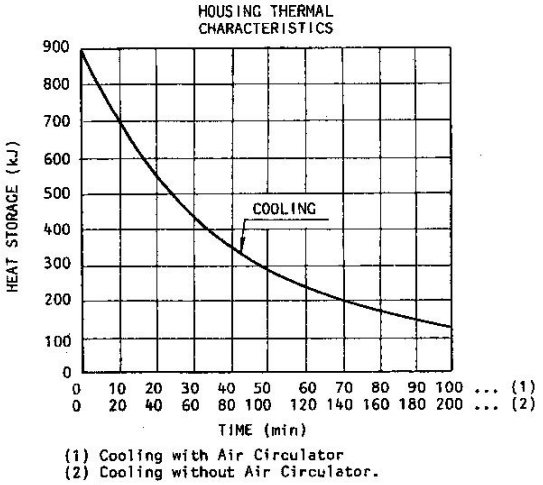
IEC CLASSIFICATION-CLASS 1 TYPE B

Single Phase - Full Wave
Target: 2.8” (74mm) Diameter, 16, 140,000 H.U.
Stator Frequency: 60 Hz. - 3200 RPM Min.

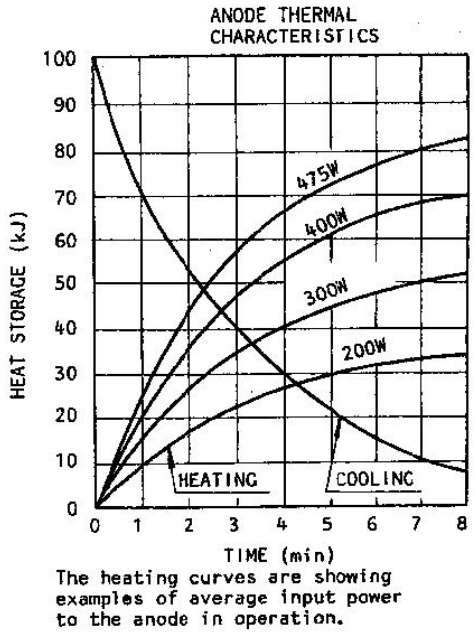




HOUSING HEATING AND COOLING CURVES



ANODE HEATING AND COOLING CURVES

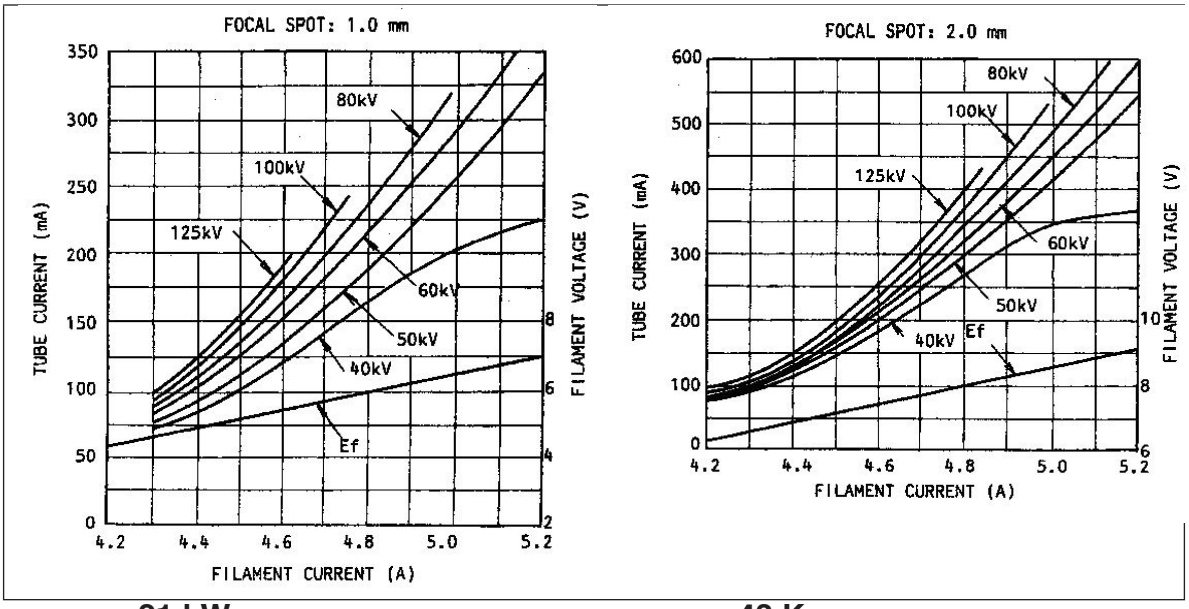


TOSHIBA X-RAY TUBE EMISSION AND FILAMENTCHARACTERISTICS

Model E7239X - E7239FX - E7239GX

Listing UL/CE 0197

SINGLE-PHASE



21 kW **43 Kw**

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10.4 TUBE LIMIT SOFTWARE – FOR TXR 325D

TIMER MODEL NUMBER T-7776C-29

(THESE TUBE LIMITS ARE PERMANENT AND CAN ONLY BE CHANGED BY BURNING NEW SOFTWARE)

MODELS TXR 325 D

MA	50	100	150	200	300	400	MAX MAS
kVp	MAX Allowed Exposure Time In Seconds						
50 Min 125 Max	6.0						300
		1.5					150
			3.0				450
				2.0			400
					0.5		150
						0.2	80

TUBE: **RAD 8**
F.S. **LARGE: 2.0**

F.S. **SMALL: 1.0**

10.5 TUBE LIMIT SELECTION TABLE - FOR TXR 325M, TXR 425 AND TXR 525SFQ CONTROLS

TIMER MODEL NUMBER 7776A
TIMER PROGRAM CHIP T-7776AL5-60

(THESE TUBE LIMITS CAN BE CHANGED BY SETTING THE DIP SWITCHES)

TIMER DIP SWITCH SETTINGS – SET SWITCHES AS SHOWN IN THE TABLE BELOW

IED LIMIT P/N	TUBE	SWITCH		
		1	2	3
T-7776A-15	RAD 8 60 HZ.	ON	ON	ON
T-7776A-23	RAD 68 60 HZ. .6-1.2 MM	OFF	OFF	ON
T-7776A-18	RAD 68 60 HZ. 1-2.0 MM	ON	OFF	ON
T-7776A-16	RAD 13 60 HZ. 1-2.0 MM	ON	ON	OFF
T-7776A-14	RAD 74 60 HZ .6-1.5 MM	ON	ON	OFF

10.6 TUBE LIMIT CHART - PROGRAM T-7776AL5-60 Rad 8

MODELS TXR 325 M and TXR 425							TXR 525 SFQ
MA	**50**	**100**	**150**	**200**	**300**	**400**	**500**
kVp	**MAX Allowed Exposure Time In Seconds**						
50	6.0	6.0	6.0	3.0	2.0	1.5	0.5
60	6.0	6.0	6.0	3.0	2.0	1.5	0.5
70	6.0	6.0	6.0	3.0	2.0	0.75	0.25
80	6.0	6.0	6.0	3.0	1.5	0.4	0.15
90	6.0	3.0	6.0	3.0	1.0	0.2	0.05
100	6.0	3.0	6.0	3.0	0.5	0.1	0.025
110	6.0	2.0	3.0	2.0	0.3	0.066	0.008
120	6.0	1.5	3.0	1.5	0.25	0.041	None
125	6.0	1.0	3.0	1.25	0.15	0.25	None

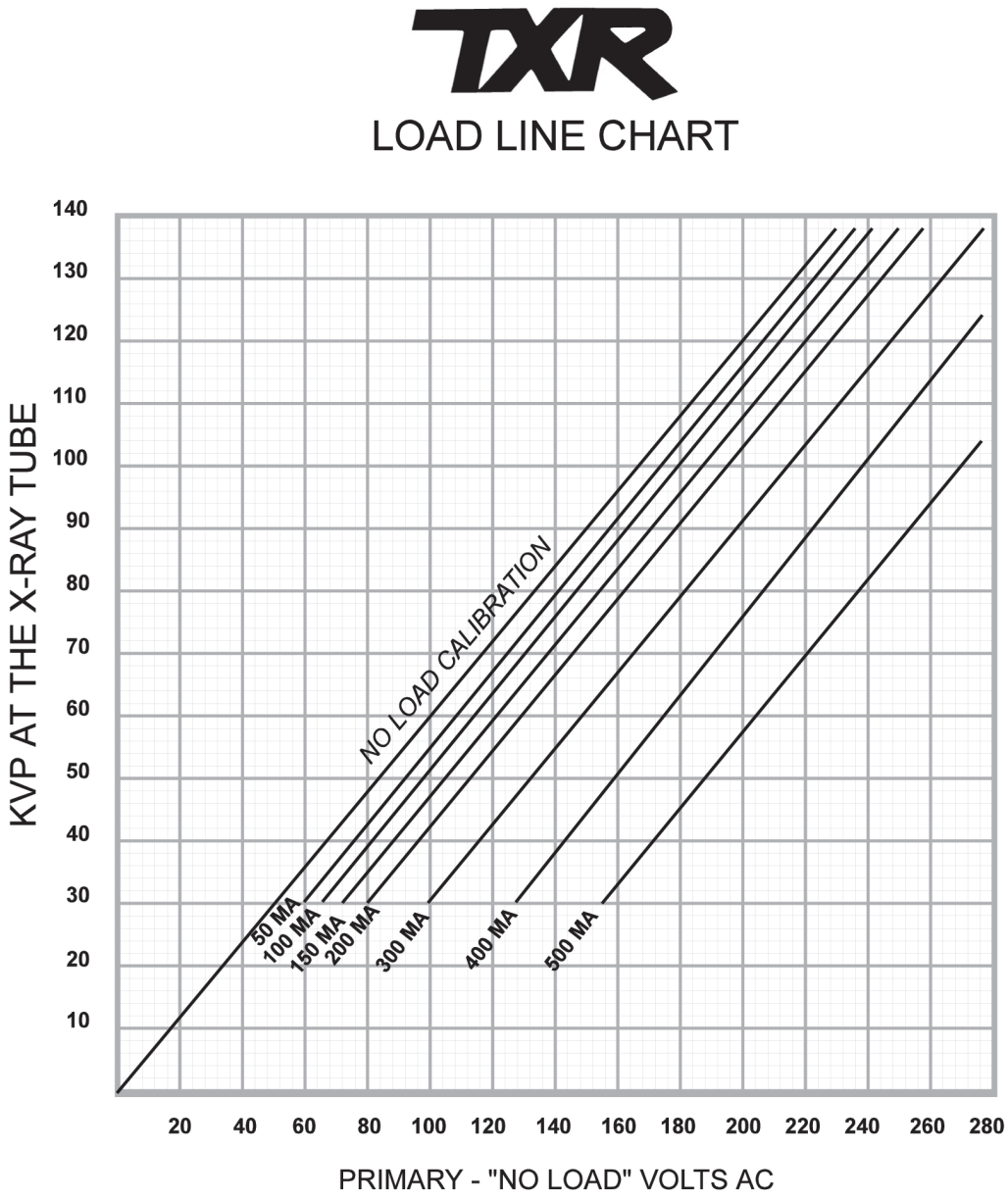
TUBE: **RAD 8**
F.S. **LARGE: 2.0** F.S. **SMALL: 1.0**

10.7 TUBE LIMIT CHART - PROGRAM T-7776AL5-60 Rad 74

MODELS TXR 325 M AND TXR 425							TXR 525 SFQ
MA	**50**	**100**	**150**	**200**	**300**	**400**	**500**
kVp	**MAX Allowed Exposure Time In Seconds**						
50	6.0	6.0	3.0	3.0	2.0	1.5	1.0
60	6.0	6.0	3.0	3.0	2.0	1.5	1.0
70	6.0	6.0	3.0	3.0	2.0	1.25	0.5
80	6.0	6.0	3.0	3.0	2.0	0.5	0.2
90	6.0	3.0	3.0	3.0	1.5	0.3	0.066
100	6.0	3.0	3.0	3.0	0.75	0.15	0.016
110	6.0	2.0	3.0	3.0	0.5	0.066	None
120	6.0	1.0	3.0	2.5	0.3	0.033	None
125	6.0	1.0	3.0	2.0	0.25	0.016	None

TUBE: **RAD 74**
F.S. **LARGE: 1.5** F.S. **SMALL: 0.6**

10.8 Load Line Chart



Plot of KVP Curve for TXR 325-1 and TXR 625-1 High Voltage Generator with the TXR 325D, TXR 325M, TXR 425 and TXR 525 SFQ X-ray Control.

Effective August, 1994 and later models.

SECTION 11

MEASUREMENT BASIS

11.1 MEASUREMENT BASIS

The measurement basis to insure accurate technique factors are as follows: Timer radiation sensitive counter at the X-ray Tube port counts pulses. Accuracy is one part in 10,000. Electronic counter DHEW design. Counts primary pulsed accurately to +/- zero pulses.

Milliamperes: All mA meters are checked against a standard lab meter that is calibrated against the NRC Standard Annually. Error is less than of 1%.

11.2 KILOVOLTS PEAK BASIS

General Electric Divider Unit, located on both sides of the tube, is accurate to 3 kVp using 10 MHz Dual Trace Storage Oscilloscope. Divider is a C1515A and is calibrated annually. Uses for this device are General Purpose Radiography.

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SECTION 12

MAINTENANCE

WARNING

NEVER SPRAY ANY SOLUTION DIRECTLY ON OR INSIDE THE X-RAY CONTROL, PRINTED CIRCUIT BOARDS, HIGH VOLTAGE TRANSFORMER, X-RAY TUBE OR COLLIMATOR.

EXTERNAL CLEANING ONLY: THE PREFERRED METHOD IS TO SPRAY CLEANER ON A SOFT CLOTH AND CLEAN. DRY WITH A SOFT TOWEL AND ALLOW TO AIR DRY FOR (1) HOUR.

12.1 CIRCUIT BREAKER AND FUSE LOCATIONS

A *60 amp, 800 MAS* circuit breaker is located on the right side of the console. This breaker provides power on and over current protection. Fuses 1 through 6 are located on the bottom left side of T-7799D Rev A Mother Board. **F1** and **F2** are 8 amp 250 VAC, **F3** is 5 amp 250 VAC, and **F4, F6** are 1 amp 250 VAC. **Fuse 5** is a .1 amp, SLO-BLO 250 VAC.

12.2 KILOVOLTMETER CALIBRATION

This test requires a 300 VAC meter having an accuracy of 1% or better, and of known calibration. Turn on the machine and vary the kVp with the AC meter connected parallel to it. The kVp meter in the TXR 325 D & M, TXR 425 and TXR 525 SFQ X-Ray Control is actually a 300 VAC voltmeter calibrated in kVp. See Load Line Chart for Voltage Settings and kVp meter readouts.

Note

The proper way to calibrate or test kvp is by the use of a Divider, High Voltage Bleeder or non-invasive kVp Meter, and should only be accomplished by an X-ray service person.

12.3 MILLIAMMETER CALIBRATION

This test will require a DC Milliampmeter having a 300 mA full scale reading, with a known accuracy of 1% or better, and of known calibration. Connect the milliampmeter to mA Test + and – Terminals located on the Motherboard and test. Note Polarity. If error exceeds 5% call x-ray service personnel.

Note

The proper way to calibrate the MA is not through this method but through the method covered in "Information to Assemblers", "Adjusting the Milliampere Settings

12.4 SERVICING THE HIGH VOLTAGE TRANSFORMER

DANGER!

BEFORE INSPECTION TURN OFF EVERY INPUT POWER AND DISCHARGE HIGH TENSION CABLE PLUG AND RECEPTACLES. AFTER POWER HAS BEEN REMOVED, ELECTRIC CHARGE MAY REMAIN IN HIGH TENSION CIRCUIT.

Remove **P1** and **P2**. Remove screws from around top. Windings and all parts are connected to the top part. Lift by using Hi-Jack or by two persons lifting the two ends by the eye bolts provided. ***(This task requires two people).***

OIL, INSULATING

Type: Diala AX or equal. Cold oil contracts, warm oil expands. Make sure transformer is filled no lower than 1 inch from the top and no closer than inch.

Do Not Contaminate Oil by immersing hands into oil. Oil is most of the high voltage insulation. Do not let moisture saturate oil by leaving the cover off the tank or by storing in a cold room then heating repeatedly. This will cause moisture to collect inside the tank.

When the Transformer is re-inserted into oil and the oil fill level is up to standard, operate the unit on lower kVp levels. The best method is to leave the transformer submerged over night before re-starting to eliminate air bubbles.

12.5 SERVICING THE X-RAY TUBE

The service you should receive is simply to clean, calibrate, and re-insulate the receptacles of your X-ray tube. It should be performed as stated in Information to Assemblers - Installing High Voltage Cables. **Caution:** Do not spray cleaner onto the X-ray tube. The preferable method is to spray cleaner on a soft rag, wipe and dry. Allow 1 hour to air dry.

12.6 CIRCUIT THEORY

12.6.1 KVP METER

The kVp Meter along with the kVp Compensating Circuit is fairly simple to understand and test. When the X-Ray Control is energized 95-110 VAC potential is present from MT-1 and MT-2 terminals. This is always a bucking voltage. This voltage is coupled to each end of the kVp Meter Compensation Adjustment Resistor (2500 ohm 100 watt). You should read the same voltage across the resistor. If you do, turn OFF X-Ray Control and remove FUSE 4 and measure the resistance. If 2500 ohms is not measured replace the resistor. Should the resistor overheat or OPEN, remove MT-1 and MT-2 and order the replacement Compensation Transformer from the factory. If the resistance is 2500 ohms check all connections ensuring H1 Voltage is present at each compensating band that is selected. If all these measurements are proper replace the kVp Meter Board.

The kVp Meter Compensation Resistor serves two purposes:

(A) The kVp Meter Compensation Resistor is parallel to the Autotransformer allowing immediate correction of kVp Meter Settings should line voltage fluctuate. The fluctuation is normally no lower than 95 and no higher than 110 VAC. This is the proper voltage range.

(B) The kvp Meter Compensation Resistor is connected for each mA (Load by individual mA relays K1 through K7 C Contacts. Compensation adjustments are for unit loss that occurs when current is moving in the high voltage secondary. Because of loading, kVp will decrease at the X-Ray tube. The bucking voltage selected from the 95-110 VAC supply bucks H1 to H2 Voltage. The final Voltage difference is coupled to the kVp Meter allowing it to pre-read the correct kVp that will appear at the X-Ray tube.

The relationship of kilovoltage output to primary voltage input *(P1, P2)* will not change unless the turn ratio of the high voltage transformer has changed due to a partial breakdown. Partial breakdown occurrences are very rare. Should you suspect a partial breakdown in the high voltage transformer detection is quite simple. Remove the High Voltage Transformer from the tank and measure the resistance in each winding. The resistance across P1 and P2 is 7 ohms. The resistance across the output of either high voltage transformer windings will vary from 8000 to 8100 ohms.

After reassembling the transformer wait 24 hours before testing. Re-energize the equipment by turning on the main switch and make an exposure of approximately 2 seconds at 60 kVp, 50 mA. Observe the mA meter reading. The reading should be 50 mA. Select 90 kVp at 50 MA, 2 seconds, and make an exposure. The reading should be 50 MA. Take an exposure 120 kVp at 50 MA, 1 second. MA should be within the tolerance. Now begin calibrating all MA and kVp stations observing actual MA and kVp outputs. Higher current readings could indicate other problems. See trouble shooting section.

12.6.2 MAS/ERROR CODE METER

The Dual Function MAS – ERROR Code Meter serves three functions. It displays pre-set MAS, calculates MAS during exposures and at the end of exposures gives a total MAS. It also serves to Display Overloads and Error Messages. This meter cannot be adjusted. Its readings are from the X-ray Timer's software.

12.6.3 MA METER

The MA meter is a simple Digital resistor/diode Display that indicates MA stations selected. This meter cannot be adjusted.

12.6.4 TESTING HIGH VOLTAGE RECTIFIERS

Properly testing high voltage rectifiers requires special test equipment. Replace suspected defective rectifier board and return old one to the factory for testing. This is the simplest and safest way to test these type parts.

DANGER! ***DO NOT MAKE ANY TEST EXPOSURES WITH TRANSFORMER OUT OF OIL.***

12.6.5 ERROR CODE CHART

Models TXR 325 D, TXR 325 M, TXR 425 and TXR 525 SFQ X-Ray Controls come equipped with Self Diagnostics. Should a problem arise, observe the mAs meter display for one of the following error codes.

ERROR CODE	DESCRIPTION
O.L.	Indicates – Exceeds Tube Limit
E02	Indicates – KVP over range
E03	Indicates – KVP under range
E04	Indicates – Opening in MA cables or switch
E05	Indicates – Opening in Timing cable or switch
SCR	Indicates – Leaky or shorted SCR

SECTION 13

MAINTENANCE SCHEDULE FOR
RADIATION SAFETY OF X-RAY APPARATUS

In order to assure continued compliance to the IEC and Federal Performance Standards, maintenance inspections and test should be carried out by qualified personnel on original installation and at intervals of 6 months or less. Specific instructions for performing these maintenance activities are provided by the individual manufacturers.

This schedule is a guide that relates to conformance to the IEC and DHHS/FDA Standards and is not intended to assure general equipment performance, which must be carried out independently. Detailed instructions for inspections, maintenance, calibration, validation and documentation are included in additional manuals which are included with the equipment.

13.1 TUBE ASSEMBLIES

1. **Radiation Leakage**. Look for obvious physical damage, which would affect radiation shielding and proper beam limiting device function.
2. **Beam Quality**. Confirm that the minimum filtration required is in the useful beam. Check interlock where applicable.
3. **Field Limitation and Alignment**. Check indicators on beam axis and centering.

13.2 GENERATORS AND CONTROLS

1. **Line Voltage and Voltage Regulation**. Measure line voltage and voltage regulation to confirm that both are within manufacturers specifications and that supply line is connected to the proper line terminals, if applicable.
2. **Calibration**.
   (A). Perform the manufacturers calibration procedure, including, but not necessarily limited to testing and adjusting kV, mA, mAs, and timer factors to specifications in manufacturers instructions.
   (B). Confirm that exposure cannot be make if timer is not set on a specific time or if timer is set to zero, if applicable.
3. **Contactors and Relays**. Inspect electromechanical contactors and relays for pitting, poor contact, loose, or missing parts. Replace if necessary.
4. **High Tension Cable and Transformer Bushings**. Check for proper filament circuit contact to insure consistent mA output.
6. **Visual Exposure Indicator**. Confirm that the means provided and specified by the manufacturer for indicating, visually, the occurrence of an X-Ray exposure (mAs meter, pilot light, etc.) is functioning during and only during an exposure.
7. **Audible Exposure Indicator**. Confirm that the audible indicator provided by the manufacturer to indicate the termination of an X-Ray exposure is functioning in the manner specified by the manufacturer and only in the manner specified.
8. **Inspect and Test Dials and Knobs**. Inspect knobs on timers, kilovoltage, milliampere selectors and any other adjusting knobs to be sure that the pointer is indicating to the proper value and is fastened tight.

9. **X-Ray Exposure Switch**. Confirm that any switch provided for activating an X-Ray exposure requires continuous pressure to maintain the exposure or that release of the switch terminates the exposure.
10. **Warnings and Indicators Legible**. Inspect and confirm that all warning labels and embossed, painted, silk screened, or other wearable technique factor indicators have not been defaced or worn so as to be illegible.

13.3 ATTENUATION OF THE X-RAY BEAM

Avoid Excessive Attenuation to the X-ray Beam from material interposed between the patient and the X-ray Image Receptor, which can cause unnecessarily high levels of Absorbed Dose and Stray Radiation.

The Attenuation Equivalent of the items listed in Table 1, when forming part of an X-ray Equipment System and located in the path of the X-ray Beam between the Patient and the X-ray Image Receptor, shall not exceed the applicable maximum values given in the table.

Inspect table -tops and cradles for any physical damage or deviations, which might alter the attenuation characteristics.

Reference IEC 60601-1-3 CL 29.206 ands 21 CFR 1020.30n

Table 1

Item	Maximum ATTENUATION EQUIVALENT mm Al
PANEL FRONTS (Total of all layers)	1.0 mm
CRADLE	2.0 mm
PATIENT SUPPORT, stationary, without articulated joints.	1.0 mm
PATIENT SUPPORT, movable, without articulated joints.	1.5 mm
NOTES: 3. Devices such as Radiation Detectors are not included in the items listed in this table. 4. Requirements are given concerning the Attenuation properties of Radiographic Cassettes in IEC 406, of Intensifying Screens in Appendix A of IEC 658 and of Anti Scatter Grids in IEC 627.	

13.4 CASSETTE HOLDERS

1. **Inspect the front cover**, if provided, of the cassette holder for any physical damage or modification which would alter the attenuation characteristics.
2. **Interlocks**. Test and confirm the proper operation of interlocks, if provided for the operation of positive beam limitation.
3. **Alignment Indicators**. Test and confirm the proper operation and accurate indications of means provided to accomplish alignment between the X-Ray field and the image receptor.
4. **Alignment in Positive Beam Limitation** *(P.B.L.)* If provided for operation with positive beam limitation, test and confirm proper alignment between the X-Ray field and the image receptor.

13.5 BEAM LIMITING DEVICES

1. **Radiation Leakage**. Inspect beam limiting device and its attachment to the X-Ray tube housing for physical damage, loosening or wear which might affect leakage radiation. Verify that the combination of tube housing and beam limiting device is listed as compatible.

2. **Beam Quality**.
   (A). Verify that all filtration elements, incidental and added, as provided by the certified beam limiting device and tube housing, are present and show no evidence of physical damage or alteration which might alter attenuation.
   (B). Verify operation of filter - kV interlock in systems with more than one thickness of filtration.
   (C). Perform such maintenance as specified by manufacturer, e.g., tightening of hardware, lubrication, etc.

3. **Variable Field**. Verify functioning of step less adjustment of X-Ray field size. Verify that the minimum field size of 5 x 5 cm. can be achieved at 100 cm.

4. **Visual Definition**.
   (A). Verify that misalignment between the visually defined field and the X-Ray field does not exceed 2% of S.I.D.
   (B). Verify average illumination exceeds 160 lux (15 foot candles).
   (C). Verify that the edge contrast ratio of light field exceeds 4 and 3 respectively for stationary and mobile radiographic equipment.
   (D). Perform manufacturers routine maintenance.

5. **Field Indication and Alignment**.
   (A). Verify the proper functioning of the means for alignment of the center of the X-Ray field with the center of the image receptor.
   (B). Verify that the numerical indications of field size result in X-Ray field dimensions in the plans of the image receptor are within 2% of S.I.D. of the dimensions of the image receptor.
   (C). Perform manufacturers routine maintenance.

6. **Positive Beam Limitation**.
   (A). Verify automatic adjustment of X-Ray field size to image receptor size within 5 seconds of insertion of image receptor, or inhibition of exposure until field congruency is obtained.
   (B). Verify that the X-Ray size conforms to that of the image receptor within 3% of S.I.D. per axis 4% of S.I.D. total.
   (C). Verify operation of optional field size reduction and that field can be reduced to 5 x 5 cm. or less at 100 cm.
   (D). Verify that return to positive beam limitation occurs upon a change in image receptor.
   (E). Verify that the bypass mode, where provided, functions when not using the cassette tray or permanently mounted vertical cassette holder, and when either beam axis or table angulation if not within 10 of the horizontal or vertical during any part of the exposure. Verify automatic return to positive beam limitation when more of the above...
   (F). Verify operation of over ride key, where...

8. **Single Image Receptor Size**.

Verify presence integrity and functioning of means provided to limit X-Ray field size to not greater than the image receptor, and to align the field and receptor centers to within 2% of S.I.D.

9. **Other X-Ray Systems**.

Verify presence, integrity and functioning of means specified and provided for the certified component to limit the X-Ray field such that each dimension does not exceed image receptor size by more than 2% of S.I.D. and to align the centers of the X-Ray field and receptor to within 2% of S.I.D. Verify presence and visibility of markings identifying image receptor size and S.I.D.

10. **Field Limitation and Alignment**.

(A). Verify that the total misalignment of X-Ray field with the respective edges of the selected portion of the image receptor does not exceed 3% of S.I.D. for length or width, nor 4% of magnitudes for the two directions.

(B). Verify that X-Ray field size can be adjusted smaller than the selected portion of the film, and that at maximum S.I.D. a field size of less than 5 x 5 cm. can be provided.

(C). Verify that the centers of the X-Ray and selected film portion coincide within 2% of S.I.D.

(D). Perform manufacturers routine maintenance.

11. **Source Skin Distance**

Verify the presence and integrity of the means specified and provided for the certified component to **limit source skin distance to no less than 45 cm**.

Check that the certification label and component identification label are affixed to all certified components.

Consult DHEW Publication No. (FDA) 75-8003, dated July, 1974 for specific compliance requirements.

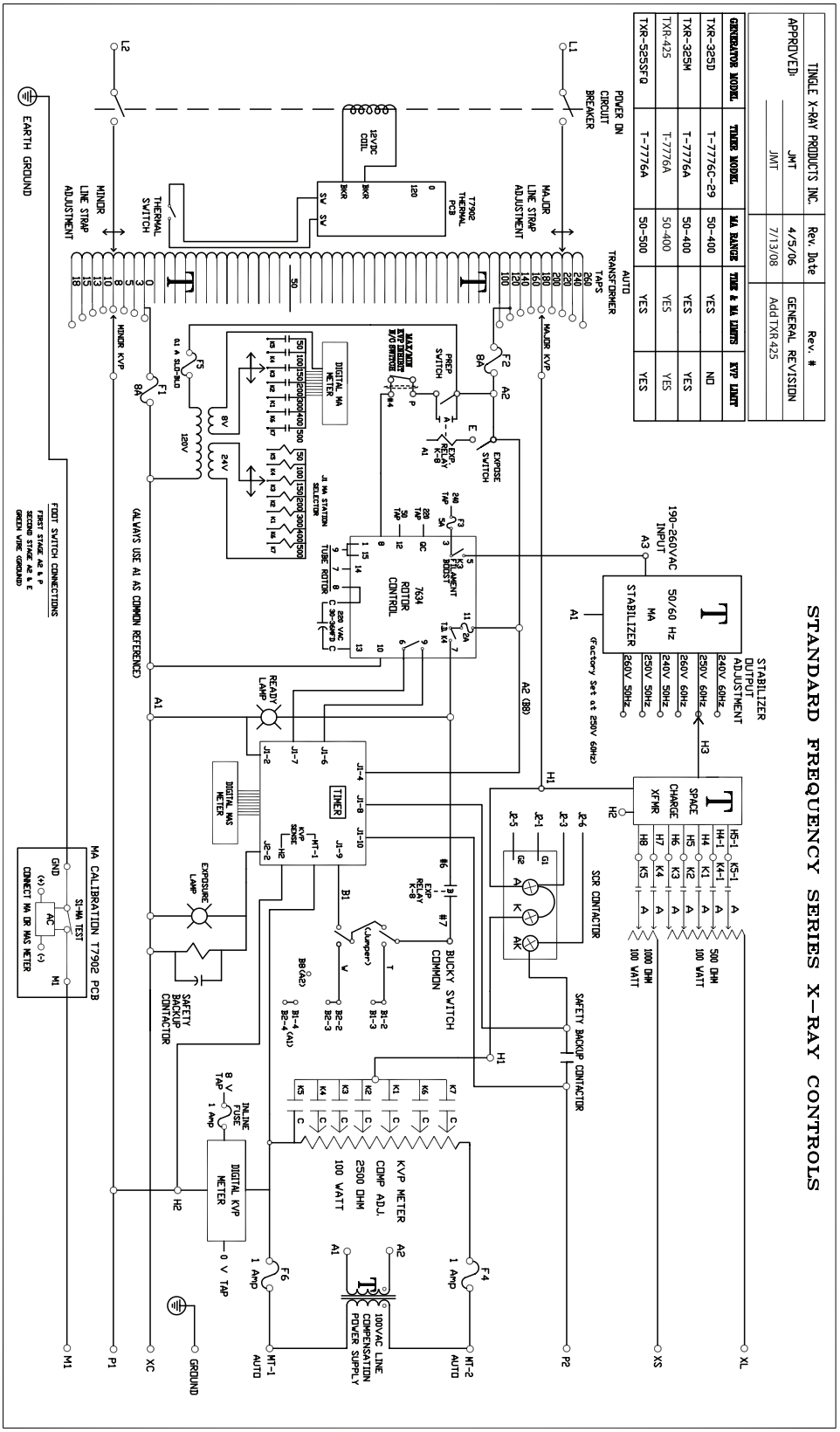
Also consult B.R.H. Routine Compliance Testing for Diagnostic X-Ray Systems or Components of Diagnostic X-Ray, in which 21 CFR Subchapter J is applicable, DHEW Publication (DFA) 75-8012, dated

September, 1974 for details on test procedures and equipment specifications and details.

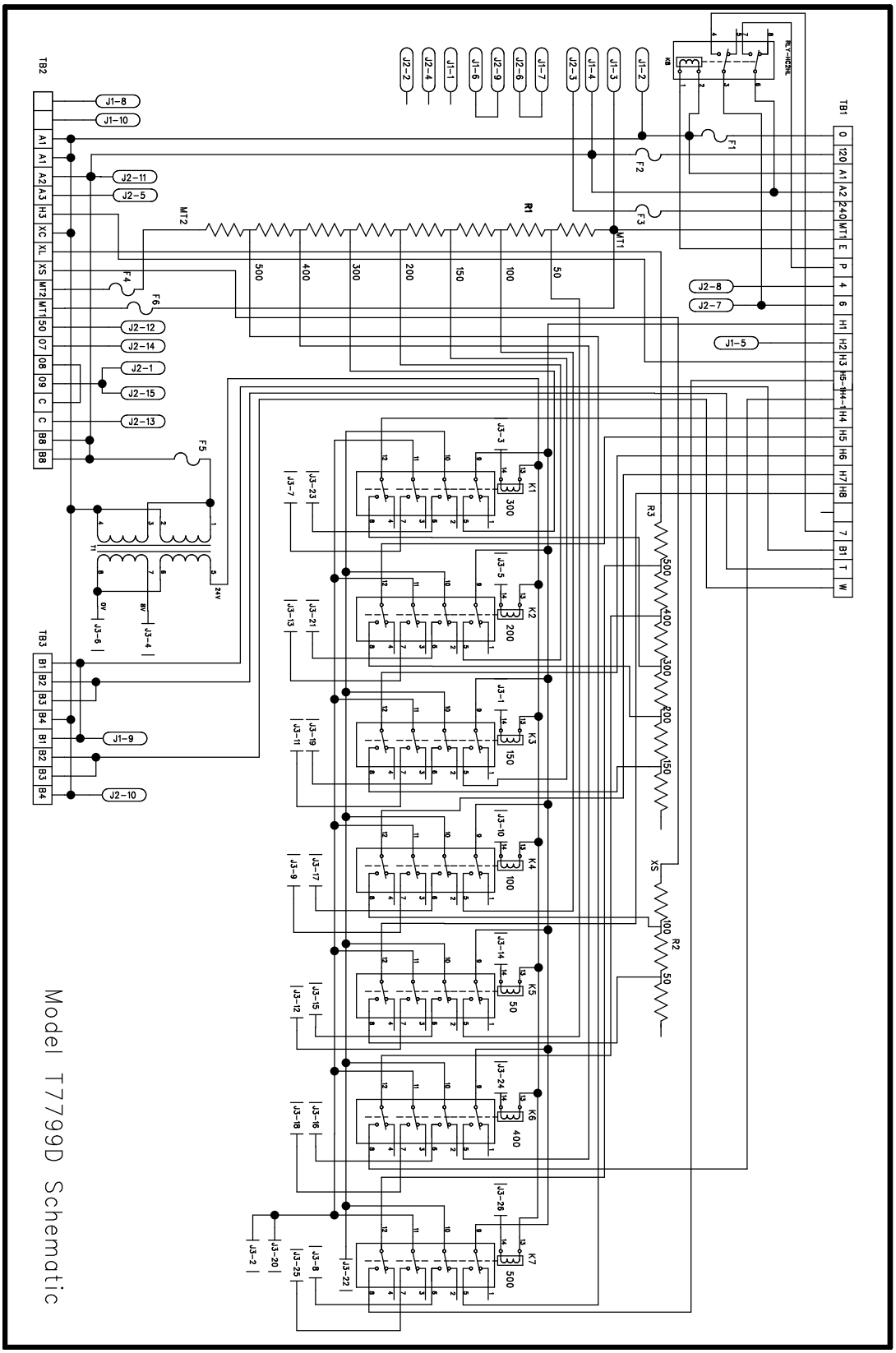
After initial installation, performance of these periodic activities is the responsibility of the owner/user, as they are not provided at no cost under the manufacturers warranty.

SECTION 14
SCHEMATIC DRAWINGS

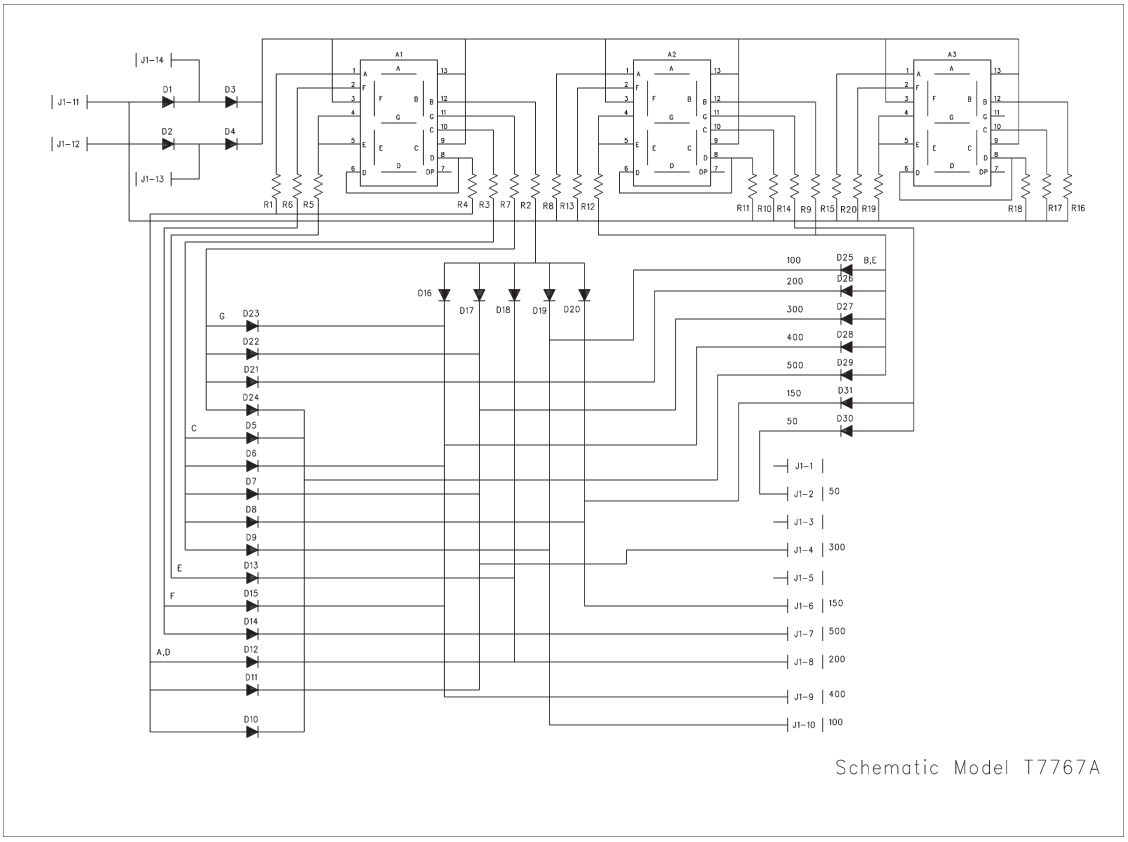
14.0 STANDARD FREQUENCY SERIES CONTROLS



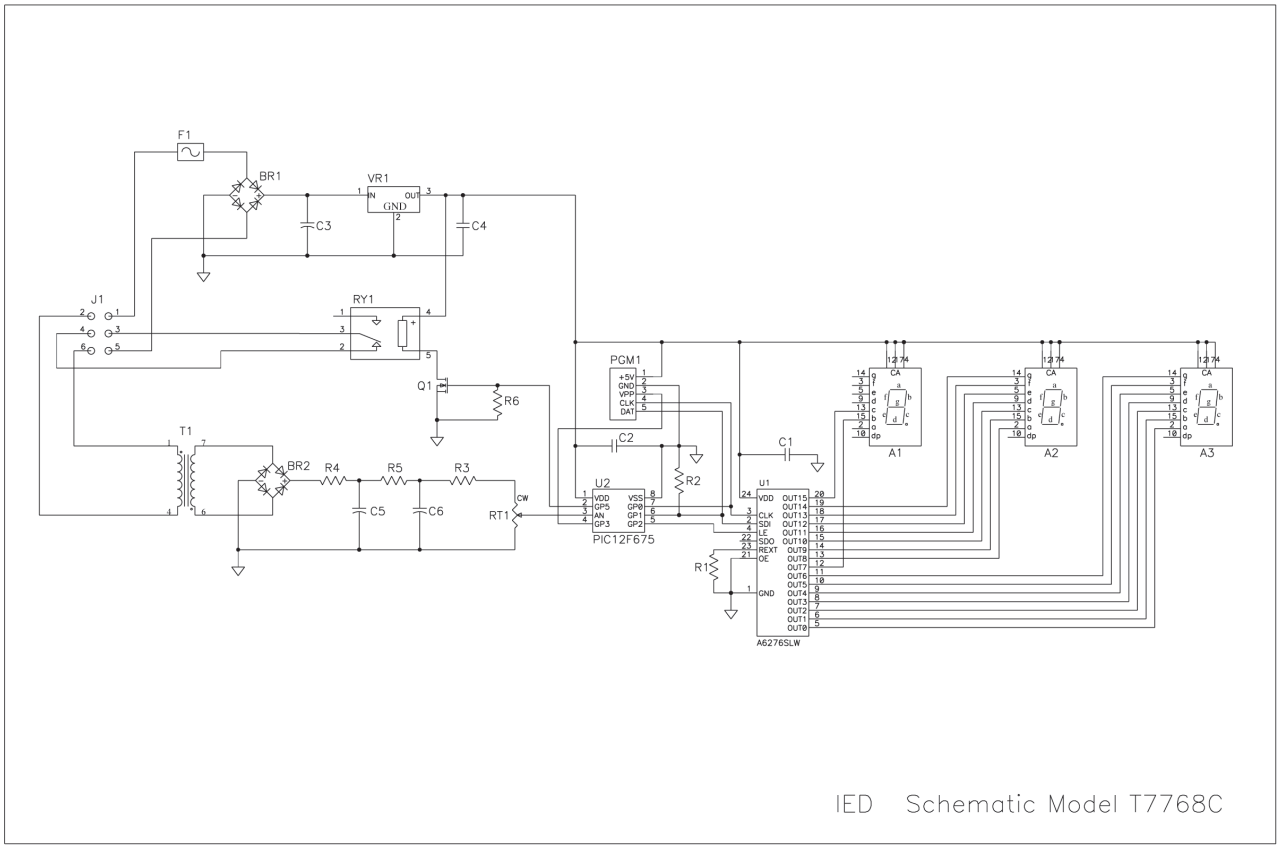
14.1 T-7799C MOTHER BOARD



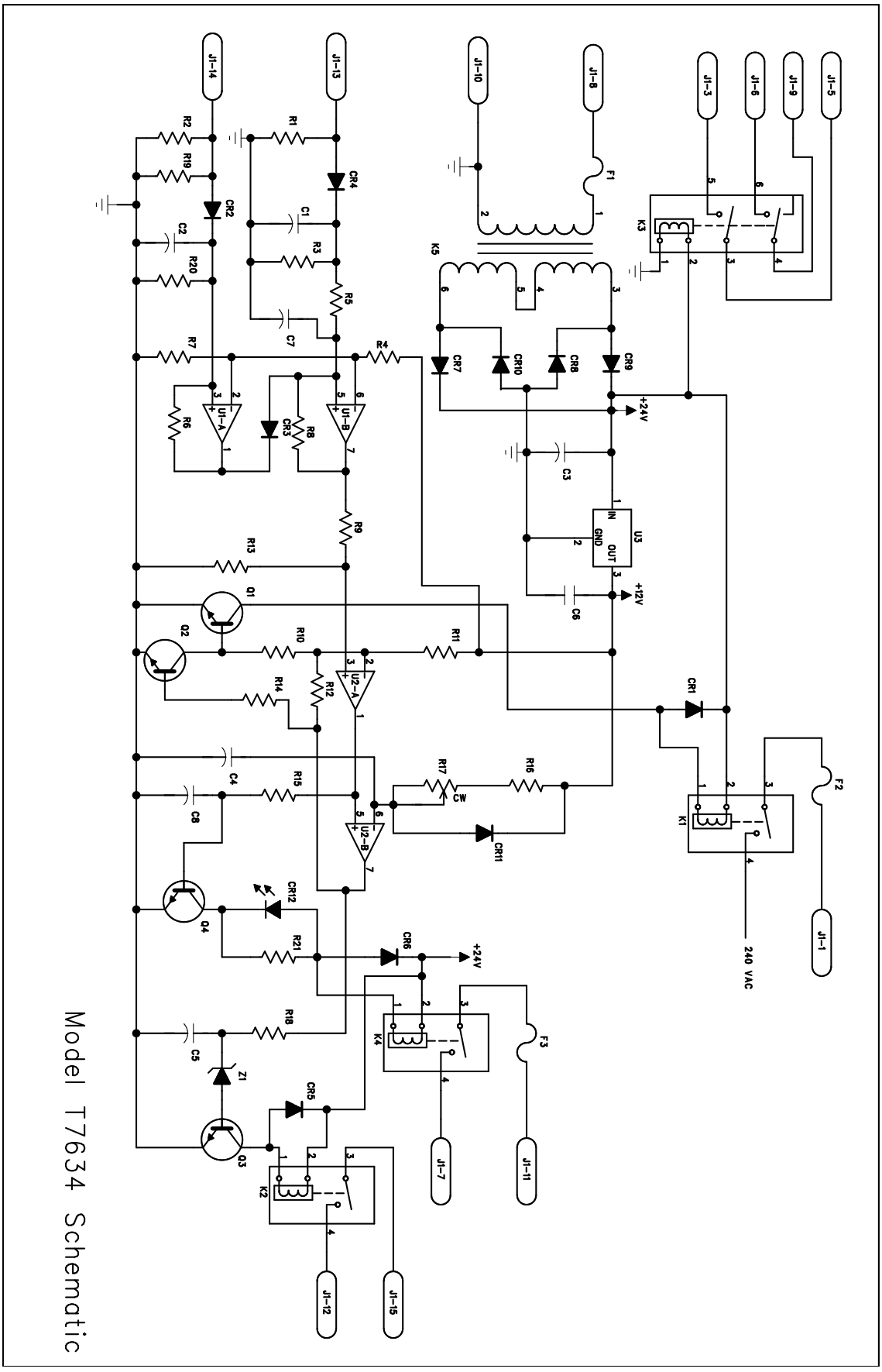
14.2 T-7767A MA METER



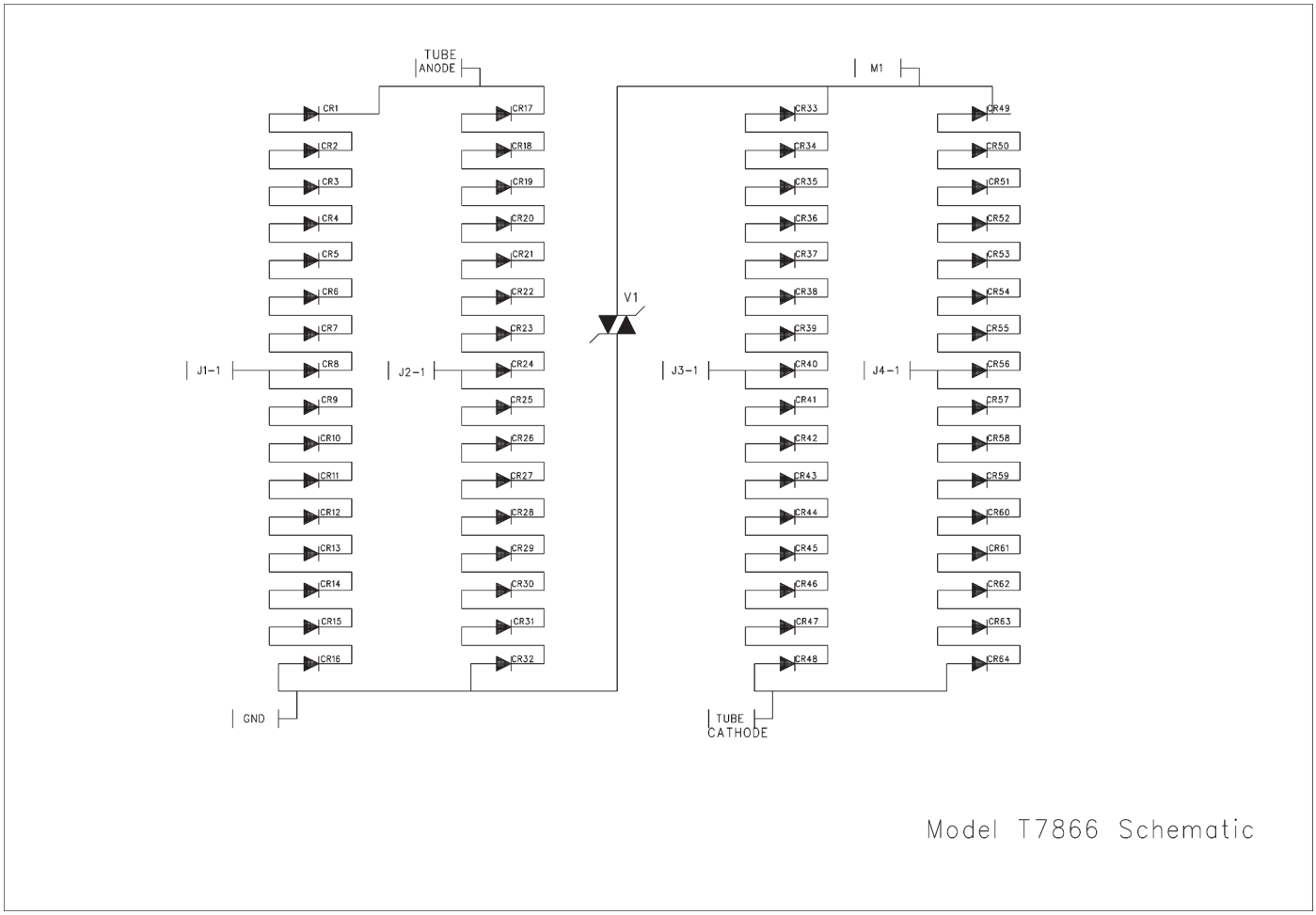
14.3 T-7768B KVP METER



14.4 T-7634 ROTOR CONTROL

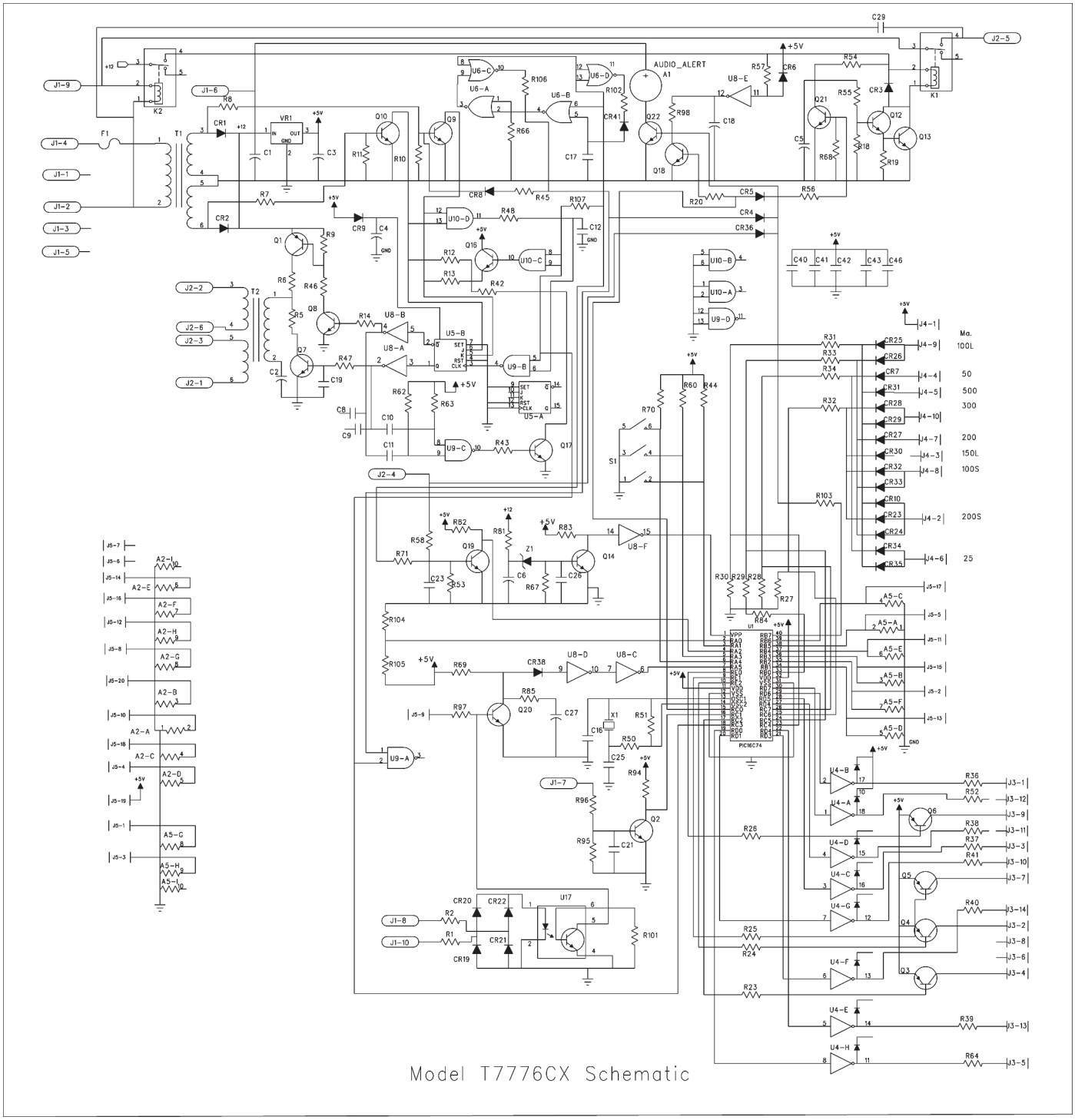


14.5 T-7866 HIGH VOLTAGE DIODE BOARD

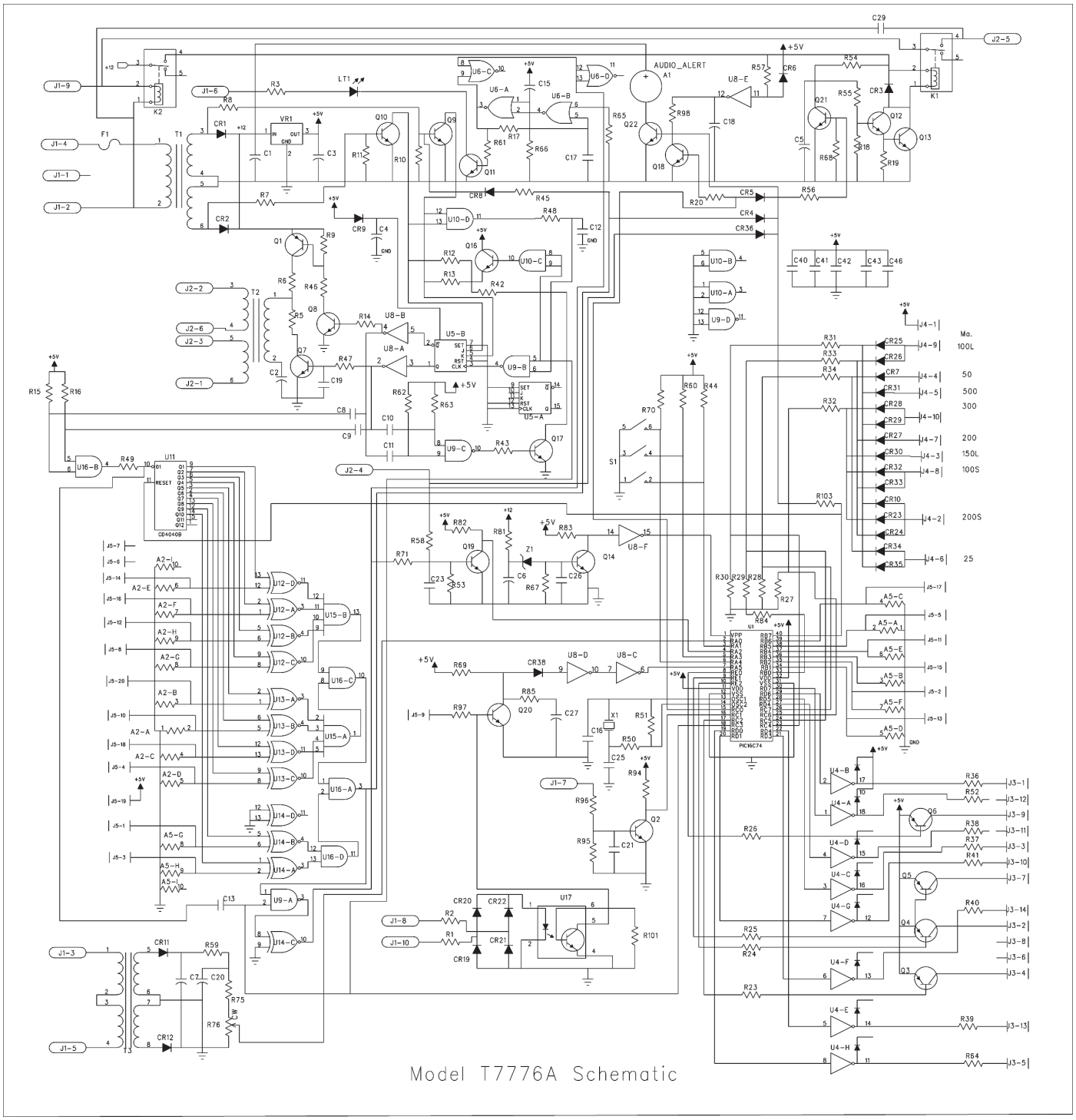


Model T7866 Schematic

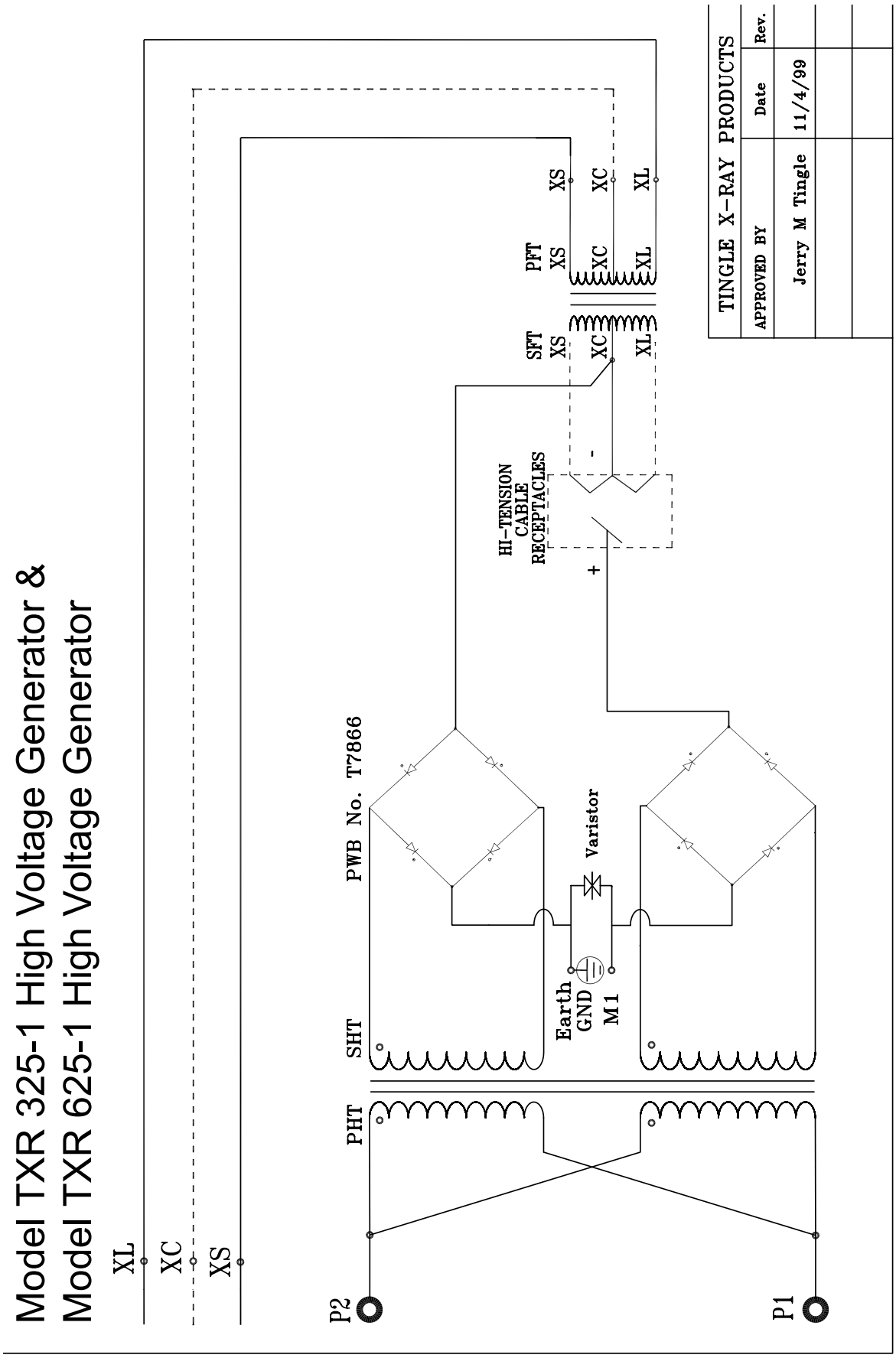
14.6 T-7776CX TIMER



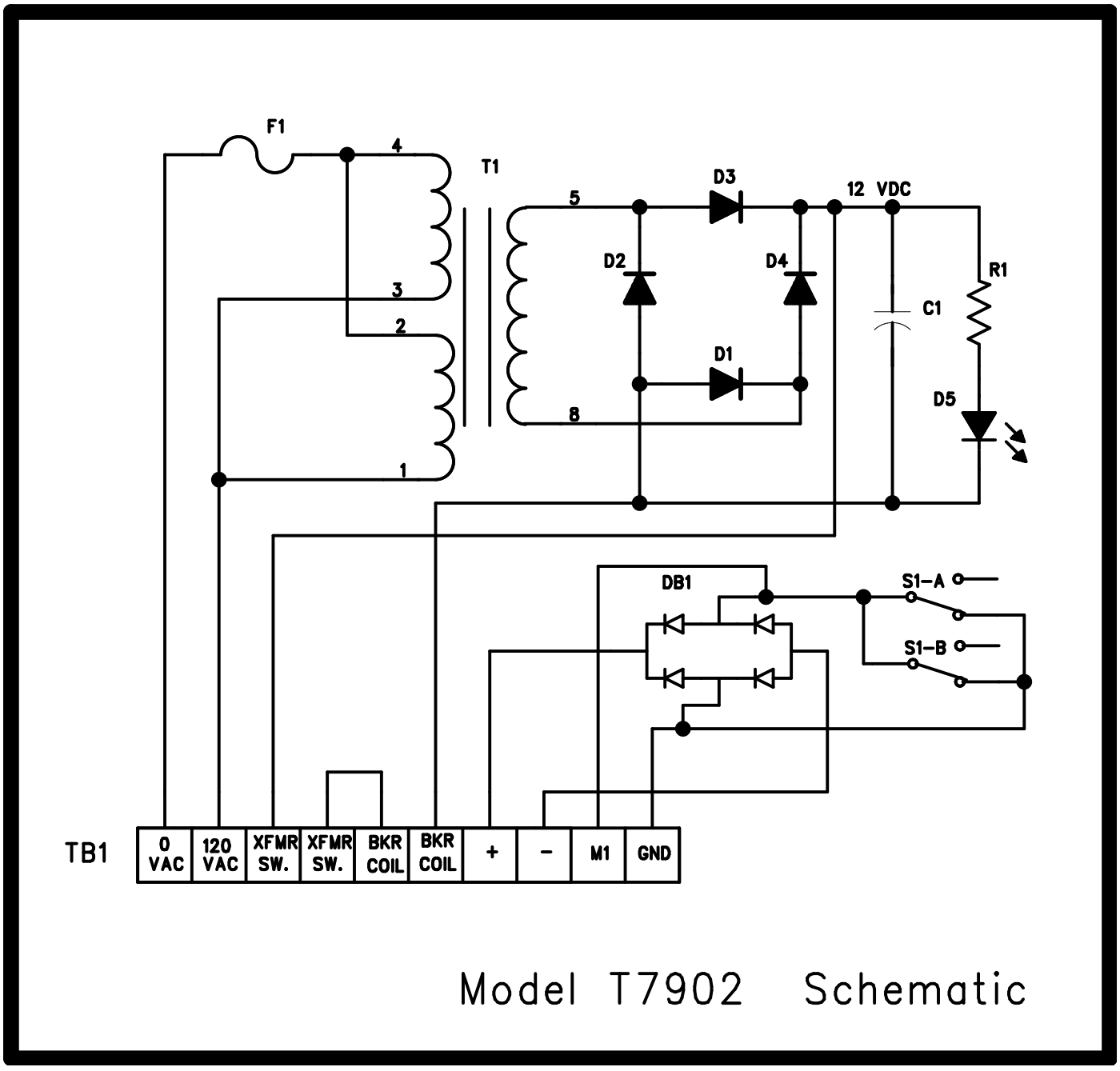
14.7 T-7776A TIMER



14.8 TXR 325-1 AND 625-1 HV TRANSFORMER



14.9 THERMAL AND MA CALIBRATION BOARD INTERCONNECTS

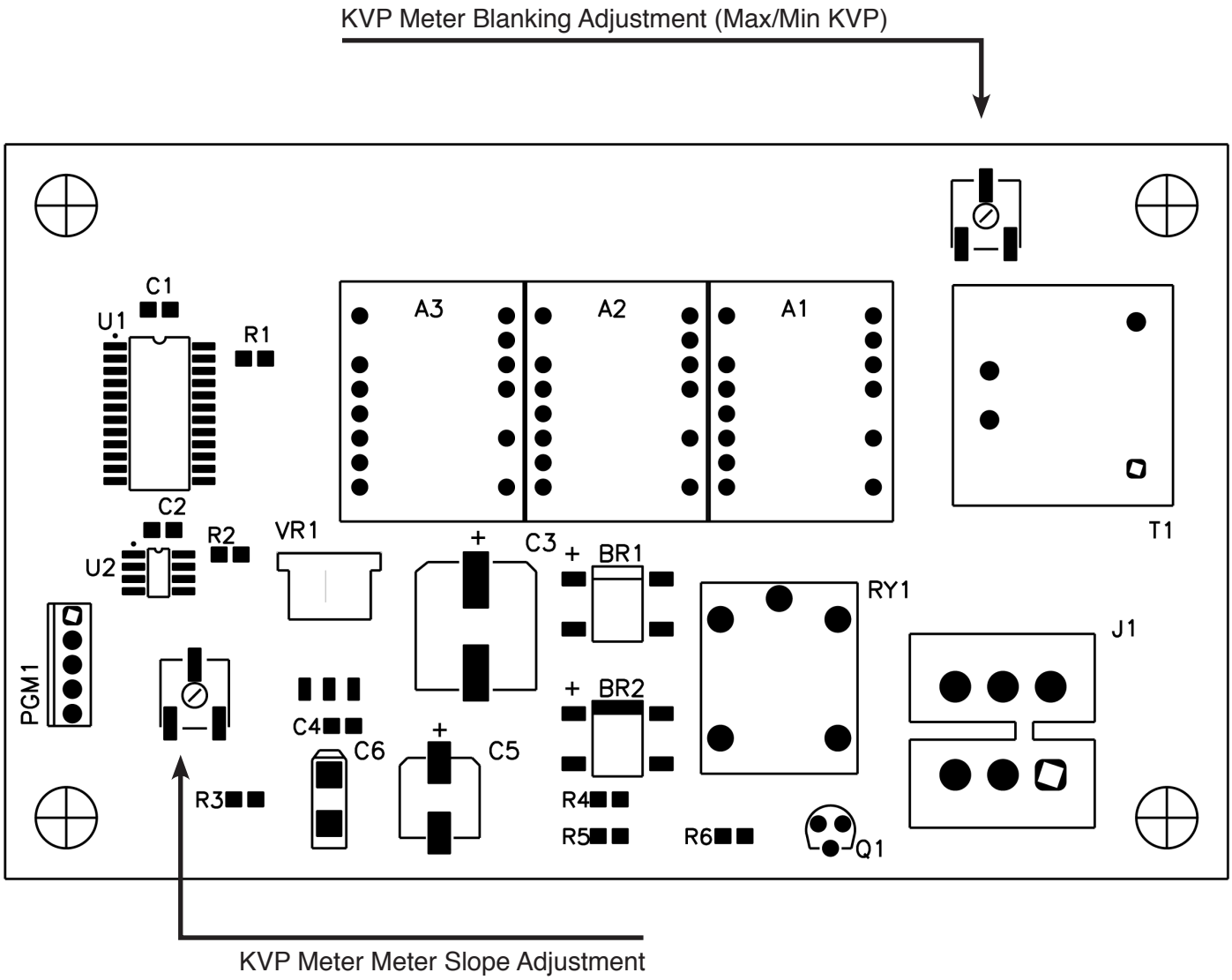


14.10 KVP METER ADJUSTMENTS

NOTICE: Meter Slope Adjustment is accomplished by turning RT1 Potentiometer right or left.

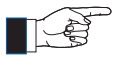
Procedure. Set the Selector to 50 mA. Set kVp until 80 is displayed on the readout. Take a 1 second x-ray exposure. Observe the actual output as indicated on your 4000 meter or divider. Set RT1 so that the meter reads the acual kVp output.

Using the Calibration Sheet continue calibrating the x-ray control until completed. Verify and enter all data.



SECTION 15
DATA SECTION

15.1 INSTALLATION DATA

Note 

Enter the data with a pencil so that it can be modified later due to future changes

Enter the following information.

HOSPITAL OR CLINIC			
INSTALLED AND CALIBRATED BY		DATE	

15.2 MAINTENANCE HISTORY

After service calls and Periodic Maintenance has been performed, enter the information on the form below.

DATE	PERFORMED BY	SERVICE NOTE

15.3 CALIBRATION DATA SHEET

PROCEDURE: To simplify setup tasks and calibration, the following checks and tests have been formatted in a progressive order. When returning the Warranty Card to the factory, include a photocopy of the completed Calibration Data Sheet.

SETTING THE LINE STRAP

Measure Line Supply and fill in block. Move +Major Line Strap to next higher Voltage Tap. Move Minor Line Strap to Voltage Tap that confirms Line to Auto Transformer Match

Line Supply Voltage	Connect Major Line Strap To	Set Minor Line Strap To	Line/Autotransformer Match	Confirm Line Match A1-A2
		-		118-122VAC

MA CALIBRATION

Procedure: Set timer to 1/10 second. Select mA Stations in the order listed below. (All calibration exposures are taken at 80 kVp – Time between exposures is 3 minutes). Carefully adjust each filament-limiting resistor until MAS Measured equals Console MAS Display.

Select 80 kVp	50 mA	100 mA	150 mA	200 mA	300 mA	400 mA	500 mA
Console MAS Display	5 mAs	10 mAs	15 mAs	20 mAs	30 mAs	40 mAs	50 mAs
Record MAS Measured							

DO NOT ATTEMPT ADJUSTING KVP AT THIS TIME

KVP CALIBRATION
(Exposures at 1/10 second)

After completing MA Calibrations confirm 80 KVP output at the Tube matches the 80 displayed on Console KV Meter. For more detailed instructions See SECTION 5.3.1 KVP CALIBRATION. After 80 KVP has been confirmed continue with 60 & 110 KVP

Select kVp	50 mA	100 mA	150 mA	200 mA	300 mA	400 mA	500 mA
80							
60							
110							

RECORD ACTUAL KVP

MA-SPACE CHARGE CHECKS (LOW)

Select 60 kVp	50 mA	100 mA	150 mA	200 mA	300 mA	400 mA	500 mA
Console MAS Display	5 mAs	10 mAs	15 mAs	20 mAs	30 mAs	40 mAs	50 mAs
Record MAS Measured							

RECORD MAS MEASURED AT THE KVP LISTED ABOVE

MA-SPACE CHARGE CHECKS (HIGH)

Select 110 kVp	50 mA	100 mA	150 mA	200 mA	300 mA	400 mA	500 mA
Console MAS Display	5 mAs	10 mAs	15 mAs	20 mAs	30 mAs	40 mAs	50 mAs
Record MAS Measured							

RECORD MAS MEASURED AT THE KVP LISTED ABOVE

TIMER REPRODUCABILITY CHECK

(Exposures taken on 150 mA station at 70 kVp – Time between exposures is 3 minutes)

Make 4 exposures at 1/30 of a second				
Make 4 exposures at 1/10 of a second				
Make 4 exposures at 1/4 of a second				
Make 4 exposures at 1 second				

RECORD TIME IN MILLISECONDS

mR Data (Exposures at 1/10 second – FFD 40 inches)

kVp	50 mA	100 mA	150 mA	200 mA	300 mA	400 mA	500 mA
60							
80							
110							

RECORD ACTUAL OUTPUT M/R

SECTION 16

WARRANTY

TINGLE X-RAY, LLC

5-Year-Warranty

For a period or 5 years from the date of shipment from the factory, new equipment manufactured by Tingle X-Ray, LLC (TXR), is warranted as follows: any parts proven defective will be repaired or replaced free of charge, F.O.B. factory, if the defective parts are returned to the factory for inspection, charges prepaid. The warranty covers parts only and does not include any on-site labor costs.

This warranty does not apply to high voltage cables and X-Ray tubes, or to damage caused by misuse, neglect, or during shipment, and is void if service is performed by persons other than authorized TXR Dealers or representatives, or if equipment is interconnected with components not manufactured by TXR and/or not approved by TXR for compatibility.

TXR reserves the right to pass judgment on cause of breakage or failure.

Auxiliary equipment not manufactured by TXR is not covered by the above but carries the warranty of the manufacturer.

This warranty is not transferable to a new owner unless authorized by the factory in writing.

This warranty is not in effect unless the warranty card is completed and returned to the manufacturer.

16.1 ASSIGNED MODEL AND SERIAL NUMBERS

MODEL NUMBER: _____

SERIAL NUMBER: _____

DATE OF MANUFACTURE: _____

TINGLE X-RAY, LLC

5481 Skyland Boulevard East • Cottondale, Alabama 35453 USA

Telephone toll free in the USA: 1(800) TXR-X-Ray
Telephone (205) 556-3803 • Fax (205) 556-3824 • www.txr.com

PUBLICATIONS AVAILABLE FOR STANDARD FREQUENCY SERIES UNITS

A full set of manuals are provided with each x-ray control.
A complete replacement set may be ordered. Cost $50.00.

Manuals may be ordered for replacing damaged ones or to use for planning or training BMET's.

MANUAL	COST PER COPY
Pre-Installation Manual M-2008-7-12	$20.00
Installation Manual M-2008-7-13	$35.00
Operation Manual M-2008-7-14	$25.00
Maintenance Manual M-2008-7-15	$20.00

Shipping Charges are extra. Sales Tax may apply.