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HFQ SERIES HIGH-FREQUENCY PROGRAMMABLE X-RAY GENERATOR

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DATE	REVISION	PAGE	DESCRIPTION
11/13/89	B	3-3	Added seasoning procedures
11/13/89	B	3-4 through 3-11	Update page numbers
11/13/89	B	4-2	Expanded procedures
11/13/89	B	5-2	Clarify HV tank installation procedure
11/13/89	B	5-3	Added description for buss bar adjustment
11/13/89	B	5-4	Added printer connection procedure
11/13/89	B	5-5 through 5-8	Updated page numbers
11/13/89	B	5-9 and 5-10	Added figures for bakelite terminal
11/13/89	B	7-14	Corrected typographical error
11/13/89	B	7-15	Expanded description of source charger
11/13/89	B	7-16	Added theory for power shut off board (A9)
11/13/89	B	7-16	Added theory for distribution board (A7)
11/13/89	B	8-9	Printer installation procedure moved to Section 5, Installation
11/13/89	B	10-1 through 10-21	Added schematics and board layouts
12/19/89	C	2-2	Modified output specification range
12/19/89	C	3-10	Add description of AEC fault reset
12/19/89	C	3-11	Added description of tube heating display
12/19/89	C	3-12	Changed page number
12/19/89	C	4-1	Added KVP-C error message
12/19/89	C	5-5	Added connect procedure for DMP 133
12/19/89	C	6-6	Add caution to season unit
12/19/89	C	6-10	Revised calibration procedure
12/19/89	C	8-1	Corrected figure
12/19/89	C	8-2	Corrected typographical error
12/19/89	C	8-4	Corrected typographical error
12/19/89	C	8-5	Corrected typographical error
12/19/89	C	10-8	Updated schematic
12/19/89	C	10-9	Updated PCB layout
12/19/89	C	10-18	Updated schematic
12/19/89	C	10-19	Added PCB layout

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DATE	REVISION	PAGE	DESCRIPTION
1/15/90	D	5-1	Corrected Typo
1/15/90	D	5-2	Update part number for wire moulding
1/15/90	D	5-5	Add ATM system installation procedure
1//15/90	D	5-6 through 5-9	Changed page numbers/update fig.5-3
1/15/90	D	5-10, 5-11	Update Bakelite Panel drawings
1/15/90	D	5-12, 5-13, 5-14	Added drawings for ATM installation
1/15/90	D	Section 10	Updated schematics/PCB layouts
2/16/90	E	1-4	Updated NCRP report number
2/16/90	E	2-1	Moved Table 2-1
2/16/90	E	2-2, 2-3	Added HFQ power specifications, tables
2/16/90	E	2-4 through 2-8	Incremented page numbers
2/16/90	E	5-3	Added reference to power requirements
2/16/90	E	5-15	Added remote switch connection diagram
2/16/90	E	6-1	Revised source charger calibration proc.
2/16/90	E	6-2	Added line monitor calibration procedures
2/16/90	E	6-3, 6-4	Changed page numbering
2/16/90	E	6-5	Revised SES configuration direction, (step 6)
2/16/90	E	6-6	Added information for VSENSE status menu
2/16/90	E	6-7	Added DC REF. menu
2/16/90	E	7-1	Added line voltage monitor/OCP driver
2/16/90	E	7-8	Changed VBATT to VSENSE
2/16/90	E	7-17	Added theory for line voltage monitor
2/16/90	E	7-18	Added theory for OCP driver
2/16/90	E	10-22 through 10-25	Added schematic and layouts
6/25/90	F	6-1, 6-2	Revised source charger calibration proc.

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DATE	REVISION	PAGE	DESCRIPTION
8/90	F	2-1	Added weights for HFQ models
8/90	F	2-3	Added note to Table
8/90	F	2-4	Added compatible Tubes and Collimators
8/90	F	3-7, 3-9	"FREEZE" value explained
8/90	F	5-3	Added cable information to OCP installation
8/90	F	5-6	Added Tomo Interface
8/90	F	5-6 through 5-8	Revised pagination
8/90	F	5-9	Added Tomo Interface Wiring Table
8/90	F	5-10	Changed Pin O to U
8/90	F	5-11 through 5-17	Revised pagination
8/90	F	6-1, 6-2	Added to Source Charger Calibration
8/90	F	6-3 through 6-12	Revised pagination
8/90	F	6-10, 6-11	Revised MA Calibration procedures
8/90	F	6-11, 6-12	Revised AEC Calibration procedures
8/90	F	7-14	AEC Board 208094 replaced 208091
8/90	F	7-15, 7-16	Source Charger revised; added to Warning
8/90	F	8-8, 8-9	Corrected figure errors
8/90	F	9-1	Added fuse warning
8/90	F	9-1	Replaced Software Test w/ Built-In Diag.
8/90	F	9-2	Revised Calibration Check List
8/90	F	9-4 though 9-7	Using the Built-In Diagnostic Utility
8/90	F	9-7	Added figure for PCB Location
8/90	F	Section 10	Updated schematics/PCB layouts
8/29/90	G	6-7	Added Exposure Counter Menu
8/29/90	G	6-6 through 6-13	Revised page and figure numbering
9/14/90	H	6-1, 6-2	Changed stored energy voltage
9/14/90	H	7-15	Changed stored energy voltage
9/14/90	H	10-19	Changed stored energy voltage

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DATE	REVISION	PAGE	DESCRIPTION
10/3/90	I	2-3	Defined wire size
10/3/90	I	5-8	Corrected connection points
10/3/90	I	6-13	Revised kVp value
10/30/90	J	10-1	Revised Interconnection Diagrams
10/30/90	J	10-2	Revised Interface Board
10/30/90	J	10-17, 10-18	Revised AEC Interface Board
10/30/90	J	10-19, 10-20	Added AEC Board, 208104
10/30/90	J	10-21 - 10-28	Revised paging
12/14/90	K	2-2, 5-3	Added compliance requirement
12/14/90	K	6-7, 6-9	Revised S.E.S. voltage
12/14/90	K	10-4, 10-5	Revised schematics
12/14/90	K	10-8, 10-9, 10-12	Revised schematics
1/91	L	Section 1	Reorganized section
1/91	L	2-1	Revised weights
1/91	L	2-4	Added power specs for 240 VAC, option; added compatible tube
1/91	L	2-5	Corrected typographical errors
1/91	L	2-7, 9-8	Revised generator diagram
1/91	L	2-8	Added Compliance Label location
1/91	L	3-1, 3-2	Auto shut down timer: 60 minutes
1/91	L	3-4	Corrected typographical errors
1/91	L	Section 4	Renamed and revised section
1/91	L	5-2	Added to H.V. tank installation
1/91	L	5-3	Added to Verify Input Power proc.
1/91	L	5-4	Added to System Interconnections
1/91	L	5-7	Added to Final Inspection proc.
1/91	L	5-12, 5-13	Revised panel diagrams
1/91	L	6-1	Added reference to NEMA
1/91	L	6-2	Revised measured voltage levels
1/91	L	6-11, 6-12	Revised mA calibration procedures

***SECTION 1,
PREFACE***

INTRODUCTION

Congratulations on selecting the HFQ Series, the finest radiographic system designed today. BENNETT's HFQ series x-ray generator systems incorporate state-of-the-art technology, a true high-frequency (100 kHz) resonant power source, anatomically programmable technique selection and Quartz accurate electronics.

Manual Overview

The HFQ Series Installation and Operation Manual is intended for use by both technologists and field engineers. It consists of ten sections. The first four sections provide the general information and procedures necessary to operate the BENNETT HFQ system; the second part of the manual provides the technical information required to install, calibrate, and troubleshoot the system. A detailed theory of operation and system schematics are included as well.

The following is a brief overview of the contents of each section:

- Section 1, *PREFACE* - includes a system description, safety notices and recommendations, shipping information, compliance and x-ray protection notices and warranty information.
- Section 2, *GENERAL INFORMATION* - includes component specifications, system options, an overview of operating modes and a description of system controls and indicators.
- Section 3, *SYSTEM OPERATION* - provides complete operating procedures, including power on/off procedures, operating modes and exposure selection criteria.
- Section 4, *SYSTEM DIAGNOSTICS* - contains a description of error messages and a list of common system faults with suggested responses.
- Section 5, *INSTALLATION* - provides installation and interconnection procedures.
- Section 6, *CALIBRATION* - provides calibration procedures, including kVp, mA, and system electronics.
- Section 7, *THEORY OF OPERATION* - provides an analysis of signal flow on both block and component levels.
- Section 8, *PROGRAMMING* - describes procedures for editing existing techniques and creating new techniques in the x-ray control memory.
- Section 9, *PREVENTIVE MAINTENANCE AND TROUBLESHOOTING* - provides routine maintenance guidelines and schedules; built-in system diagnostic utilities are also discussed.
- Section 10, *SCHEMATICS* - includes a set of system schematics.

SYSTEM DESCRIPTION

The HFQ Series are anatomically programmable high-frequency x-ray generators. Operating at 100 kHz resonance, the HFQ systems offer remarkable performance as a diagnostic tool with dramatic reductions in exposure times and patient radiation dose.

The HFQ accommodates up to 72 anatomically programmed techniques. kVp, mAs, and mA are automatically selected depending upon the thickness of the anatomical region. Techniques can be modified at any time by switching to manual mode or by editing the existing techniques.

When the Automatic Thickness Measurement (ATM) option is added, the system has the ability to automatically measure the thickness of a region of interest (ROI) in conjunction with the patented Auto-Tech system.

The HFQ Series is also available as a stored energy system (HFQ SE) that allows you to plug it into a standard household power receptacle (110 VAC).

BASIC CONFIGURATIONS AND OPTIONAL FEATURES

BASIC CONFIGURATIONS

The HFQ Series x-ray generators are state-of-the-art programmable systems. Since the requirements of radiological practices vary widely, BENNETT's basic system design provides for easy future upgrades. The HFQ Series is available in six base configurations, either as Stored Energy (SE) or non-SE systems as follows:

- HFQ-300 or HFQ-300SE (300 mAs at 125 kVp)
- HFQ-450 or HFQ-450SE (450 mAs at 125 kVp)
- HFQ-600 or HFQ-600SE (600 mAs at 125 kVp)

NOTE: BENNETT HFQ 300SE, 450SE, or 600SE models can all be connected to a standard 110 VAC power source.

OPTIONAL FEATURES

A variety of options provide the flexibility to meet individual requirements:

- Automatic Thickness Measurement (ATM) System: the ATM option uses an internal sonar device to measure the anatomical region of interest (ROI) and then select and set the optimal technique factors.
- Automatic Exposure Control (AEC) System: uses an ion chamber to assure proper exposure times. This provides uniform film density from patient-to-patient and film-to-film.

SAFETY NOTICE

The HFQ Series High-Frequency X-Ray generator, manufactured by **BENNETT X-RAY CORP.** will function reliably when operated, maintained, and repaired according to the instructions provided in this manual.

BENNETT X-RAY CORP. cannot assume responsibility for any malfunctioning of this equipment resulting from improper operation, maintenance, or repair, or from damage or modification of its components.

This equipment can be hazardous to both patient and operator unless established safe exposure factors are observed.

X-ray equipment is sold to be used exclusively by or under the prescribed direction of a person who is licensed by law to operate equipment of this nature.

BENNETT X-RAY CORP. disclaims all responsibility from any injury resulting from improper application of this equipment.

SAFETY RECOMMENDATIONS

Mechanical/Electrical

All moveable assemblies and parts of this equipment must be operated with reasonable care. Manufacturer's equipment recommendations described in this manual (included with equipment) must be observed.

Routine inspection of these assemblies should be performed by qualified service personnel on a semi-annual basis. Only properly trained service personnel should be permitted access to internal assemblies, as live electrical components may be present. Be sure line disconnect switches are open or other appropriate safety precautions are followed before service work is performed.

Failure to follow manufacturer's or service personnel's recommendations may result in serious injury.

CAUTION: GROUNDING: this equipment is grounded to an earth ground through the electrical power cord ground wire. It must be connected into a properly grounded electrical box. Under no circumstances should it be operated without the proper three wire power cord attached.

CAUTION: The HFQ/HFQSE Series generators are shipped with a tube loading program specifically designed for the individual x-ray tube and anode rotation speed of the tube supplied. The program is based on focal spot size and anode heat dissipation of the tube insert.

COMPLIANCE NOTICE

The certified model **BENNETT** x-ray system you have purchased has been designed, manufactured, and calibrated to comply with governing Federal Regulations 21 CFR Subchapter J and the performance standards attendant thereto.

Scheduled maintenance is essential to the assurance of continued integrity of this equipment with respect to regulatory compliance. The continuance of certified performance to the regulatory standard is incumbent upon the user's diligent conformance to recommended maintenance instructions.

All certified products installed require the filing of an Assembler's Certification Form FD-2579 (enclosed with the machine) by the Assembler (i.e., the installer). A copy of the Quality Assurance Form (pink copy) must be provided upon completion of the installation.

X-RAY PROTECTION NOTICE

X-ray equipment may cause injury if used improperly. The instructions in this manual must be adhered to when operating the HFQ. **BENNETT X-RAY CORP.**'S authorized dealers will gladly assist you in placing your system into operation.

Personal radiation monitoring and protective devices are available. You are urged to use them to protect against unnecessary x-radiation exposure.

It is important that you be fully acquainted with applicable government radiation protection regulations. Many provisions of these regulations are based on recommendations of the National Council of Radiation Protection and Measurements. Recommendations for medical x-ray protection are published in NCRP Report Number 102, available from:

NCRP Publications
7910 Woodmont Ave.
Suite 1016
Bethesda, MD 20814

Those responsible for the planning of x-ray equipment installations must be thoroughly familiar and comply completely with NCRP Number 49, "Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma-Rays of Energies up to 10 MEV", as revised or replaced in the future.

SHIPPING INFORMATION

The shipper is relieved of any responsibility for damage during shipment after the unit is picked up by the carrier.

Examine all cartons and crates carefully at time of delivery. If damage is apparent, have delivery driver write a "Damaged Shipment Note" on copies of the freight bill, sign it, and file the appropriate carrier claim. Should you discover

SHIPPING INFORMATION (Continued)

concealed damage, immediately notify the transporting agent and ask for an "Inspection of Damage". Carrier will not accept concealed damage claim if filed after 15 days from date of receipt of merchandise.

Open crate or carton marked "packing list enclosed" first. Remove packing list and use as guide to open remaining cartons. Do not dispose of packing material until packing list is matched with actual parts received. Should there be a shortage or damage, notify the manufacturer immediately.

WARRANTY

Providing the warranty card(s) are completed and returned to the manufacturer within ten (10) days after receipt of the equipment, **BENNETT X-RAY CORP.** warrants all new x-ray equipment of their manufacturer and all tubes in that equipment on the following terms:

- **BENNETT X-RAY CORP.** warrants all equipment manufactured by it and bearing its name to be free from defects in material and workmanship under normal use and service. Scope of this warranty extends to the original purchaser from the date of purchase and its applicable only when the equipment is installed and operated according to factory recommendations. The warranty does not extend to damage or wear caused by misuse, abrasion, corrosion, negligence, accident, faulty installation, or tampering in a manner to impair or alter its normal operation.
- X-Ray Tubes used in the x-ray equipment are warranted against defects in material and workmanship from date of shipment from the factory.
- **BENNETT X-RAY CORP.** does not assume responsibility for loss or damage in transit to equipment or tubes returned for examinations. On any item returned for inspection, repair, or replacement, transportation charges both ways must be paid by the buyer.
- **NO REPLACEMENT OR REPAIR WILL BE MADE WITHOUT CHARGE IF THE EQUIPMENT OR TUBE INDICATES AFTER EXAMINATION BY AND IN THE OPINION OF BENNETT X-RAY CORP. THAT THE DAMAGE WAS CAUSED BY IMPROPER HANDLING.**
- **THE FOREGOING WARRANTIES ARE EXCLUSIVE, AND ARE IN LIEU OF ALL OTHER WARRANTIES (WHETHER WRITTEN, ORAL, OR IMPLIED) INCLUDING WARRANTY OR MERCHANTABILITY IN OTHER RESPECTS THAN EXPRESSLY SET FORTH ABOVE AND WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, EXCEPT AS HEREIN PROVIDED, EVERY FORM OF LIABILITY FOR DIRECT OR CONSEQUENTIAL DAMAGES OR LOSS IS EXPRESSLY EXCLUDED AND DENIED.**
- **SEE WARRANTY CERTIFICATE FOR DURATION.**

**SECTION 2,
GENERAL
INFORMATION**

**SECTION 2,
GENERAL INFORMATION**

GENERAL INFORMATION

HFQ SERIES GENERATOR SPECIFICATIONS

As shown in Figure 2-1, the HFQ Series High-Frequency generator is a complete microprocessor based, anatomically programmable x-ray generator system with a 100 kHz resonant power source. A separate operator control panel, attached to the system via cable, affords the operator complete control over the x-ray generator at all times.

DIMENSIONS

<u>Generator Cabinet</u>	<u>Operator Control Panel (OCP)</u>
Height: 63 1/2-inches	8-inches
Width: 24-inches	10-inches
Depth: 17-inches	4 1/16-inches (maximum)
Weight: Model Dependant	3-pounds

SPECIFICATIONS

kVp Range:	40-125 kVp in 1 kVp steps
kVp Accuracy:	± 5%
mA Range:	Model dependant (see Table 2-1)
mA Accuracy:	± 10% or 5 mA, whichever is greater
Time Range:	5 milliseconds to 6 seconds, 200 steps
Time Accuracy:	± 1% ± 3 milliseconds. Time is measured at the 90% level of the peak kV
mAs Accuracy:	± 12% for time greater than 100 milliseconds. Below 100 milliseconds accuracy is a product of time and mA
Duty Cycle:	1% of full load or x-ray tube limits, whichever is less

Note: Specifications for all configurations are identical, except as noted in chart and power requirements. All specifications do not include measurement instrumentation accuracy.

Table 2-1. Model Dependant Specifications

SPECIFICATION	HFQ -300 SERIES	HFQ - 450 SERIES	HFQ - 600 SERIES
OUTPUT @ 125 KVP	300 MAS	450 MAS	600 MAS
MA STATIONS:			
SMALL FOCUS	25, 50 AND 75	25, 50 AND 75	25 AND 75
LARGE FOCUS	75, 100, 125 AND 150	100, 150, 200 AND 225	100, 150, 200, 250, 300
WEIGHT (LBS.)	350	375, 450(SE)	400, 475(SE)

GENERAL INFORMATION

POWER REQUIREMENTS (HFQ Model)

For any electrical installation, all electrical wiring/connections must be installed by a qualified electrician and conform to national and local codes. Requirements for health care facilities (National Electric Code NFPA No. 70) must be followed. Common power specifications are described below and configuration dependant electrical requirements are listed in Tables 2-2 and 2-3.

GENERAL ELECTRICAL COMPLIANCE REQUIREMENTS

These general guidelines must be followed in order to comply with the National Electric Code:

- All wiring must be copper.
- Insulation rating of the wire must be at least 50% of momentary current (as listed in Table 2-3, HFQ Electrical Requirements).
- All fuses, circuit breakers and disconnect switches should conform to the above requirement of 50% of momentary current.
- For all installations, a separate earth ground (#6 AWG insulated wire) must be installed. This #6 AWG insulated wire must be the **only** wire connected to the copper ground terminal.

POWER SPECIFICATIONS (HFQ Model)

200-270 VAC 50/60 Hz (configured at time of installation)

Less than 3 amps long term

Line regulation 7% at full load

Fully automatic line voltage compensation, maximum overall line voltage variations (non equipment related) not to exceed +/- 5%

Maximum line current measured at 125 kVp, maximum mA at 7% line regulation; refer to Table 2-2

Table 2-2. HFQ Momentary Line Current Requirements

LINE VOLTAGE	HFQ -300	HFQ - 450	HFQ - 600
200 VAC	190-AMPS	280-AMPS	370-AMPS
240 VAC	160-AMPS	235-AMPS	306-AMPS
270 VAC	140-AMPS	210-AMPS	275-AMPS

GENERAL INFORMATION

MODEL	VOLTAGE	WIRE SIZE/LENGTH *			DISCONNECT TO GENERATOR 15 FT. MAX.	MOMENTARY LINE CURRENT	SERVICE RATING	DISTRIBUTION XFMR RATING	LINE RESISTANCE
		50 FEET	100 FEET	200 FEET					
HFQ 300	208	#2 AWG	#00 AWG	300 MCM	#4 AWG	183 AMPS	100 AMPS	25 KVA	0.08 OHMS
	240	#2 AWG	#0 AWG	250 MCM	#4 AWG	160 AMPS	100 AMPS	25 KVA	0.10 OHMS
HFQ 450	208	#0 AWG	200 MCM	450 MCM	#2 AWG	270 AMPS	150 AMPS	35 KVA	0.06 OHMS
	240	#1 AWG	#000 AWG	350 MCM	#2 AWG	235 AMPS	150 AMPS	35 KVA	0.075 OHMS
HFQ 600	208	#00 AWG	300 MCM	600 MCM	#1 AWG	353 AMPS	200 AMPS	50 KVA	0.04 OHMS
	240	#0 AWG	250 MCM	500 MCM	#1 AWG	306 AMPS	200 AMPS	50 KVA	0.05 OHMS

*NOTE: Wire size from Distribution Transformer to Disconnect Switch

Table 2-3. HFQ Electrical Requirements

GENERAL INFORMATION

POWER SPECIFICATIONS (HFQ SE Model)

SPECIFICATION	HFQ SE	240 VAC OPTION
Input Voltage (configured at time of installation)	105 - 130 VAC 50/60 Hz	220 - 240 VAC 50/60 Hz
Long Term Amps	Less than 6 amps	Less than 3 amps
Momentary Amps	Less than 20 amps during rotor start up time	Less than 10 amps during rotor start up time
Line Regulation	10% at 20 amp load	10% at 10 amp load
Line Voltage Compensation	Fully automatic, max. overall line voltage variations (non-equippt related) not to exceed +/- 5%	Fully automatic, max. overall line voltage variations (non-equippt related) not to exceed +/- 5%

TUBE AND COLLIMATOR COMPATIBILITY

Tube: Eureka: Rad 8 Insert, Rad 9 Insert, Rad 13 Insert, Rad 14 Insert, Rad 21 Insert, Rad 25 Insert, Rad 28 Insert, Rad 74 Insert

Toshiba: DRX1403, E7239X, E7242X

Collimator:



BENNETT/Dial-X, D-50M, D-60SA or D-70A Series.

OPERATING MODES

- Manual - permits the operator to select all technique factors.
- Automatic Exposure Control (AEC) - uses an ion chamber to assure proper exposure times (optional feature).
- Auto-Tech^R - exclusively designed by BENNETT to further enhance radiographic imaging. Auto-Tech uses pre-programmed techniques that set kVp, mA, and time automatically. When used in conjunction with the optional Automatic Thickness Measurement (ATM) feature, anatomical thickness of the ROI is automatically calculated and displayed on the OCP. During exposure, the AEC works in conjunction with Auto-Tech to provide uniform, repeatable, high quality images with the smallest variation of optical density between patients.

OPERATOR CONTROL PANEL

The separate Operator Control Panel (shown in Figure 2-2) allows complete control and access to all system functions and features. A twenty-one button touch-sensitive key pad combined with a Liquid Crystal Display (LCD) and Light Emitting Diode (LED) technology provide user-friendly control and indication of system status. Controls and indicators described in the following paragraphs can be referenced to Figure 2-2 by corresponding numbers.

- 1- **LED INDICATOR:** When an indicator lamp is lit, the corresponding function is activated.
- 2- **LCD PANEL:** Displays techniques of corresponding selection keys providing a pre-indication of kVp, mA, Time, and mAs as well as measured thickness of the Region Of Interest (ROI) in cm.
- 3- **DIRECTION KEYS:** Pressing either  or  keys (located above or below the LCD display) will increase or decrease the corresponding factors, respectively.
- 4- **AUTO-TECH^R KEY:** Pressing **AUTO-TECH^R** causes the LCD to display eight available anatomical regions for selection. Upon selection of an anatomical region, up to nine available programs for the region selected will be displayed. Once a program is selected the system will automatically measure thickness of the ROI (optional), select the pre-programmed kV for displayed thickness, select the pre-programmed mA for the selected view and select the pre-programmed time for the displayed anatomical thickness.
- 5- **AEC KEY:** Enables and disables the optional Automatic Exposure Control (AEC) function.
- 6- **MANUAL KEY:** Places the system in manual mode allowing the operator to select all technique factors without system intervention.
- 7- **TABLE BUCKY KEY:** Activates the bucky. This function is automatically activated if "TABLE BUCKY" is used in an Auto-Tech^R program.
- 8- **NON-BUCKY KEY:** Allows for techniques that do not use a bucky. The LED illuminates when "non-bucky" is selected. This function can be pre-programmed to activate if a non-bucky technique is used in an Auto-Tech^R program.
- 9- **WALL BUCKY KEY:** Activates the wall bucky. This function can be pre-programmed to activate when wall bucky techniques are used in the Auto-Tech^R program.
- 10- **AEC FIELD SELECT KEY:** This key selects the field or combination of fields used to sense the amount of radiation entering the film cassette.

OPERATOR CONTROL PANEL (Continued)

- 11 - PREP KEY:** Starts the tube rotor, pre-heats the filament, and performs a self test.
- 12 - EXPOSURE KEY:** Starts exposure. If **PREP** has not been pressed prior to **EXPOSE** there is a time delay prior to exposure of approximately 1-1/2 seconds. When **PREP** is used in conjunction with **EXPOSE**, exposure is immediate.
- 13 - READY INDICATOR:** Illuminates when the system has performed all its self-checks and is ready to take an exposure. On SE versions, the READY indicator also indicates when the Stored Energy Source is at full capacity (ready to take an exposure).
- 14 - TUBE 1:** Selects Tube 1.
- 15 - TUBE 2:** Selects Tube 2 when available.
- 16 - Key Switch:** Allows access to Utility/Maintenance modes.
- 17 - Remote Power Switch:** System can be powered-on or off by this switch without using the main circuit breaker. In addition, system can be re-set with this switch after automatic power-off feature shuts the system down.

GENERAL INFORMATION

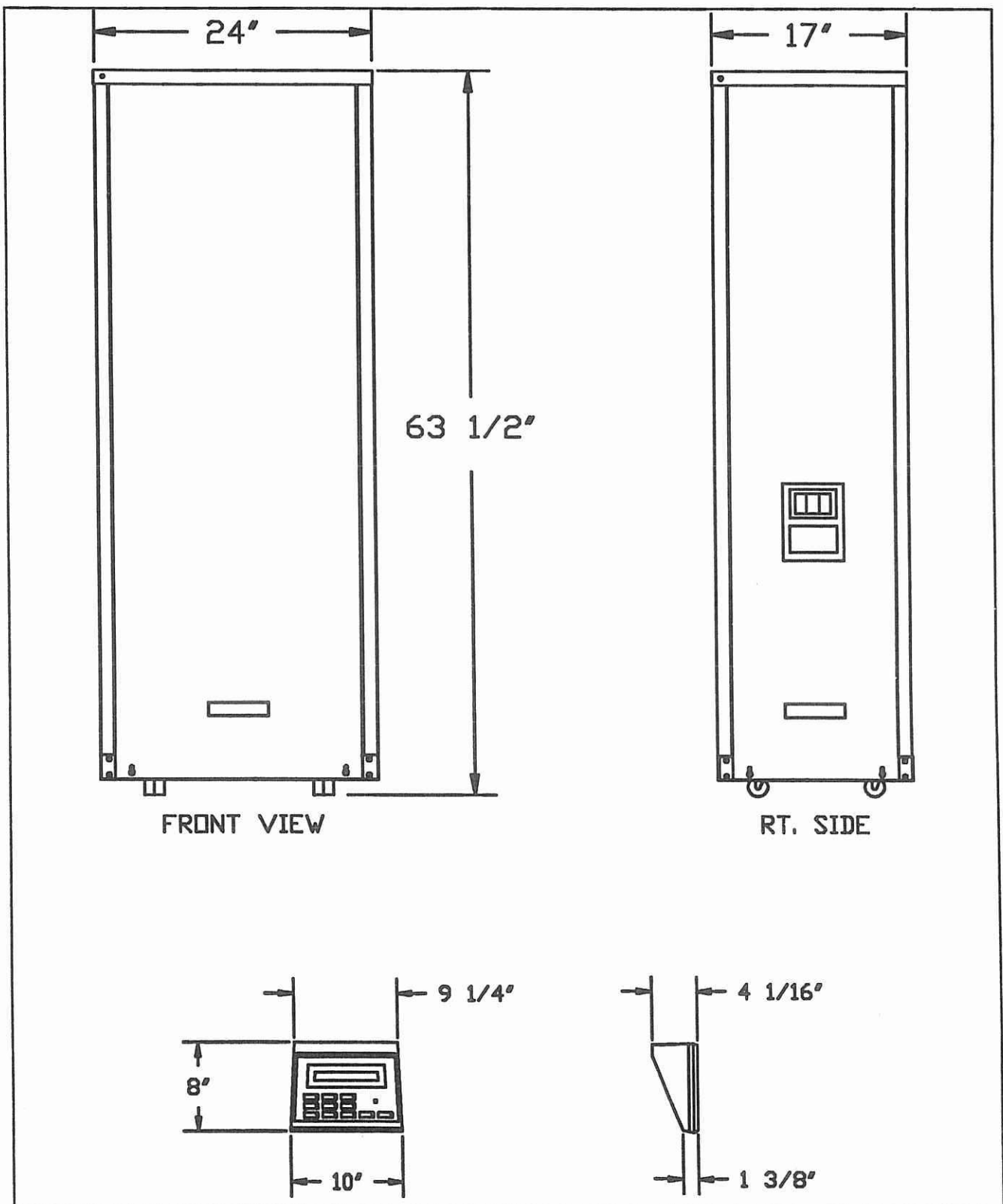


Figure 2-1. HFQ Series Generator and OCP Dimensions

GENERAL INFORMATION

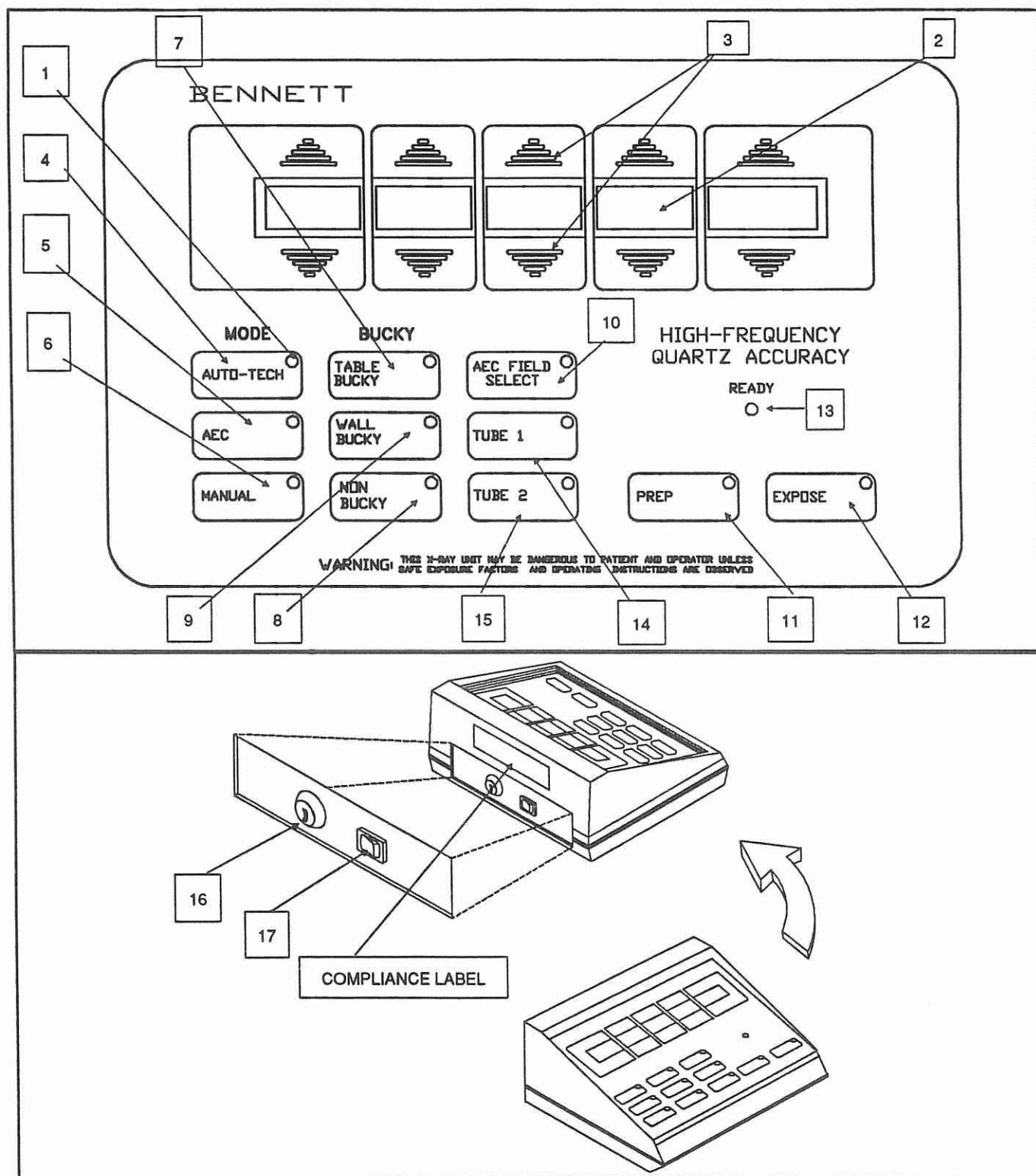


Figure 2-2. HFQ Series Operator Control Panel

**SECTION 3,
SYSTEM OPERATION**

**SECTION 3,
SYSTEM OPERATION**

OVERVIEW

This section provides the information necessary to operate the HFQ Series High-Frequency x-ray generator.

The following operating procedures are outlined and described in detail:

- Power on/off procedures
- Seasoning procedures
- Operating modes and selection: Auto-Tech, AEC and Manual
- Printing techniques

POWER ON/OFF PROCEDURES

The following are step-by-step procedures to power-on/off your system according to its status. There are three possible shut down states:

1. Complete Shut Down - The power switch and main circuit breaker were set to off. The power line might have been disconnected.
2. Remote Shut Down - The system was shut down with the remote ON/OFF power switch on the Operator Control Panel (OCP).
3. Automatic Shut Down - Power to the system was automatically disconnected (via internal timing circuit) after sixty minutes of inactivity.

TO POWER-ON YOUR SYSTEM:

From A Complete Shut Down

1. If necessary, connect the power line into the appropriate power receptacle.
2. Set the main circuit breaker on the system to the **ON** position.
3. Set the remote power switch (located on the OCP) to the **ON** position.
4. Continue with Power-On Self Test.

From A Remote Shut Down

1. Set the remote power switch to the **ON** position.
2. Continue with Power-On Self Test.

From An Automatic Shut Down

1. Set the remote power switch to **OFF**.
2. Wait five seconds and set the remote power switch to **ON**.
3. Continue with Power-On Self Test.

POWER-ON SELF TEST

When the HFQ Series generator system is first powered-on, "BENNETT X-RAY CORP." appears on the display while the system automatically runs a series of self checks to ensure proper operation. If an error is detected, the actual error (i.e., "DOOR?") will appear on the LCD. Upon successful completion of the self checks, the display will return to the last exposure setting that was used.

TO POWER-OFF YOUR SYSTEM:

For Short Periods Of Time -

1. Set the remote power switch on the OCP to the **OFF** position.
2. Ensure indicators are dark. System is now shut down.

For Long Periods Of Time -

1. Set remote power switch on the OCP to the **OFF** position.
2. Locate the main circuit breaker on the generator and set to the **OFF** position.
3. If desired, unplug the power line from the power receptacle or set the main power disconnect switch to the OFF position. System is now shut down.

AUTOMATIC POWER-OFF FEATURE

To help save power and protect system electronics when left unattended, the HFQ Series generator system is equipped with an automatic power-off feature that shuts down the unit.

After approximately sixty minutes of inactivity, the system will automatically power-off through software control, leaving all switches in the ON position.

An audible tone will be emitted for approximately 30 seconds before the system shuts down and "PRESS ANY KEY" will be displayed on the operator control panel.

To Abort The Automatic Power-off Feature - Press any key on the operator control panel.

To Re-start After Automatic Shut Down - Refer to Power-On Procedures.

DAILY SEASONING PROCEDURE

All tube manufacturers recommended seasoning procedures upon installation and daily warm-up. It is important that these procedures be performed to maintain both the tube manufacturers and **BENNETT** X-Ray's extended warranties. Refer to the tube manufacturers instructions. A typical daily seasoning procedure is provided below. This should be performed if the system is not used for several days. For longer periods or on installation, refer to tube manufacturers instructions.

SEASONING PROCEDURES

Take the exposures shown below using a 100 mA large focal spot and allow 30-seconds between exposures.

Table 3-1. Exposure Settings For Seasoning Procedures

EXPOSURE NUMBER	KVP	TIME (Seconds)
1	50	0.1
2	60	0.1
3	60	0.1
4	70	0.1
5	70	1.0
6	80	0.1
7	90	0.1
8	90	0.1
9	100	0.1
10	100	0.1
11	110	0.1
12	110	0.1

OPERATING MODES

The HFQ series can operate in four modes: Manual, Automatic Exposure Control (AEC), Auto-Tech and Auto-Tech with AEC.

- **MANUAL MODE** - requires manual calculation/selection of all x-ray techniques and exposure factors.
- **AEC MODE** - Automatic Exposure Control (optional) uses an ion chamber to ensure proper exposure times. Film density is selectable via key pad control through selection of AEC fields in use and pre-programmed film/screen combinations.
- **AUTO-TECH^R MODE** - (an exclusive BENNETT design) further enhances radiographic imaging by using a sonar Automatic Thickness Measuring (ATM) system (optional) to calculate the anatomical thickness of the Region Of Interest (ROI) and display the thickness (in cm) on the OCP. After a thickness measurement is entered (either manually or via optional ATM system), prior to exposure, the system automatically sets programmed x-ray techniques and exposure factors, including AEC mode (if available), tube selection, bucky selection, kVp, mA, and time. Programmed Auto-Tech settings can be modified at any time through the OCP, either in the actual stored program or for the current exam. During exposure the AEC (optional) works in conjunction with Auto-Tech to provide uniform, repeatable, high quality images with the smallest variation of optical density between patients.

SETTING UP TO TAKE EXPOSURES

All aspects of x-ray techniques are entered at the OCP. Prior to taking an exposure, MODE, BUCKY and TUBE must be selected. In addition, the displayed exposure factors (mA, Time, kVp and mAs) should be verified. When operating in Auto-Tech mode, all x-ray techniques and exposure factors are automatically entered for you. In Auto-Tech mode with the optional ATM system, anatomical thickness is also automatically calculated and entered.

PRE-EXPOSURE SELECTIONS

This procedure outlines step-by-step instructions to set up x-ray techniques and exposure factors prior to exposure. Since these procedures are mode and option dependant, refer to the appropriate operating mode to begin. A flow chart on the following page provides a graphic representation of the pre-exposure selection process. Selections are made by pressing the appropriate key on the OCP or the up/down arrows on the LCD portion of the LCD.

SYSTEM OPERATION

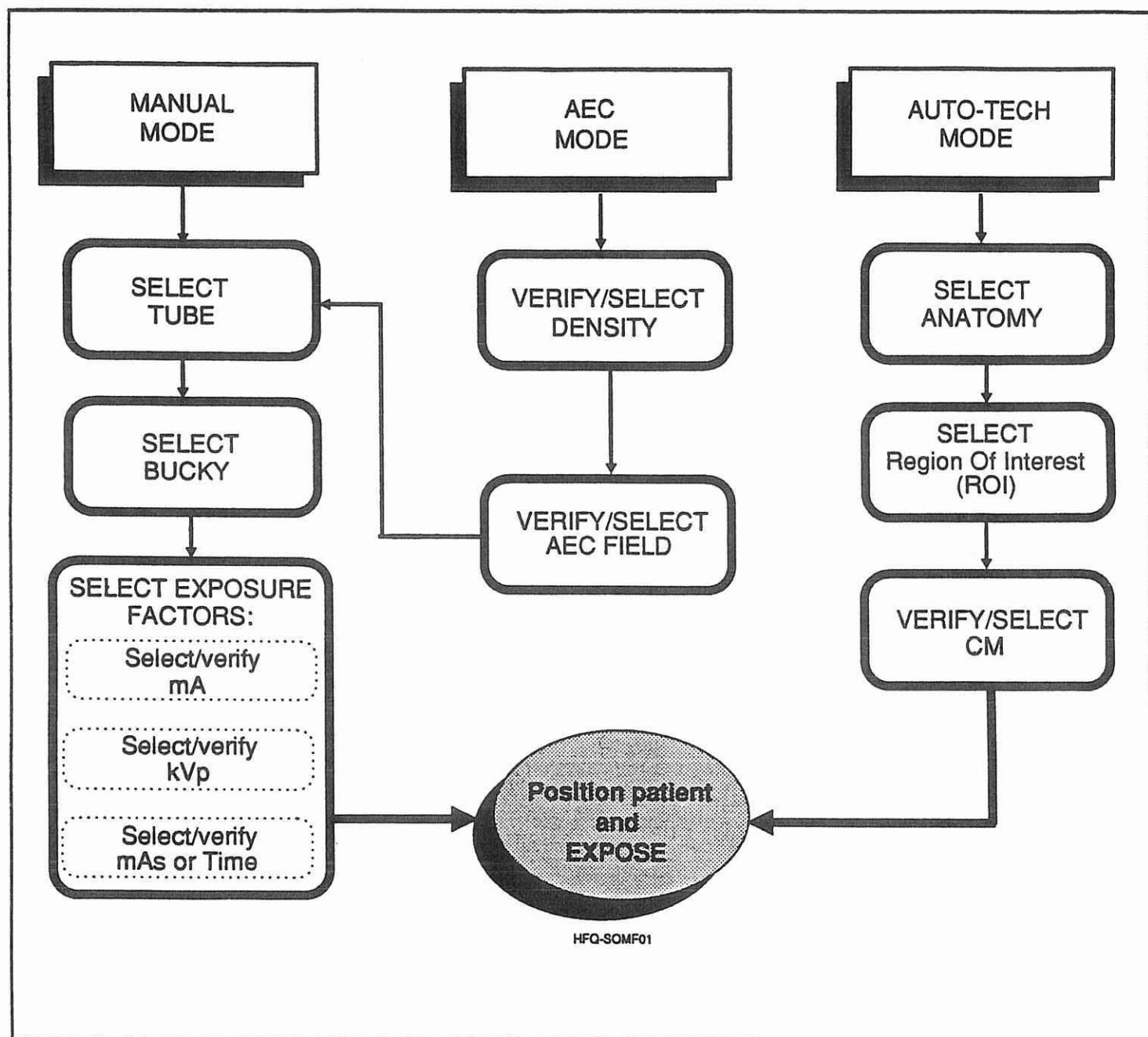


Figure 3-1. Mode Selection Flow Chart

Select An Operating Mode

There are four possible modes of operation, depending on the options selected with your system. The two basic modes are Auto-Tech and Manual. Automatic Exposure Control (AEC) can be used as a stand alone mode (by itself) or in conjunction with Auto-Tech.

1. Select a mode of operation by pressing the appropriate key;
AUTO-TECH **AEC** or **MANUAL** .
2. Once selected, ensure that the corresponding indicator is illuminated.
3. Continue with the required procedures as follows:
AUTO-TECH Selected - Go to Select Anatomy
AEC Selected - Go to Select Density
MANUAL Selected - Go to verify /Select Tube and Bucky

Select Anatomy

When Auto-Tech is selected, x-ray techniques and exposure factors are automatically set according to your specific program. An anatomy selection menu (example shown in figure 3-2, below) will be displayed on the LCD.

1. Select the appropriate anatomy by pressing the ☐ or ☐ sector key associated with the desired anatomy.

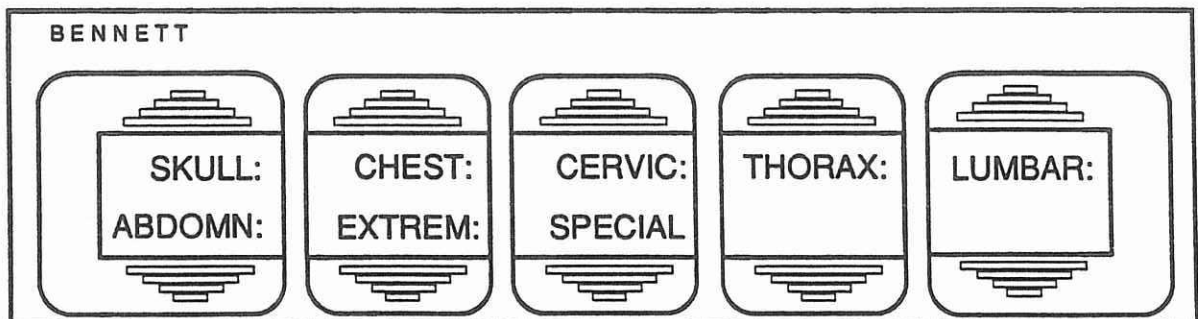


Figure 3-2. Auto-Tech Anatomy Selection Menu

Select an ROI

After anatomy selection is pressed, a selection of available Regions of Interest will be displayed.

1. Select the appropriate ROI by pressing the \wedge or \vee sector key associated with the desired ROI (see figure 3-3). ROI names and/or designations can be modified, added or deleted from the program as described in Section 8, Programming.

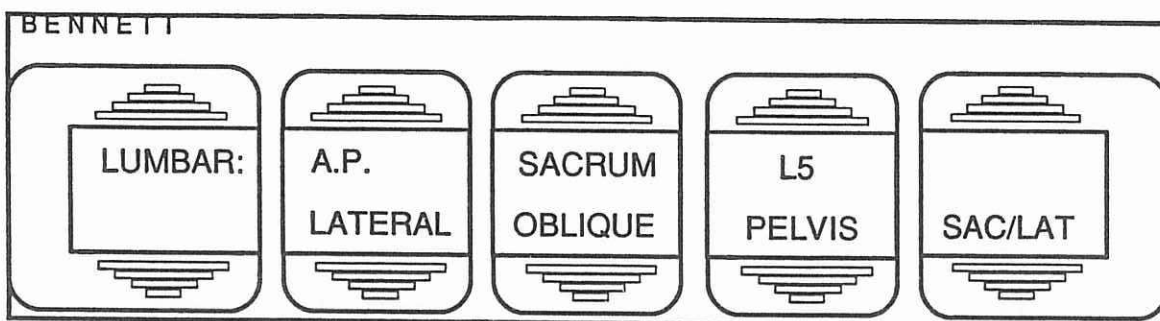


Figure 3-3. Region Of Interest (ROI) Selection Menu

Verify/Select Measurement

If your system is equipped with the optional ATM, thickness of the ROI (in cm) will be displayed automatically when the patient is positioned. In addition, selected SID is indicated by arrow as shown in figure 3-4.

1. If necessary, use the up/down sector keys on the LCD to increase or decrease the displayed cm. Initially, the CM value is set to 0. In Auto-Tech mode, press the down sector key to advance to first (smallest) cm value available, as set in the Auto-Tech program. When CM values are entered manually, an asterisk appears beside the value. This is referred to as the "FREEZE" value.
2. If AEC mode is available and you want it to be enabled in conjunction with Auto-Tech, press **AEC** and continue with Verify/Select Density. If not, continue with Enter/Verify CM.

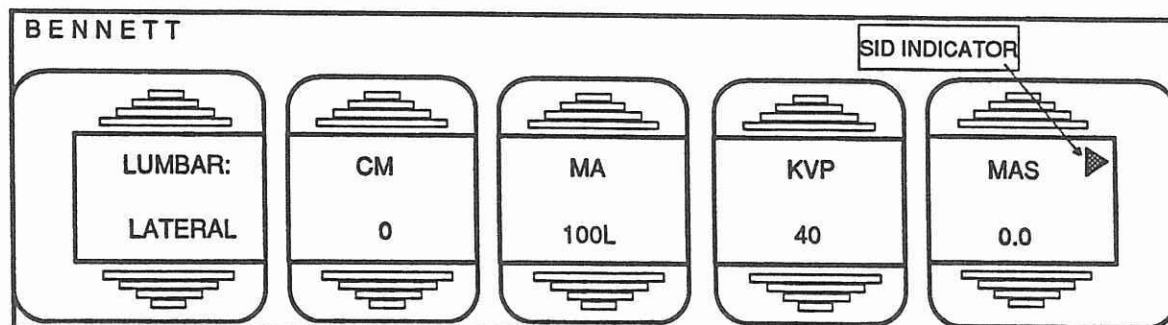


Figure 3-4. Initial Auto-Tech Menu (Non-ATM, AEC Off)

Verify/Select Density

When AEC mode is enabled, a segment of the LCD will display the currently selected film density setting and AEC field (example shown in figures 3-5 and 3-6). Density (DNS) and AEC field selection locations in the LCD depend upon the operating mode. In addition, the AEC FIELD SELECT indicator will be illuminated. Available density settings (DNS value) are from +5 to -5. The 0 (zero) setting is depicted as N (normal), which is the initial setting.

1. To increase or decrease density, press the Δ or ∇ sector keys in the DNS field, respectively. Each density step increases or decreases density by about 15%.

Verify/Select AEC Field

A configuration of three boxes depicted on the LCD (see figures below) displays currently selected fields. A shaded or hollow box indicates whether a field is used or unused, respectively.

Note: Ensure that the appropriate BUCKY mode is enabled prior to AEC FIELD selection.

1. To select a different AEC field, press **AEC FIELD SELECT** until the desired configuration is displayed. There are seven possibilities.

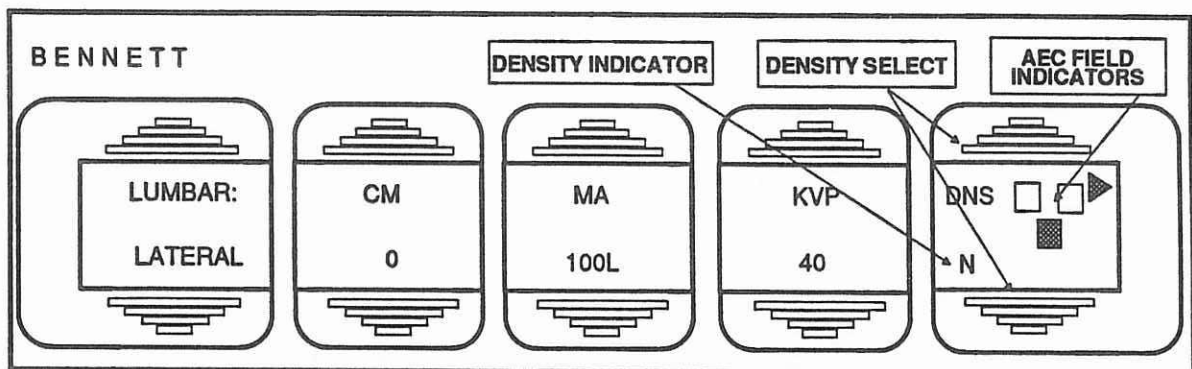


Figure 3-5. Auto-Tech Menu (AEC On, AEC Field Select)

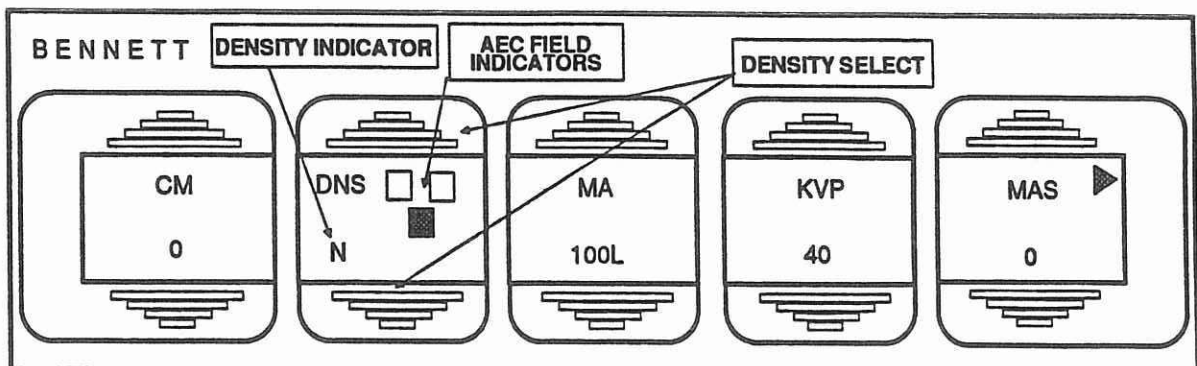


Figure 3-6. AEC Mode Enabled, Field Selection Settings

Verify/Select Tube and Bucky

When Auto-Tech mode is not selected, ensure that the proper tube is enabled (corresponding indicator illuminated).

1. If necessary, press **TUBE 1** or **TUBE 2** as required, and ensure that the associated indicator(s) are illuminated.
2. In any operating mode, verify that the appropriate BUCKY technique is selected (indicator illuminated).
3. If necessary, press the appropriate key: **WALL BUCKY**, **TABLE BUCKY** or **NON BUCKY**.
4. Continue with Verify/Select Exposure Factors

Verify/Select Exposure Factors

In Auto-Tech mode, exposure factors (Seconds, mA, kVp and mAs) are pre-programmed by your program. However, you can modify any displayed factor or enter your own for manual or AEC modes. Once you have verified that all x-ray techniques and exposure factors are correct, you can prepare to take an x-ray exposure.

Displayed exposure factor values (see example displays below) can be increased or decreased by pressing the respective \uparrow or \downarrow arrow keys associated with the factor. When techniques are modified from the original settings, up/down arrows are displayed next to the modified technique to indicate that its corresponding factor was increased or decreased, respectively. For example, as shown in figure 3-8, MA was increased, KVP was decreased and MAS was decreased. A manually selected CM value ("FREEZE" value) is indicated by an asterisk (as shown in figure 3-7).

Note: Values displayed are not necessarily correct techniques, they are used only as an example.

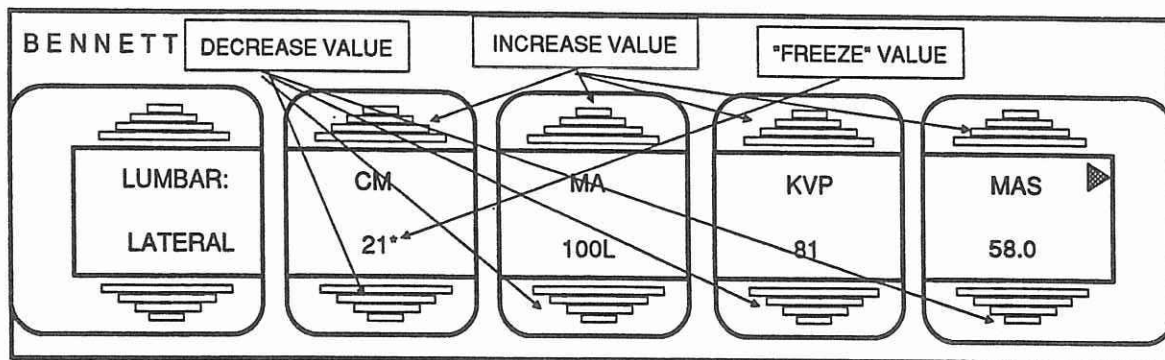


Figure 3-7. Initial Auto-Tech Menu, Manual CM Entry

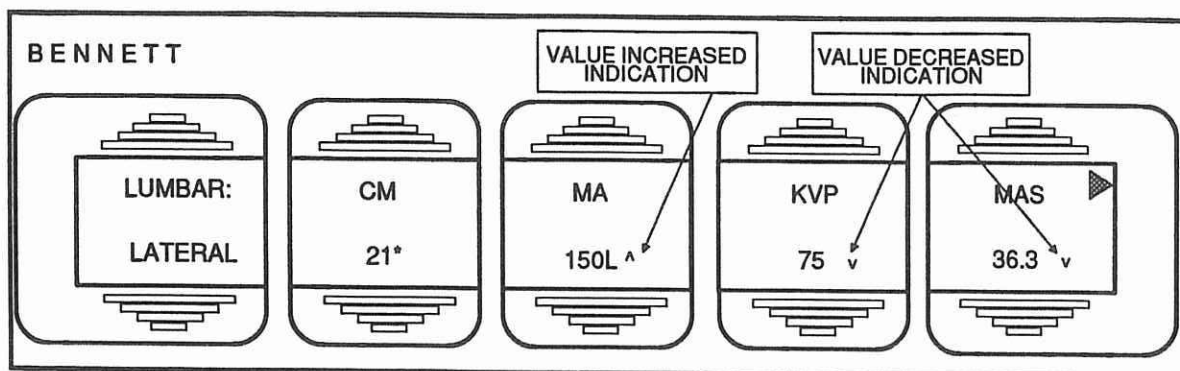


Figure 3-8. Auto-Tech Menu With Modified Techniques

PREPARING TO TAKE AN X-RAY EXPOSURE

After exposure factors have been verified as above, ensure that all other x-ray exposure precautions are met. If you have not already done so, position the patient accordingly and ensure that the patient is comfortable. Refer to Image Quality (page 3-12) for additional suggestions.

TAKING EXPOSURES

For Instantaneous Exposures:

1. Press and hold **PREP** until the PREP lamp is lit steady.
2. Press and hold **EXPOSE** until the exposure is complete (system will emit an audible tone).

For Delayed Exposures:

1. To take exposures that are delayed by approximately one and one-half seconds, press and hold the **EXPOSE** key as described above without using the PREP key.

FAULT RESET

When AEC mode is enabled, exposure time/termination is controlled via ionization chamber sensing circuits. In addition, a back-up time is pre-programmed into the system to help prevent excessive patient dose in the event of an AEC system malfunction. If the AEC exceeds the back-up time, exposure will be terminated and a fault/reset message will be displayed in the current FLM segment of the OCP display (example shown in figure 3-9). Press **RESET** to clear the fault. If the fault persists, the system may be used in manual mode until the fault can be isolated/corrected.

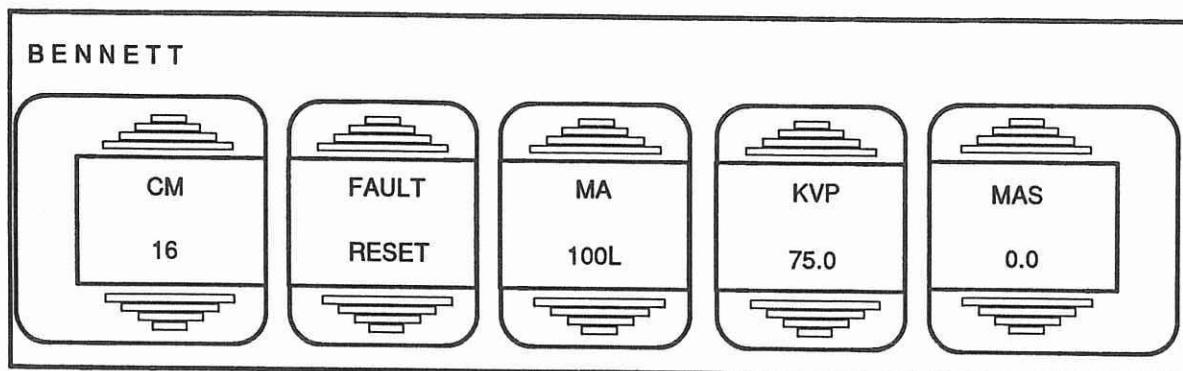


Figure 3-9. AEC Fault/Reset Display

TUBE HEATING DISPLAY

Prior to taking an exposure, the amount of tube anode heating (in thousands of heat units) will be displayed momentarily on the OCP display as KHU (example shown below). The stored anode heat units can be displayed at any time by pressing **PREP**.

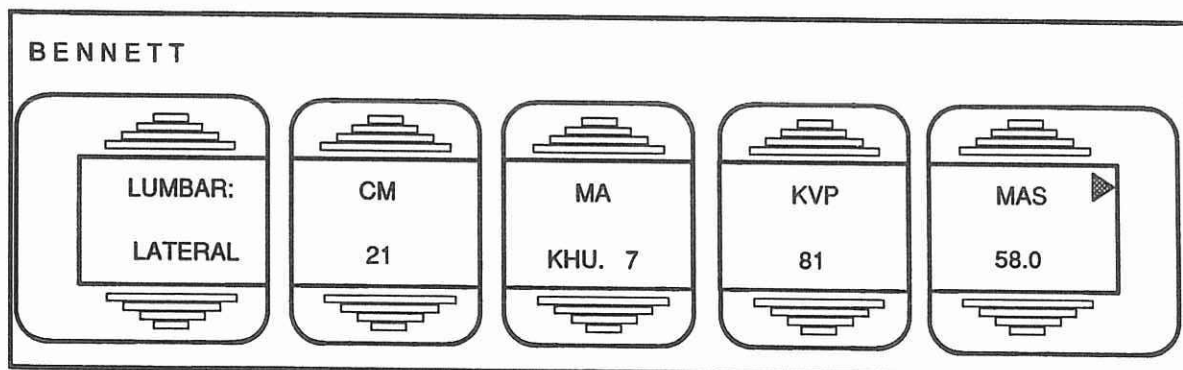


Figure 3-10. Tube Heating Display

IMAGE QUALITY

You should always keep in mind the following basic parameters to achieve the best results in diagnostic film quality:

- Make sure that your system is operating properly by scheduling routine quality assurance and preventive maintenance as required.
- Motion artifacts can be reduced by making the patient as comfortable as possible. Always treat the patient with the utmost care.
- Patient positioning is achieved by making sure the area of interest is on the film.
- Decreasing kVp value increases contrast.
- Increasing mAs value darkens the image.

PRINTER

If a printer is connected to the system, the techniques used will be printed at the end of each exposure. The exposure number, mode selected (anatomical region in Auto-Tech mode), thickness in cm, kVp, mA, and mAs are all displayed. Printer compatibility and connection procedures are described in Section 5, Installation.

A typical printout is shown below:

expos. #1669 LUMBAR: AP 27 CM 62.0 KVP 150L mA 48 mAs

***SECTION 4,
SYSTEM DIAGNOSTICS***

***SECTION 4, SYSTEM
DIAGNOSTICS***

OVERVIEW

This section is for system users or technicians to assist in locating and correcting minor system faults, should they occur. The majority of these faults can be corrected without a service technician. System faults that require the attention of a service representative are referenced in Section 9, Preventive Maintenance and Troubleshooting.

ERROR MESSAGES AND DESCRIPTIONS

When the unit will not fire, an audible alert will sound twice and one or more "error codes" will appear on the display.

Refer to the following descriptions for assistance in interpreting the fault code displayed on the Operator Control Panel:

BUCKY?	A bucky has been selected but it did not return the ready signal to start exposure or AEC is selected and no bucky has been selected.
CALIB?	The calibration data in the EEPROM is not correct.
DOOR?	The door interlock circuit is not closed.
FAULT?	Indicates that there is a problem with the AEC.
FILAM?	Indicates there is a problem with the filament or filament control circuit.
HYFOB?	(Hold Your Finger On Button) Exposure terminated prematurely because EXPOSE key was released before exposure was timed-out.
KVP?	Indicates a problem with the anode circuit or high voltage transformer.
KVP-C?	Indicates a problem with the cathode circuit or high voltage transformer.
LINE?	Indicates a problem with either the A.C. supply or line voltage monitor.
MASTR?	Problem with master EE Prom being copied from or to.
NO MA?	Control tried to take an exposure, but there was no tube current during exposure time.
PBL?	Positive beam limitation circuit is open. Check collimator.
PRNTR?	Indicates a problem exists between the control and the printer.
RETRY?	EEPROM program did not correctly save data. Try again or replace.

ERROR MESSAGES AND DESCRIPTIONS (Continued)

ROTOR?	Tube rotor is too hot or not getting correct current to start. Check rotor circuit.
S.E.S.?	Stored Energy Source voltage (displayed) is low.
TIMER?	A problem exists with the timer circuit.
TUBE OVERLOAD	Indicates that you have exceeded the tube maximum load capability. Reduce technique factors.
WAND?	Wand used in ATM option is in the wrong position.

POSSIBLE FAULTS

MAIN CIRCUIT BREAKER/SYSTEM CIRCUIT BREAKER ON AND OCP IS DARK

- Is the power line plugged into the receptacle or connected to the main circuit breaker ?
- Is there power at the receptacle or the main circuit breaker?
- Is the remote ON/OFF switch on the OCP in the ON position ?
- Auto Shut Off feature activated - If system was left unattended for 60 minutes or more, the Automatic Shut Off feature was activated. You can reset the system by setting either main or remote ON/OFF switch to OFF, then back to ON position. Refer to Section 3, System Operation for additional information.
- If any of the system checks outlined above do not solve the problem, refer to Section 9, Preventive Maintenance and Troubleshooting.

NO EXPOSURE

- Are any error messages displayed ?
- In areas where power is known to be erratic, or if a "brownout" or power reduction has taken place, it is prudent to check your input power.

PRINTER DOES NOT PRINT (OR DOES NOT PRINT PROPERLY)

- Is power on ?
- Is the printer connected to the system at the microprocessor board ?
- Is the cable attached to the printer ?
- Is the printer configured properly ? (Refer to Section 5, Installation.)
- Refer to the printer owner manual for switch configuration/troubleshooting.

IMAGE QUALITY

- Motion artifacts ? Relax the patient. Make the patient as comfortable as possible. Check once again for proper positioning.
- Is there not enough contrast ? Decrease kVp. Check the dark room, film expiration date, chemicals and developer temperature.

THICKNESS MEASUREMENT (CM VALUE)

- Incorrect readout? Check the thickness reference (refer to Section 8, Programming).