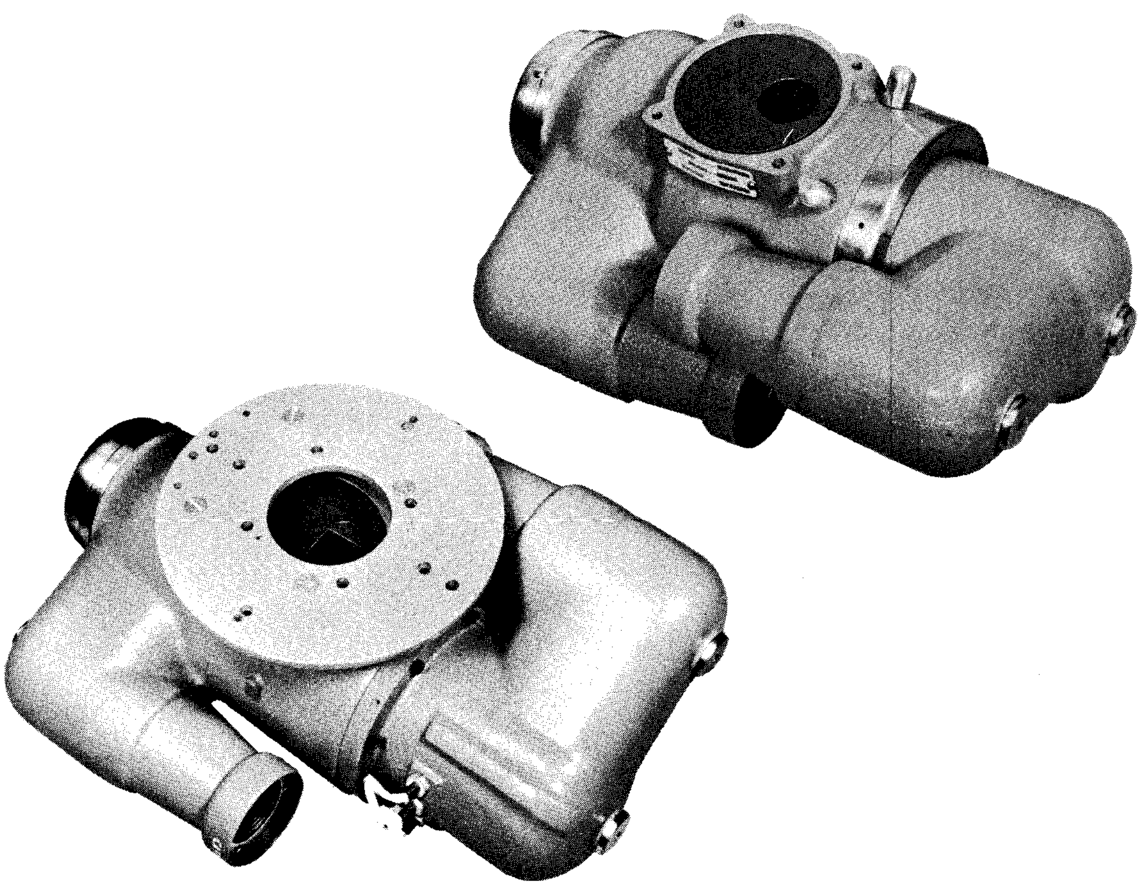
# PX-17 SERIES X-RAY TUBES

## PG215:F2 (T55-302)



**PICKER** X-RAY
A PICKER CORPORATION DIVISION
595 Miner Road, Cleveland, Ohio 44143 U.S.A.

Dec '68

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## RADIATION WARNING

X-Rays and Gamma-Rays are dangerous to both patient and operator unless established safe exposure procedures are strictly observed.

The useful beam can produce serious or fatal bodily injuries to any persons in the surrounding area if used by an unskilled operator. Adequate precautions must always be taken to avoid exposure to the useful beam, as well as to leakage radiation from within the source housing or to scattered radiation resulting from the passage of radiation through matter.

Those authorized to operate, participate in or supervise the operation of the equipment must be thoroughly familiar and comply completely with the currently established safe exposure factors and procedures described in the National Council on Radiation Protection and Measurements (NCRP) "Medical X-Ray and Gamma-Ray Protection for Energies up to 10 Mev — Equipment Design and Use" NCRP Report #33 as revised or replaced in the future.

Those responsible for the planning of X-Ray and Gamma-Ray equipment installations must be thoroughly familiar and comply completely with the structural shielding requirements outlined in NCRP #34 as revised or replaced in the future.

Failure to observe these warnings may cause serious or fatal bodily injuries to the operator, patient or those in attendance.

# CONTENTS





PG215:F2 • December 1968

## HOW TO USE THIS MANUAL

This manual provides complete descriptions, and installation instructions, as well as rating charts and an explanation of their proper use, for the PX-17 Series — a series of heavy-duty, rotating anode X-ray tubes designed for use at up to 125 kVp.

Where the material applies to all tubes in the series, it is grouped together. Specific data on each tube type, on the other hand, is presented on a series of separate sheets, permitting non-applicable sheets to be discarded when a manual relating to one type only is wanted. Installation information is supplied in a similar form so that it, too, may be discarded when the installation is complete.

Tube rating charts, which many customers like to mount near the X-ray control, are grouped conveniently on sheets to provide a neat, uniform display. Charts are provided for single-phase 60 Hz power supplies as well as for three-phase. Again, non-applicable charts may be discarded to avoid confusion.



## PX-17 SERIES X-RAY TUBES

For use up to 125 kVp, the PX-17 series of X-ray tubes are designed for a variety of applications where a heavy-duty rotating anode tube is required. An optional heat sensor is available with these tubes to provide positive indication of anode temperature at a remote location. Also, these tubes can be supplied optionally with a 175,000 HU anode heat storage capacity insert in place of the standard 140,000 HU capacity insert.

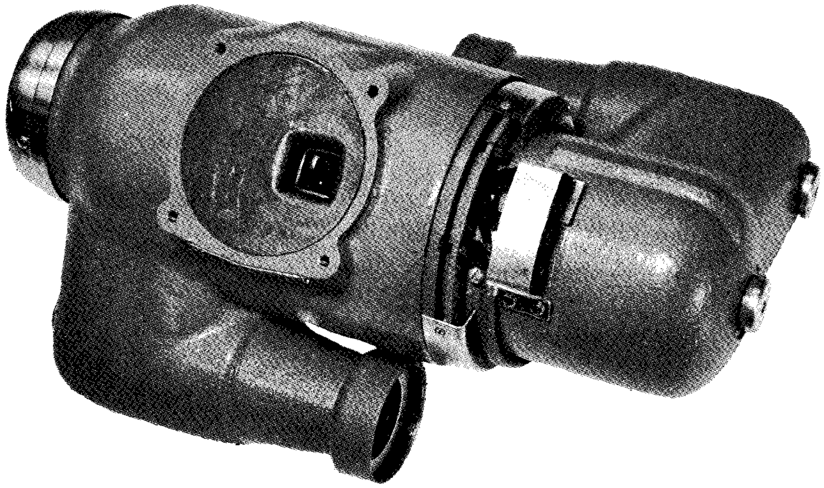
Each of the tubes in the PX-17 Series (PX-17A and PX-17B) differ in the way the cable terminals are oriented for the specific application.

## PX-17 SERIES APPLICATIONS AND OPTIONS

| WITH 140,000 HU ANODE STORAGE CAPACITY | | WITH 175,000 HU ANODE STORAGE CAPACITY | | PICKER EQUIPMENT APPLICATION |
|---|---|---|---|---|
| WITHOUT HEAT SENSOR | WITH HEAT SENSOR | WITHOUT HEAT SENSOR | WITH HEAT SENSOR | |
| PX-17A | PX-17AF | PX-17AH | PX-17AHF | Ceiling Tubemount (Catalog 6208, 6242 Series)<br>Twin Track Tubestands (Catalog 6210)<br>Bi-Rail Tubestands (Catalog 6213 Series) |
| PX-17B | PX-17BF | PX-17BH | PX-17BHF | Constellation II Type Tables<br>Satellite Tables (Catalog 6200 Series)<br>Cardiac Tables (Catalog 6160 Series) |

**PICKER** X-RAY
*TUBE DATA*

# PX-17A, PX-17AF, PX-17AH, PX-17AHF X-RAY TUBE UNIT



## DESCRIPTION

The PX-17A, PX-17AF, PX-17AH and PX-17AHF are heavy-duty, 125 kVp rotating anode X-ray tubes especially designed for the Picker Cat. 6208 and 6242 Series Ceiling Tubestands, Cat. 6210 Twin Track Tubestands and Cat. 6213 Series Bi-Rail Tubestands. The PX-17AF is the same as the PX-17A but includes a Picker heat sensing device.

The PX-17AH tube is provided with a high heat (175,000 HU anode heat storage capacity) insert; the PX-17AHF is the same as the PX-17AH but includes a heat sensing device.

## FEATURES

Conservatively Rated
For voltages up to 125 kVp for single- or three-phase operation.

Universal-Type Tube Housing
Opposed parallel cable terminals to provide neat cable drape and minimum cable drag for overtable use.

High-Voltage Cable Terminals
Conform to American Standard C86.1 and Federal Standard No. 72.

Superimposed Focal Spots
1.0 and 2.0mm Standard.
Optional for PX-17AH and PX-17AHF
0.5 and 1.5mm
0.7 and 2.0mm
0.3 and 1.0mm - 10° target

Picker Heat Sensing Device
(In PX-17AF or PX-17AHF tube units and requires 3684C heat indicator.) Responds to anode heat to warn of excessive anode temperature.

Complete Factory Replacement Units
Entire unit supplied ready for installation.

## CONSTRUCTION

Shockproof Housing
The hermetically sealed cast bronze and brass housing, with transparent port, encloses the X-ray tube, stator assembly and expansion bellows. These bellows allow the special insulating oil to expand and contract over the full range of operating temperatures of the X-ray tube.

1

Rayproofing
In accordance with Bureau of Standards Handbook 76 and NCRP Report #33.

Minimum Ambient Temperature
15° Fahrenheit.

Finish
Gray-green enamel with chrome trim.

Tube Insert
Envelope: Hard glass with window of controlled thickness.
Anode: Solid tungsten disk or rhenium tungsten faced molybdenum target supported by a molybdenum stem on a specially designed copper rotor and bearing structure.
Cathode: Line focus, double element, tungsten filaments (one element for each focal spot).
Focal Spots
For PX-17A, PX-17AF tubes:
1.0 and 2.0mm Standard with T40K-113 insert.

For PX-17AH, PX-17AHF tubes:
1.0 and 2.0mm Standard with T40K-73 insert.

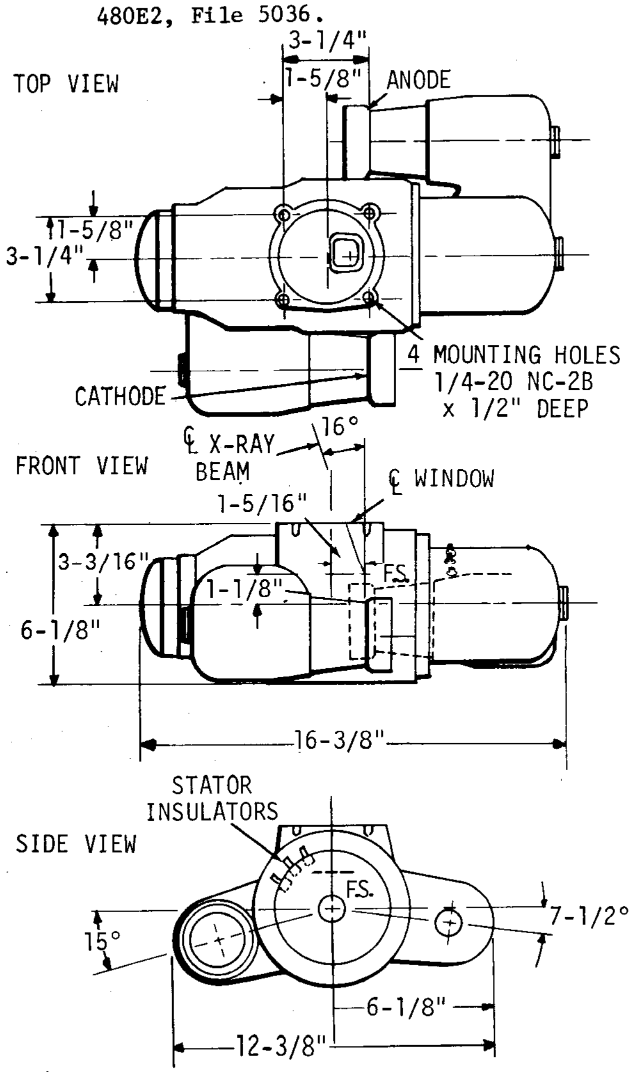
0.7 and 2.0mm Optional with T40K-71 insert.
0.5 and 1.5mm Optional with T40K-116 insert.
0.3 and 1.0mm 10° target optional with T40K-120 insert.

X-Ray Coverage - 17° target
17° from central ray with cutoff at 15° by anode heel, completely covering a 17x17 square inch area or a 21-inch diameter circle at a 40-inch target-to-film distance.

Total Inherent Filtration
Approximately 1.0mm aluminum equivalent at 100 kVp.

Weight
44 pounds (tube only less cables) to be counterbalanced.

Listings
Underwriters Laboratories Guide 480EO File E7063A.
Canadian Standards Association Guide 480E2, File 5036.




Specifications subject to change.

Optional Items
Cat. 3684C Heat Indicator for both over- and undertable tubes.
Cat. 1252S Blower for overtable tube.

## RATINGS

Maximum Voltage
125 kVp rectified. Maximum voltage to ground: 62.5 kVp rectified.

Radiographic Ratings
In accordance with rating charts. *For a succession of exposures, total energy input within a given time interval is limited by the thermal characteristics of the tube anode and of the complete unit.*

Angio Ratings
In accordance with angio rating charts and calculation procedure.

Thermal Ratings—*For PX-17A, PX-17AF*
Heat Storage Capacity
Anode: 140,000 HU (Heat Units).*
Housing: 1,250,000 HU.
Heat Dissipation (Maximum Cooling Rate)
Anode: 40,000 HU per minute.
Housing:
Without air circulation: 15,000 HU per minute.
With air circulation: 30,000 HU per minute.

Thermal Ratings—*For 17-AH, PX-17AHF*
Heat Storage Capacity
Anode: 175,000 HU (Heat Units).*
Housing: 1,250,000 HU.
Heat Dissipation (Maximum Cooling Rate)
Anode: 40,000 HU per minute.
Housing:
Without air circulation: 15,000 HU per minute.
With air circulation: 30,000 HU per minute.

Filament Ratings

| FOCAL SPOT | VOLTS | AMPERES |
|---|---|---|
| 0.5mm | 2.3 to 5.6 | 3.5 to 5.5 |
| 0.7mm | 2.6 to 6.0 | 3.5 to 5.5 |
| 1.0mm | 3.0 to 8.5 | 3.5 to 5.5 |
| 1.5mm | 3.5 to 10.5 | 3.5 to 5.5 |
| 2.0mm | 4.0 to 12.0 | 3.5 to 5.5 |

*HU = kVp x mA x Seconds

Anode Motor Ratings

| STARTING | | | RUNNING | | |
|---|---|---|---|---|---|
| Volts | Amps. | Secs. Delay | Volts | Amps. | R.P.M. |
| 115 | 4.0 | 1.0 | 40 | 1.4 | 3400 |
| 230 | 8.0 | 1/2 | 40 | 1.4 | 3400 |

(NOTE: For 60-Hz operation.)

The 230-volt start produces approximately 2400 HU per second in the housing.

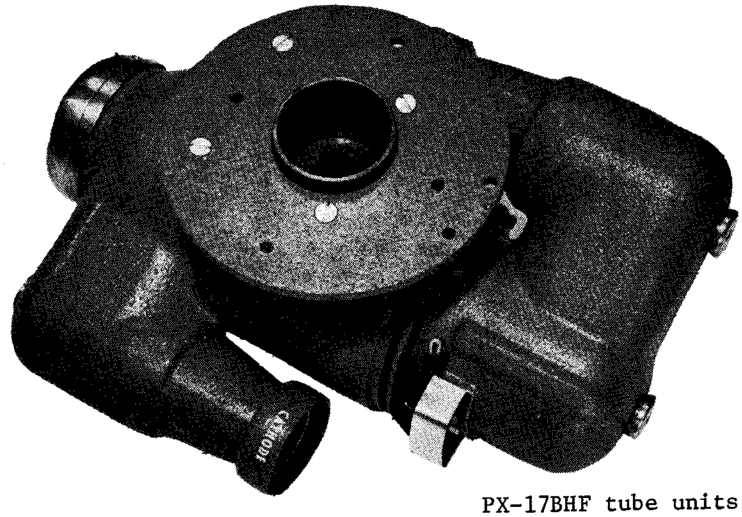
The 115-volt start produces approximately 640 HU per second.

The 40-volt running voltage produces approximately 75 HU per second.

3

# PICKER X-RAY *TUBE DATA*

# PX-17B, PX-17BF, PX-17BH, PX-17BHF X-RAY TUBE UNIT




## DESCRIPTION

The PX-17B, PX-17BF, PX-17BH and PX-17BHF are heavy-duty, 125 kVp rotating anode X-ray tubes especially designed for the Picker Constellation II type diagnostic tables, Cat. 6200 series Satellite tables, and Cat. 6160 series Cardiac tables—replacing the PX-12 series of tubes. The PX-17BF is the same as the PX-17B but includes a Picker heat sensing device.

The PX-17BH tube is provided with a high heat (175,000 HU anode heat storage capacity) insert; the PX-17BHF is the same as the PX-17BH but includes a heat sensing device.

## FEATURES

Conservatively Rated
  For voltages up to 125 kVp for single- or three-phase operation.

Universal-Type Tube Housing
  Opposed parallel cable terminals to provide neat cable drape, minimum cable drag and maximum travel in undertable applications.

High-Voltage Cable Terminals
  Conform to American Standard C86.1 and Federal Standard No. 72.

Superimposed Focal Spots
  1.0 and 2.0mm Standard.
  Optional for PX-17BH or PX-17BHF
    0.5 and 1.5mm
    0.7 and 2.0mm
    0.3 and 1.0mm 10° target

Picker Heat Sensing Device
  Responds to anode heat to warn of excessive anode temperature. (In PX-17BF or PX-17BHF tube units and requires 3684B or 3684C heat indicator.)

Complete Factory Replacement Units
  Entire unit supplied ready for installation.

## CONSTRUCTION

5

Shockproof Housing
  The hermetically sealed cast bronze and brass housing, with transparent port, encloses the X-ray tube, stator assembly and expansion bellows. These bellows allow the special insulating oil to expand and contract over the full range of operating temperatures of the X-ray tube.

Rayproofing
  In accordance with Bureau of Standards Handbook 76, and NCRP #33.

Minimum Ambient Temperature
  15° Fahrenheit.

Finish
  Gray-green enamel with chrome trim.

Tube Insert
  Envelope: Hard glass with window of controlled thickness.
  Anode: Solid tungsten disk or rhenium tungsten faced molybdenum target supported by a molybdenum stem on a specially designed copper rotor and bearing structure.
  Cathode: Line focus, double element, tungsten filaments (one element for each focal spot).
  Focal Spots
    For PX-17B, PX-17BF tubes:
      1.0 and 2.0mm Standard with T40K-113 insert.

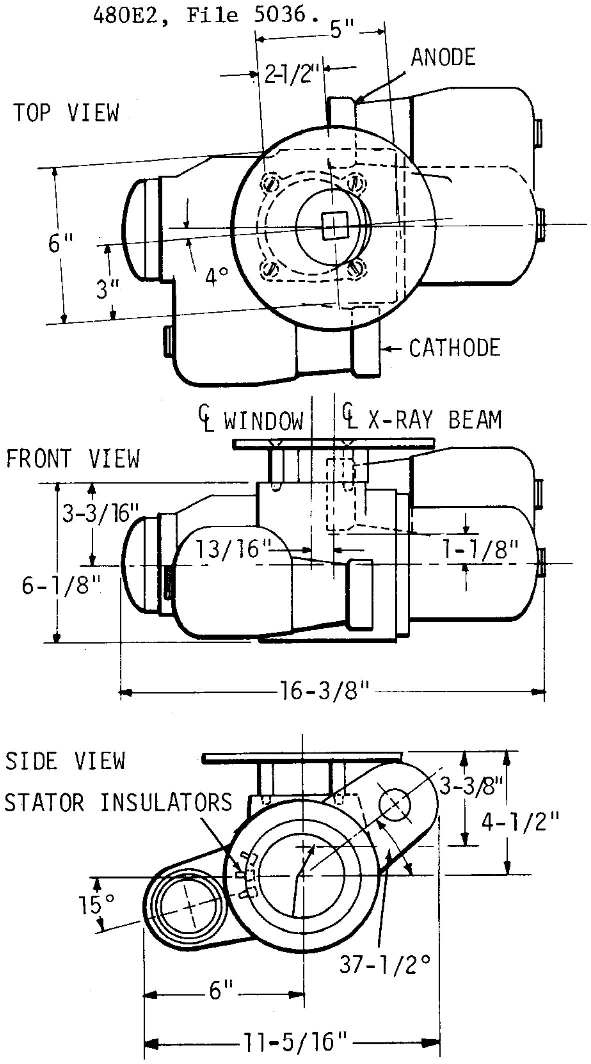
For PX-17BH, PX-17BHF tubes:
- 1.0 and 2.0mm Standard with T40K-73 insert.
- 0.7 and 2.0mm Optional with T40K-71 insert.
- 0.5 and 1.5mm Optional with T40K-116 insert.
- 0.3 and 1.0mm 10° target optional with T40K-120 insert.

X-Ray Coverage - 17° target
17° from central ray with cutoff at 15° by anode heel.

Total Inherent Filtration
Approximately 1.0mm aluminum equivalent at 100 kVp.

Weight
44 pounds (tube only less cables) to be counterbalanced.

Listings
Underwriters Laboratories Guide 480E0 File E7063A.
Canadian Standards Association Guide 480E2, File 5036.




Specifications subject to change.

Optional Items
- Cat. 3684B Heat Indicator for undertable tube.
- Cat. 3684C Heat Indicator for both over- and undertable tubes.
- Cat. 1252R Blower for undertable tube in Galaxy and Citation tables.

## RATINGS

Maximum Voltage
125 kVp rectified. Maximum voltage to ground: 62.5 kVp (rectified).

Radiographic Ratings
In accordance with rating charts. *For a succession of exposures, total energy input within a given time interval is limited by the thermal characteristics of the tube anode and of the complete unit.*

Cine Ratings
In accordance with cine rating charts and calculation procedure.

Fluoroscopic Ratings
Without air circulation: 500 HU/second, full-wave rectified for 30 minutes continuously, starting with tube unit cold; alternate periods of 10-minutes off, 10-minutes on thereafter.
With air circulation: 500 HU/second full-wave rectified, continuous indefinitely.

*The 0.3, 0.5 and 0.7mm focal spots require rotor rotation for above ratings.*

Thermal Ratings—*For PX-17B, PX-17BF*
- Heat Storage Capacity
  - Anode: 140,000 HU (Heat Units).*
  - Housing: 1,250,000 HU.
- Heat Dissipation (Maximum Cooling Rate)
  - Anode: 40,000 HU per minute.
  - Housing:
    - Without air circulation: 15,000 HU per minute.
    - With air circulation: 30,000 HU per minute.

Thermal Ratings—*For PX-17BH, PX-17BHF*
- Heat Storage Capacity
  - Anode: 140,000 HU (Heat Units).*
  - Housing: 1,250,000 HU.
- Heat Dissipation (Maximum Cooling Rate)
  - Anode: 40,000 HU per minute.
  - Housing:
    - Without air circulation: 15,000 HU per minute.
    - With air circulation: 30,000 HU per minute.

*HU = kVp x mA x Seconds

Filament Ratings

| FOCAL SPOT | VOLTS | AMPERES |
|---|---|---|
| 0.5mm | 2.3 to 5.6 | 3.5 to 5.5 |
| 0.7mm | 2.6 to 6.0 | 3.5 to 5.5 |
| 1.0mm | 3.0 to 8.5 | 3.5 to 5.5 |
| 1.5mm | 3.5 to 10.5 | 3.5 to 5.5 |
| 2.0mm | 4.0 to 12.0 | 3.5 to 5.5 |

Anode Motor Ratings

| STARTING | | | RUNNING | | |
|---|---|---|---|---|---|
| Volts | Amps. | Secs. Delay | Volts | Amps. | R.P.M. |
| 115 | 4.0 | 1.0 | 40 | 1.4 | 3400 |
| 230 | 8.0 | 1/2 | 40 | 1.4 | 3400 |

(NOTE: For 60-Hz operation.)

The 230-volt start produces approximately 2400 HU per second in the housing. The 115-volt start produces approximately 640 HU per second. The 40-volt running voltage produces approximately 75 HU per second.

7

## Section 2
# INSTALLATION

This section is for the guidance of the serviceman installing the X-ray tube and may be discarded after the tube has been installed.

### UNPACKING AND INSPECTION

Unpack the tube unit and check the nameplate for correct type and focal spot size. Inspect for shipping damage by listening for a gurgling or rattling noise when the housing is upended; examine the housing for external damage, oil leakage, etc.; and report to the carrier if necessary.

### MOUNTING

Mount the tube unit in the table, on the tubestand, etc., as described in the instructions accompanying the X-ray apparatus. *Make sure that the proper filter is in place—no less than 2.5mm of Al. equivalent.* Connect the rotor cable and the shockproof cables.

### REPLACEMENT

This tube unit may be part of a complete new installation or it may be the replacement for a tube that has failed. In the latter case, it is necessary to determine whether the failure was after a normal life before risking the new tube by operating it under the same conditions which could have caused the previous failure. The following procedure is recommended:

1. Discuss the failure with the operator to determine the type of failure, factors used at the time, indications of failure, etc.
2. Inspect the tube for air in the housing, oil leakage, spark-over in cable receptacles, open in stator cable—all of which could have made the unit inoperative without damaging the tube.
3. Inspect the tube insert through the port. If filled with oil, a puncture, generally caused by overload, has occurred. A broken insert could be caused by careless handling. Excessive tungsten deposit on the envelope generally is from target overload, but could also be from excessive filament evaporation.
4. Surface cracks, a warped or cracked target, or a continuously melted band on the target are evidences of overload. Stationary melted spots could be caused by an open in the stator circuit or by defective bearings.

### STORAGE AND SEASONING

Seasoning of rotating anode tubes prior to operation is not mandatory unless specifically indicated. However, some benefits will be derived from seasoning even the best of high-vacuum tubes, and the procedure is recommended especially in cases where tubes have been stored or inoperative for long periods of time.

Generally, proceed as follows:

Adjust the mA to approximately the maximum continuous fluoroscopic value for the maximum rated kVp. Starting at 60 percent of the maximum rated kVp, gradually increase the kVp in 5 to 10 kVp steps until reaching the maximum rated voltage. As the maximum kVp is approached, more time should be spent at each kVp step. For example, operate for a longer period between 90 percent and 100 percent rated voltage than between 60 percent and 90 percent. The longer the time a tube has been idle, the longer the seasoning interval should be. Tubes in storage for more than six months will often benefit from seasoning periods of one-half hour or longer.

Should there be any instability of mA during seasoning, reduce the kVp until the instability disappears. Then raise the kVp at a slower rate than previously.

Do not attempt to season a tube unit in which arcing occurs through the oil in the tube housing. Such arcing is usually audible as cracking, spitting or hissing sounds which become louder and more frequent as the kVp is raised.

**CAUTION**

THE MOST COMMON CAUSE OF PREMATURE FAILURE IS OVERLOAD, EITHER FROM OPERATION BEYOND THE TUBE RATING OR FROM AN EXCESSIVE NUMBER OF EXPOSURES WITH INSUFFICIENT COOLING INTERVALS.

**WARNING**

10

BEFORE PROCEEDING WITH THE FOLLOWING FILAMENT AND/OR ROTOR OPERATION CHECKS, MAKE ABSOLUTELY CERTAIN THAT THE HIGH TENSION TRANSFORMER PRIMARY WIRING HAS BEEN DISCONNECTED TO PREVENT ANY POSSIBILITY OF X-RAYS BEING EMITTED WHICH CAN RESULT IN SERIOUS OR FATAL BODILY INJURIES TO THE OPERATOR AND OTHER PERSONS IN THE SURROUNDING AREA.

## FILAMENT CHECK

Check that the proper filament (large or small focal spot) is lighted at each monitor position, including fluoroscopy and spot or cine radiography.

## ROTOR OPERATION CHECK

Energize the rotor and check that it rotates counterclockwise when looking into the tube port from the cathode end. See that the starting time delay is correct (usually between 3/4- and 1-second) and that the stator voltage drops to between 40 and 50 volts when the rotor is to be operated for fluoroscopy (necessary for 0.3, 0.5 and 0.7mm focal spots, desirable for the larger focal spot sizes). See that the X-ray and valve tube filaments boost (on modern equipment), that an exposure can be made after the time delay, and that the rotor coasts for at least 25 seconds after the stator has been de-energized. Disconnect a stator cable lead, and check that the safety circuit will prevent an exposure with the rotor stationary regardless of the monitor or high-tension switch positions.

## ADJUSTMENT AND CALIBRATION

**WARNING**

WHEN CALIBRATING THE OVERTABLE TUBE, CLOSE THE COLLIMATOR, AND EITHER DIRECT THE X-RAY BEAM AWAY FROM THE OCCUPANTS OR POSITION THE X-RAY TUBE ON THE TABLE TOP WITH THE BEAM DIRECTED DOWNWARD.

CLOSE THE SHUTTERS AND CHECK THAT THE BUCKY SLOT COVER IS IN PLACE WHEN CALIBRATING THE UNDERTABLE TUBE. SHOULD IT BE NECESSARY TO CENTER THE X-RAY TUBE OR ADJUST THE SHUTTERS WHERE X-RADIATION IS NECESSARY, WEAR FLUOROSCOPIC GLOVES AND APRON AND TAKE PRECAUTIONS TO AVOID EXPOSURE TO THE RADIATION.

FAILURE TO COMPLY WITH THE FOREGOING MAY CAUSE SERIOUS OR FATAL BODILY INJURIES TO THE OPERATOR AND OTHER PERSONS IN THE SURROUNDING AREA.

Reconnect the high-tension primary leads. Before calibrating the X-ray tube, heat the anode by making exposures on the large focal spot at low mA settings; for example, 80 kVp at 4 mA for 5 minutes, or 70 kVp at 25 mA for 10 seconds on, 10 seconds off until the target is slightly red. Allow the X-ray tube to cool for at least five minutes before proceeding with the calibration.

**WARNING**

WHEN OPERATING WITH EXPOSED HIGH TENSION CONNECTIONS, BE SURE THAT THE HIGH-TENSION LEADS ARE MOUNTED ON A SUBSTANTIAL, WELL-INSULATED SUPPORT AND ARE AT LEAST 12-INCHES FROM GROUND AND MORE THAN THREE FEET FROM THE SERVICEMAN TO AVOID ANY ACCIDENTAL CONTACT WITH HIGH VOLTAGE WHICH CAN RESULT IN SERIOUS OR FATAL BODILY INJURIES TO THE OPERATOR.

The mA should be calibrated following the procedure outlined in the instructions for the X-ray unit using high tension mA and mAs meters (unless the control meters are known to be sufficiently accurate).

It is particularly necessary to check the fluoroscopic mA against an mA meter in the high-tension circuit to correct for shock-proof cable capacity.

The kilovoltage calibration of the X-ray generator should be checked following the procedure included in instructions for the X-ray unit using the proper calibration curve.

**CAUTION**

OBSERVE THE TUBE RATINGS, PARTICULARLY THE FREQUENCY OF EXPOSURE, SO THAT THE TUBE WILL NOT BE DAMAGED DURING CALIBRATION. AT NO TIME SHOULD THE FILAMENT CURRENT RATINGS BE EXCEEDED.

If the tube unit is being installed on an obsolete or competitive generator, it may be necessary to check the kilovoltage or establish a calibration curve at each milliamperage range using a sphere gap or other method. Due to filament evaporation with use of the tube, the milliamperage calibration should be *checked periodically* and revised as required.

11

Section 3

# PX-17A, PX-17AF, PX-17B, PX-17BF

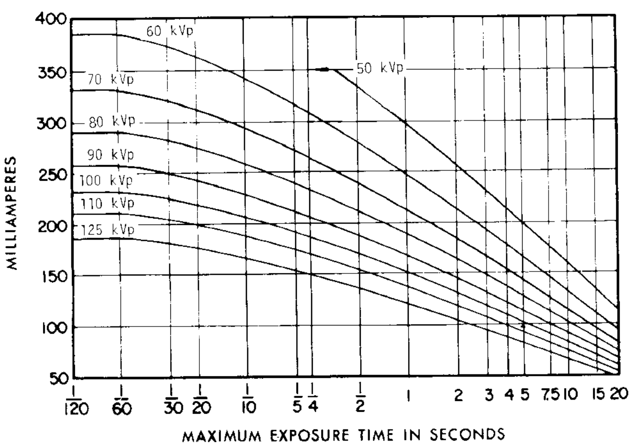
## X-RAY TUBE RATING CHARTS

### 140,000 HU ANODE HEAT STORAGE CAPACITY

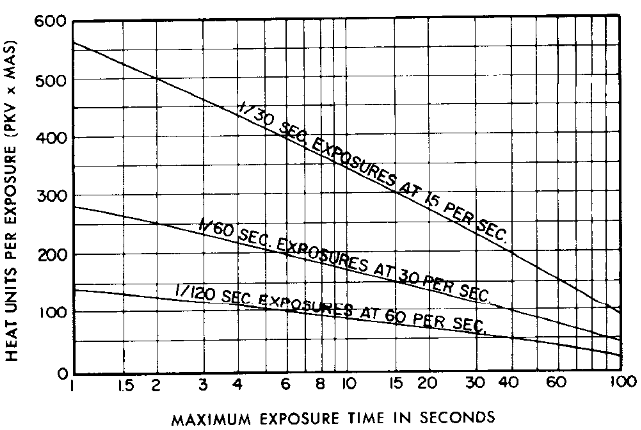
### ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - SINGLE-PHASE

## 1.0 mm. FOCAL SPOT

### RADIOGRAPHIC

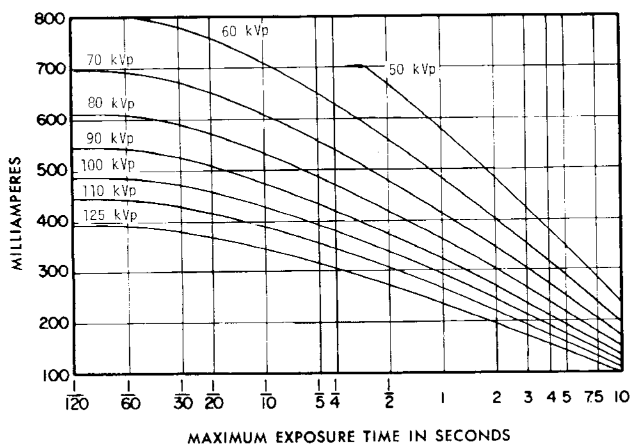



### CINERADIOGRAPHIC




## 2.0 mm. FOCAL SPOT

### RADIOGRAPHIC

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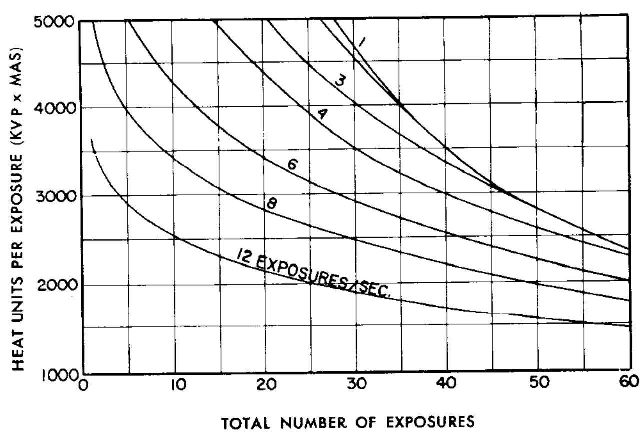





## USE OF CHARTS

1. Use these charts only if you have a PX-17A, PX-17AF, PX-17B, PX-17BF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, single-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17A, PX-17AF, PX-17B, PX-17BF

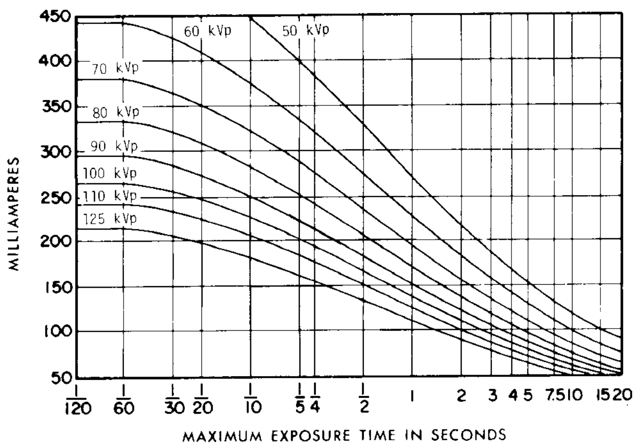
## X-RAY TUBE RATING CHARTS

**140,000 HU ANODE HEAT STORAGE CAPACITY**

**ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - THREE-PHASE**

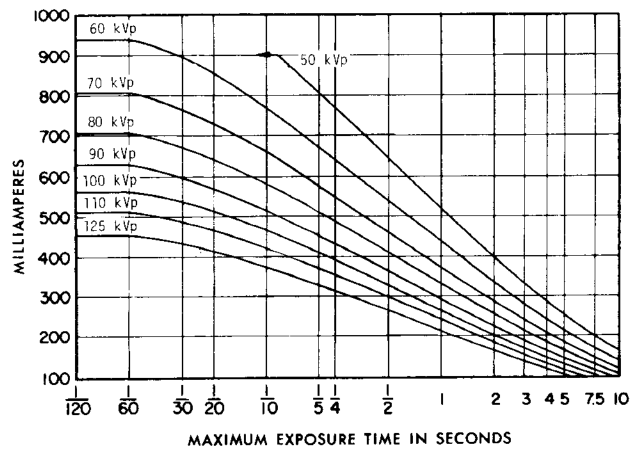
## 1.0 mm. FOCAL SPOT

### RADIOGRAPHIC



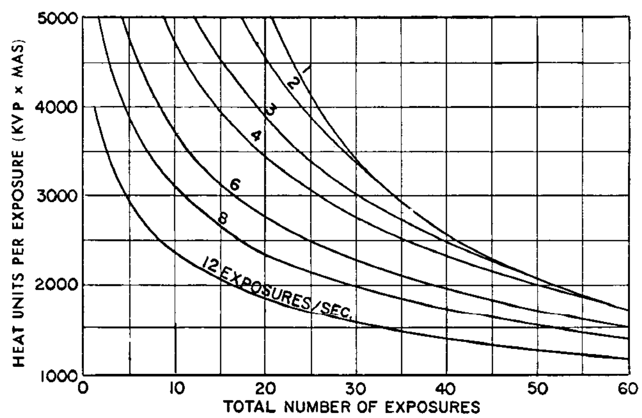

## 2.0 mm. FOCAL SPOT

### RADIOGRAPHIC




14

### ANGIOGRAPHIC




## USE OF CHARTS

1. Use these charts only if you have a PX-17A, PX-17AF, PX-17B, PX-17BF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, three-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

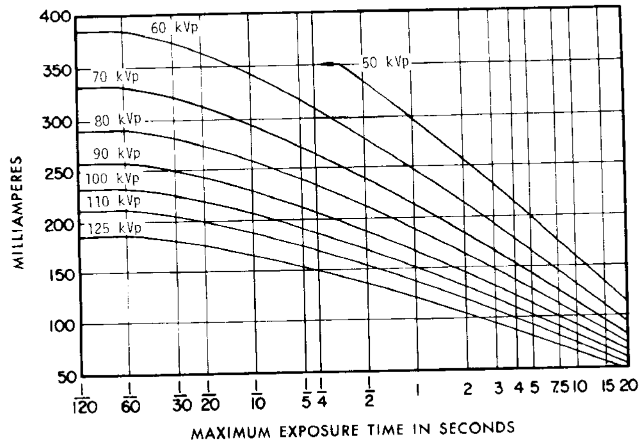
# PX-17AH, PX-17AHF, PX-17BH, PX-17BHF
## X-RAY TUBE RATING CHARTS

**175,000 HU ANODE HEAT STORAGE CAPACITY**

**ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - SINGLE-PHASE**

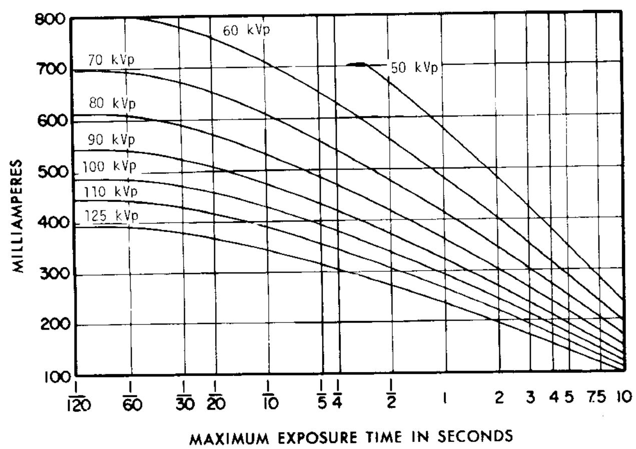
## 1.0 mm. FOCAL SPOT

### RADIOGRAPHIC



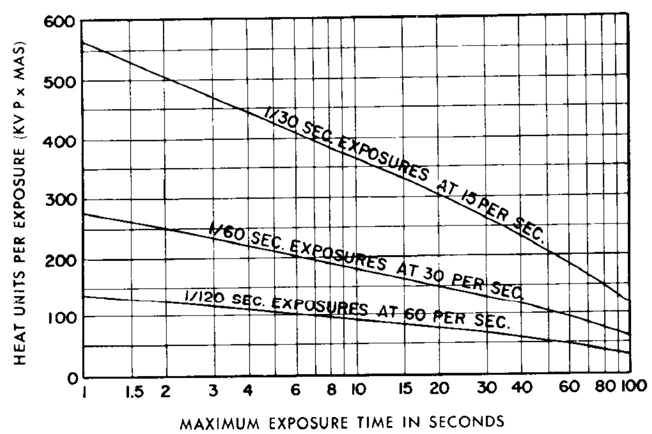

## 2.0 mm. FOCAL SPOT

### RADIOGRAPHIC

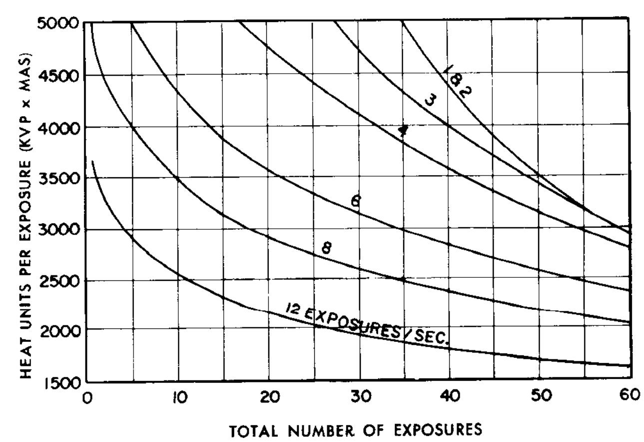





### CINERADIOGRAPHIC




### ANGIOGRAPHIC




## USE OF CHARTS

1. Use these charts only if you have a PX-17AH, PX-17AHF, PX-17BH, PX-17BHF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, single-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17AH, PX-17AHF, PX-17BH, PX-17BHF

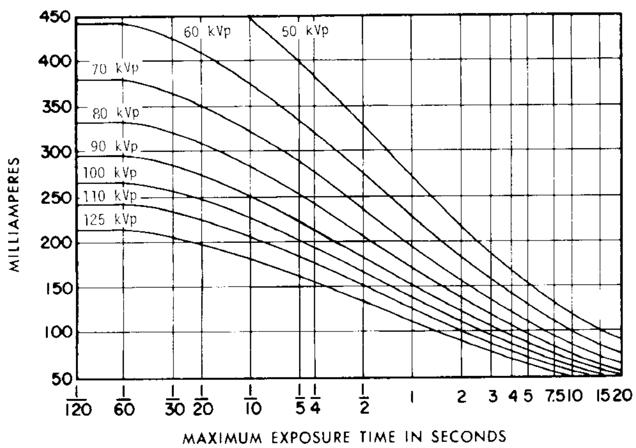
## X-RAY TUBE RATING CHARTS

**175,000 HU ANODE HEAT STORAGE CAPACITY**

**ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - THREE-PHASE**

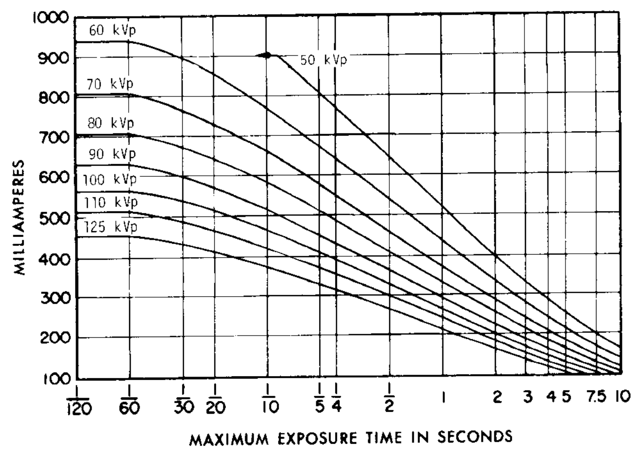
## 1.0 mm. FOCAL SPOT

### RADIOGRAPHIC



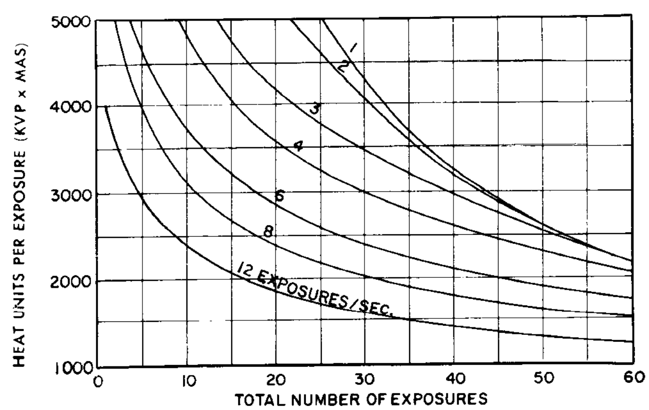

## 2.0 mm. FOCAL SPOT

### RADIOGRAPHIC




16

### ANGIOGRAPHIC




## USE OF CHARTS

1. Use these charts only if you have a PX-17AH, PX-17AHF, PX-17BH, PX-17BHF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, three-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17AH, PX-17AHF, PX-17BH, PX-17BHF

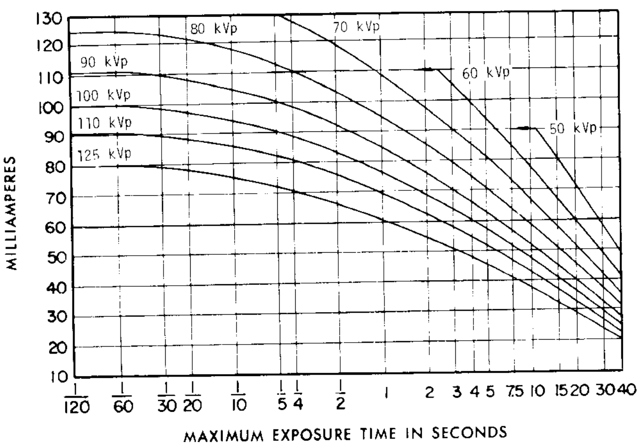
## X-RAY TUBE RATING CHARTS

**175,000 HU ANODE HEAT STORAGE CAPACITY**

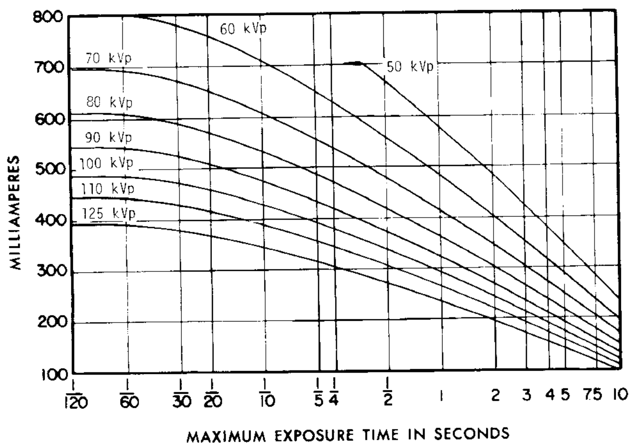
**ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - SINGLE-PHASE**

| 0.7 mm. FOCAL SPOT | 2.0 mm. FOCAL SPOT |
|---|---|

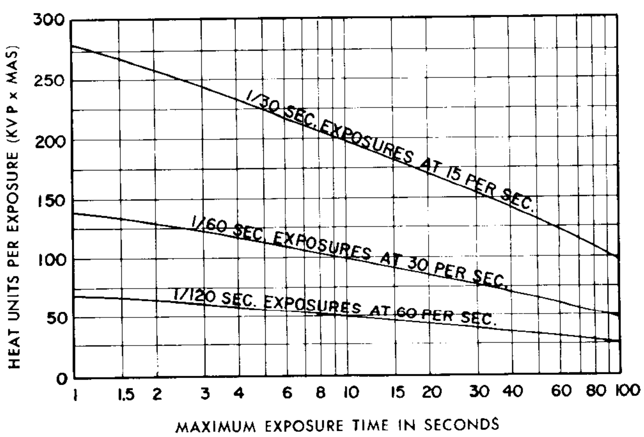
### RADIOGRAPHIC



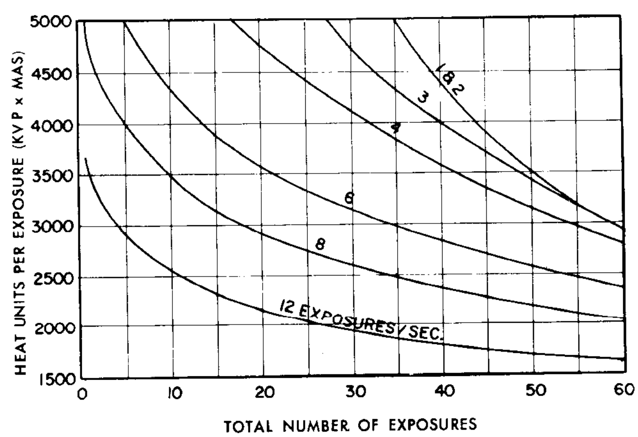

### RADIOGRAPHIC




### CINERADIOGRAPHIC




### ANGIOGRAPHIC




17

### USE OF CHARTS

1. Use these charts only if you have a PX-17AH, PX-17AHF, PX-17BH, PX-17BHF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, single-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17AH, PX-17AHF, PX-17BH, PX-17BHF

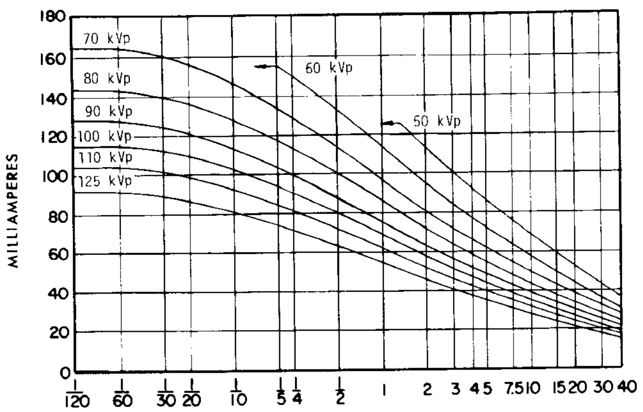
## X-RAY TUBE RATING CHARTS

**175,000 HU ANODE HEAT STORAGE CAPACITY**

**ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - THREE-PHASE**

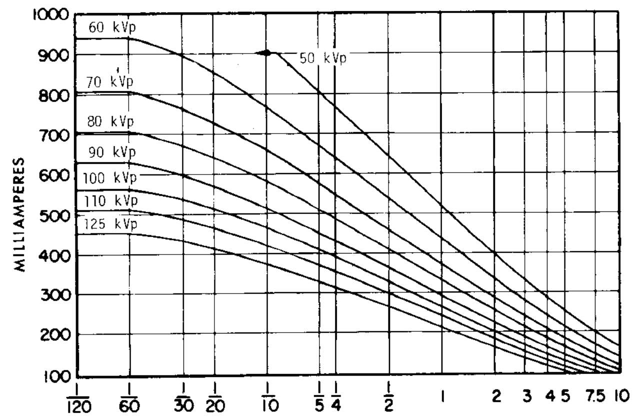
## 0.7 mm. FOCAL SPOT

### RADIOGRAPHIC



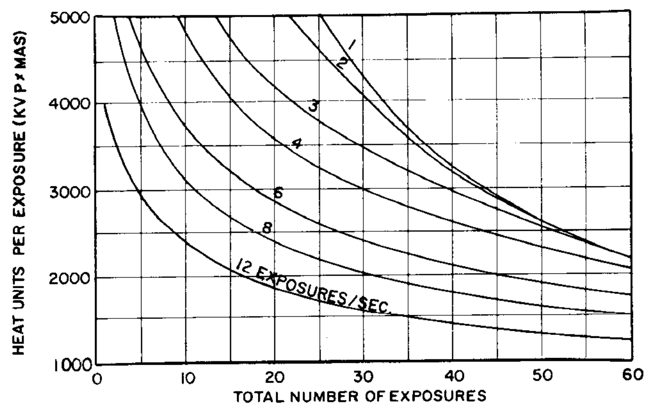

## 2.0 mm. FOCAL SPOT

### RADIOGRAPHIC




18

### ANGIOGRAPHIC




### USE OF CHARTS

1. Use these charts only if you have a PX-17AH, PX-17AHF, PX-17BH, PX-17BHF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, three-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17AH, PX-17AHF, PX-17BH, PX-17BHF

## X-RAY TUBE RATING CHARTS

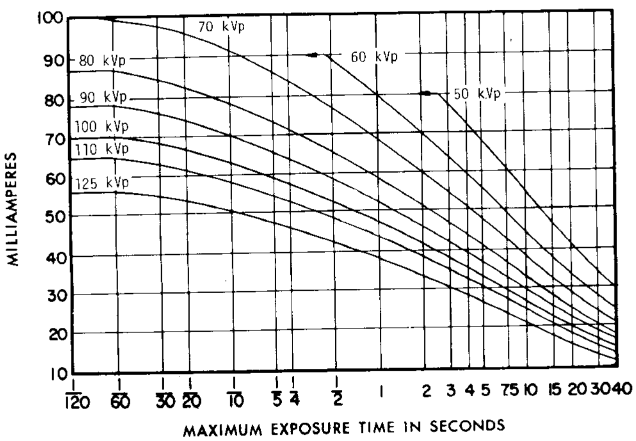
### 175,000 HU ANODE HEAT STORAGE CAPACITY

### ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - SINGLE-PHASE

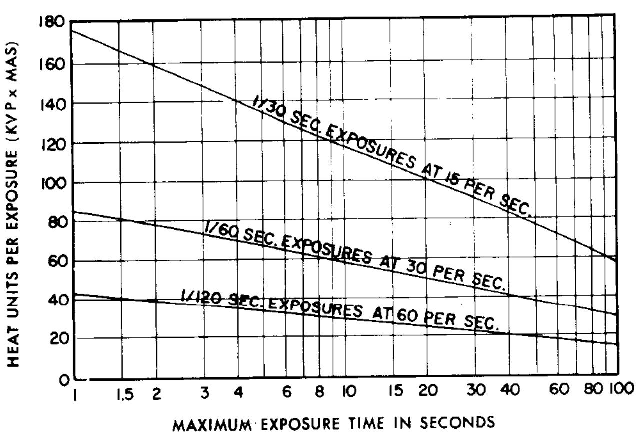


## 0.5 mm. FOCAL SPOT

### RADIOGRAPHIC

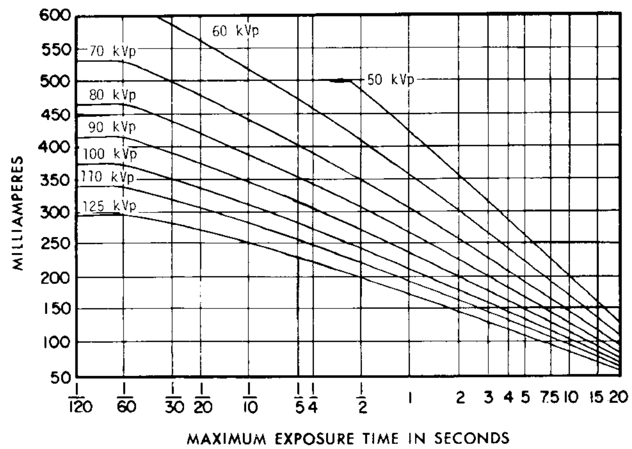



### CINERADIOGRAPHIC

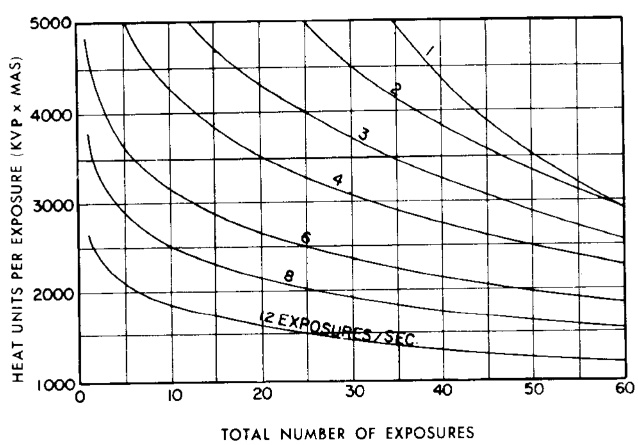



## 1.5 mm. FOCAL SPOT

### RADIOGRAPHIC




### ANGIOGRAPHIC




## USE OF CHARTS

1. Use these charts only if you have a PX-17AH, PX-17AHF, PX-17BH, PX-17BHF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, single-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17AH,PX-17AHF,PX-17BH,PX-17BHF

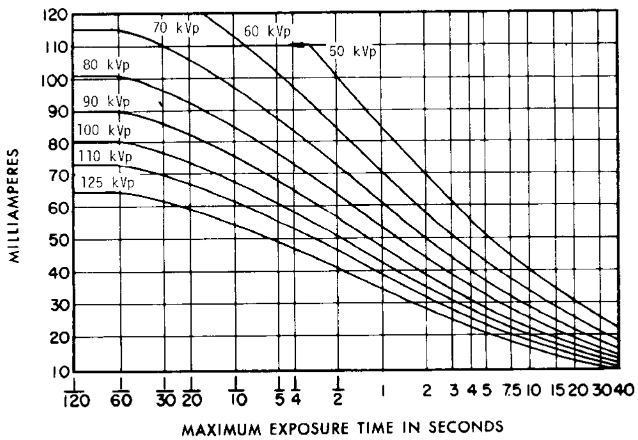
## X-RAY TUBE RATING CHARTS

### 175,000 HU ANODE HEAT STORAGE CAPACITY

### ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - THREE-PHASE

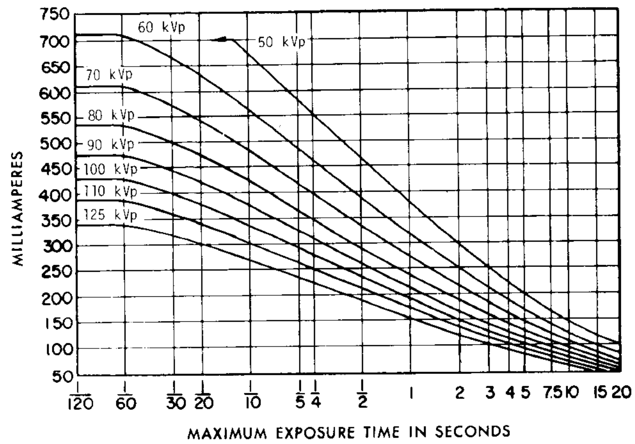
## 0.5 mm. FOCAL SPOT

### RADIOGRAPHIC

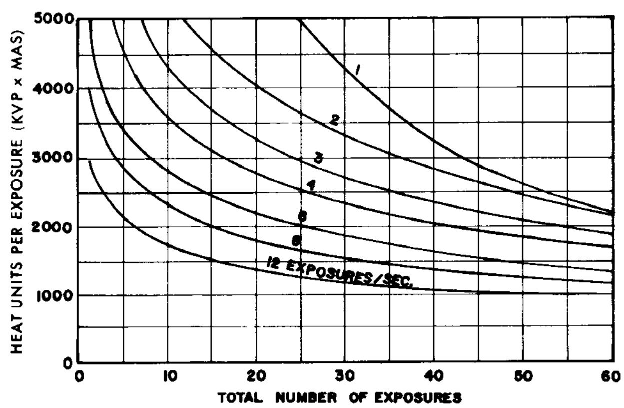



## 1.5 mm. FOCAL SPOT

### RADIOGRAPHIC




### ANGIOGRAPHIC




20

### USE OF CHARTS

1. Use these charts only if you have a PX-17AH, PX-17AHF, PX-17BH, PX-17BHF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, three-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17AH, PX-17AHF, PX-17BH, PX-17BHF

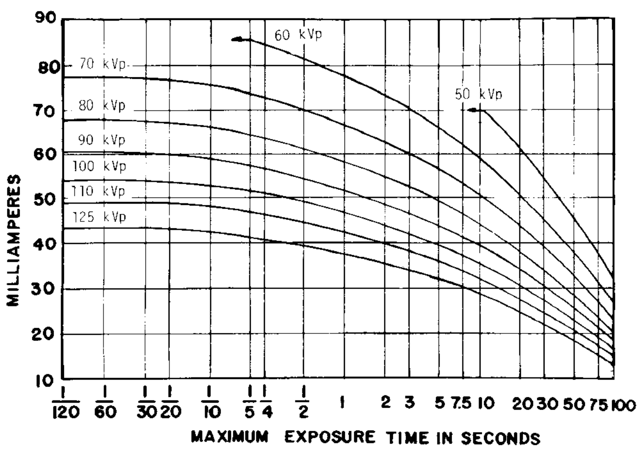
## X-RAY TUBE RATING CHARTS

**175,000 HU ANODE HEAT STORAGE CAPACITY**

**ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - SINGLE-PHASE - 10° TARGET**

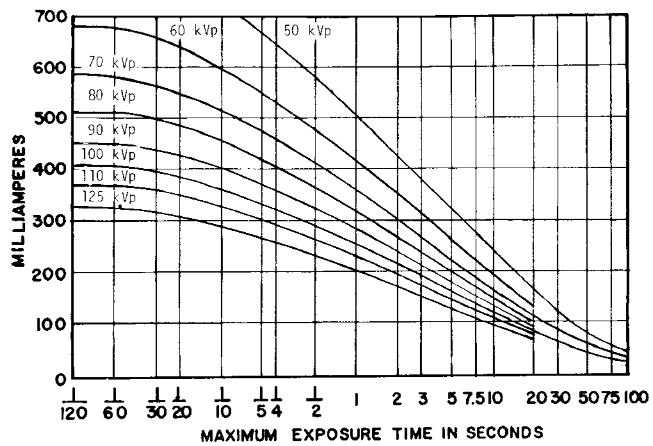
## 0.3 mm. FOCAL SPOT

### RADIOGRAPHIC

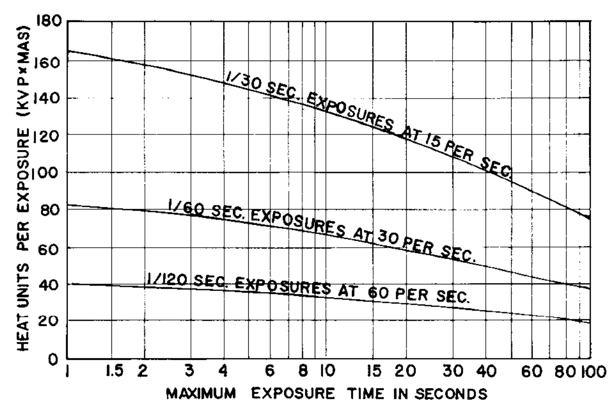



## 1.0 mm. FOCAL SPOT

### RADIOGRAPHIC

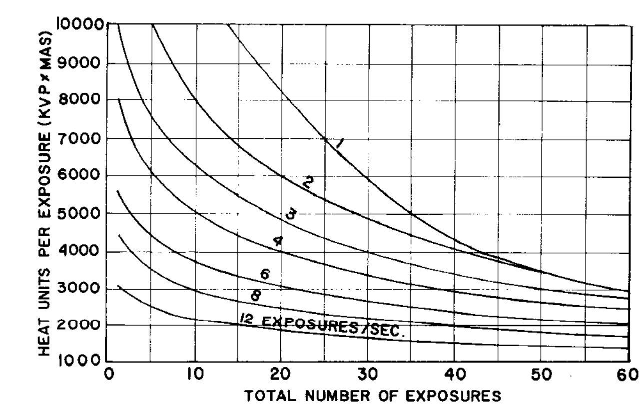



### CINERADIOGRAPHIC




### ANGIOGRAPHIC

21




## USE OF CHARTS

1. Use these charts only if you have a PX-17AH, PX-17AHF, PX-17BH, PX-17BHF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, single-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17AH, PX-17AHF, PX-17BH, PX-17BHF

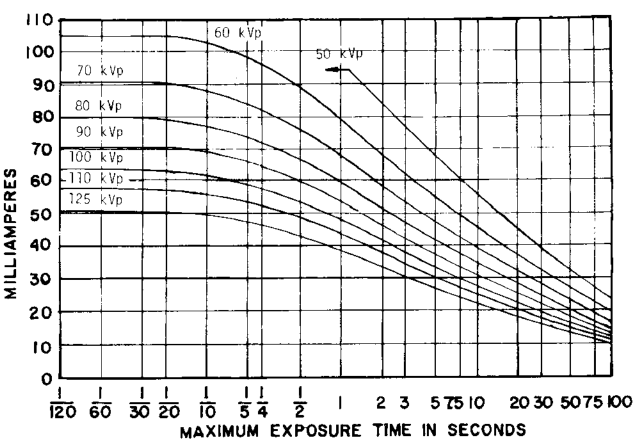
## X-RAY TUBE RATING CHARTS

### 175,000 HU ANODE HEAT STORAGE CAPACITY

### ROTATING ANODE - FULL-WAVE RECTIFIED - 60 Hz - THREE PHASE - 10° TARGET

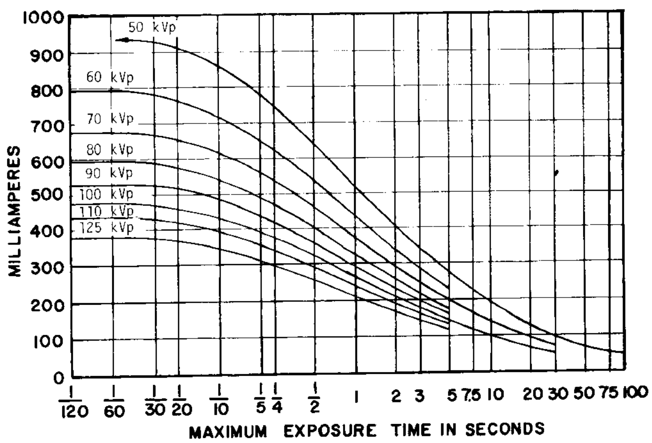
## 0.3 mm. FOCAL SPOT

### RADIOGRAPHIC

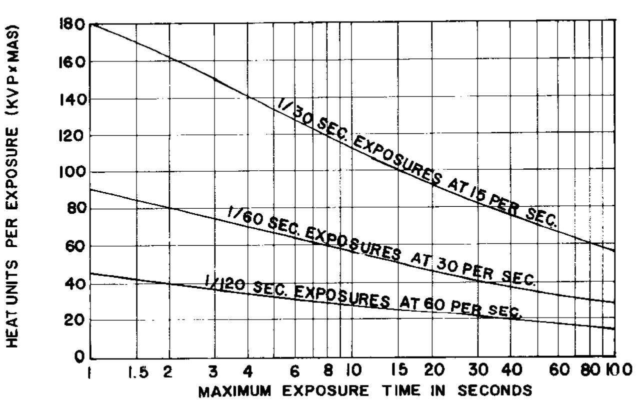



## 1.0 mm. FOCAL SPOT

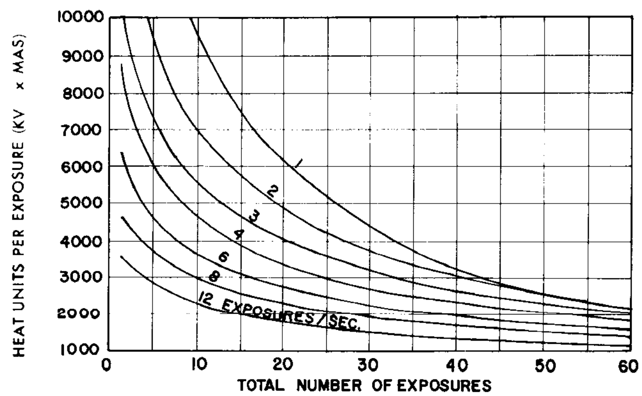
### RADIOGRAPHIC




### CINERADIOGRAPHIC




### ANGIOGRAPHIC

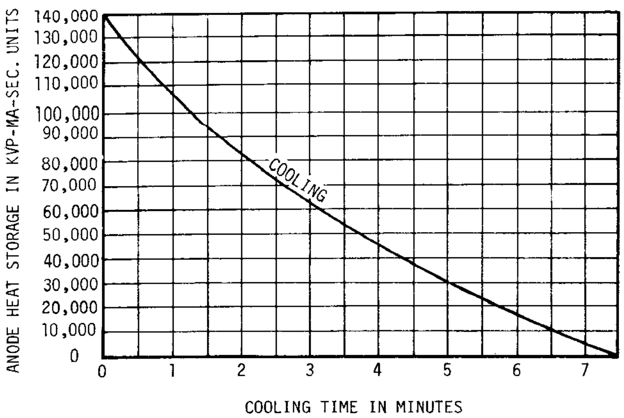



## USE OF CHARTS

1. Use these charts only if you have a PX-17AH, PX-17AHF, PX-17BH, PX-17BHF tube, the anode rotates, and it uses full-wave rectified, 60 Hz, three-phase power.
2. Pick the proper focal spot size.
3. Use the chart corresponding to the technic to be used.
4. Find the intersection of two of the three exposure factors and see that the third is *less* than the value that also intersects at that point.

# PX-17 SERIES X-RAY TUBE COOLING CHARTS

## ANODE COOLING CHARTS

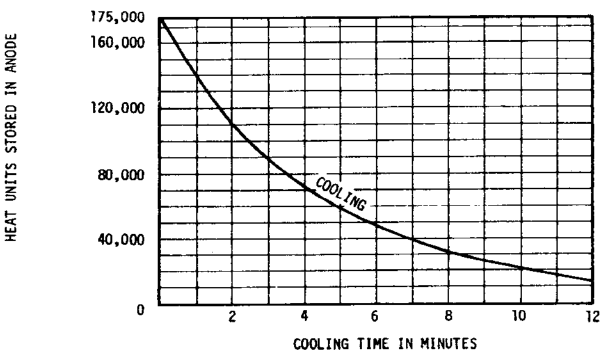



PX-17A,

PX-17AF,

PX-17B,

PX-17BF




PX-17AH,

PX-17AHF,

PX-17BH,

PX-17BHF

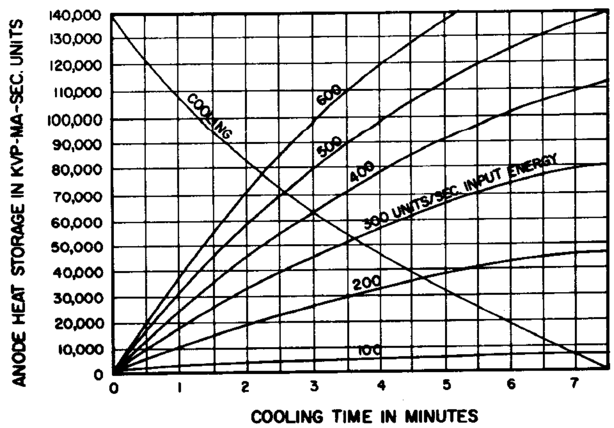
Use if more than one radiographic exposure is planned within 10 to 12 minutes.

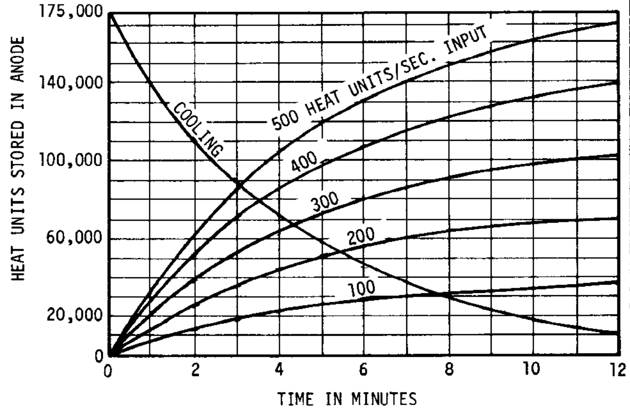
Use as follows:

1. Check each exposure against appropriate Radiographic Rating Chart.
2. Calculate heat units of each exposure (kVp x mA x Seconds) and add to units remaining in anode from previous exposures (if any).
3. Subtract units lost through cooling between exposures.
4. See that accumulating heat units never exceed the anode heat storage capacity (140,000 or 175,000 units).

*For your convenience the heat-unit scales on the Fluoroscopic Operation Charts have been increased by a Heat Input Correction Factor of 1.3 to simplify use of the charts. This value accounts for the shockproof cable capacity usually encountered. For a fuller explanation of cable capacity effects and use of the Cooling Charts, see "How to Use the Rating Charts" in this manual.

## FLUOROSCOPIC OPERATION



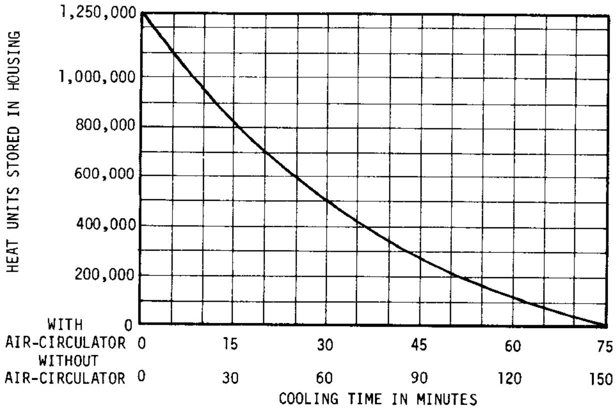




Use to determine permissible fluoroscopy and spotfilm exposure schedules.*

Use as follows:

1. Calculate the heat input rate to be used for fluoroscopy (units per second = kVp x mA).
2. Find the corresponding heat input curve (or its approximate position) on the appropriate Fluoroscopic Operation Chart and determine the number of heat units corresponding to the expected fluoroscopic exposure time.*
3. Check that the spotfilm technic is permissible using the appropriate Radiographic Rating Chart.
4. Find the total heat units for the spotfilm exposures (number of exposures x kVp x mA x Seconds).
5. Add these units to the heat units expected during fluoroscopy (step 2). The total should be less than the anode heat storage capacity (140,000 or 175,000 HU).

# HOUSING COOLING CHART






Use if heavy schedule of exposures is planned within two to four hours.

Use as follows:

1. Calculate heat units per minute (kVp x mA x exposures per minute x exposure time = HU per minute).**

2. Calculate the number of minutes of permissible operation before housing heat storage capacity is reached (minimum of operation = housing heat storage capacity ÷ heat units per minute).

3. From Housing Cooling Chart determine the waiting period required before making another series of exposures.

4. To calculate the permissible time for a succeeding series, repeat step 2 after subtracting heat units remaining from previous exposures from the housing heat storage capacity.

**If less than 15,000 HU per minute (without air circulator) or 30,000 HU per minute with air circulator) the housing will not overheat.

> **NOTE**
> The charts contained in this section are for illustrative purposes only. Use the preceding rating and cooling charts for the specific type of tube that will be used.

## Section 4
## HOW TO USE RATING CHARTS

The rating charts in this manual must be used to determine whether or not a given combination of kVp, mA, and exposure time can safely be used without damaging the X-ray tube. Since the tubes are costly, the charts should be consulted any time the tube is called upon to operate at maximum energy or for a series of exposures.

Three factors must be considered when determining permissible exposures for rotating anode X-ray tubes:

1. The maximum permissible energy value of a *single exposure*—determined from the Radiographic Rating Charts for the focal spot used, rotor speed and type of power supply.
2. The maximum rate at which a *series of exposures*, less than 10 to 12 minutes apart, may be safely made—determined with the aid of the Anode Cooling Chart and calculations.
3. The effect of a heavy exposure schedule on the *tube housing temperature*—determined from the Housing Cooling Chart.

## SINGLE EXPOSURES

Radiographic Rating Charts for single exposures are based on the assumptions that the anode, at the beginning of the exposure, is at room temperature and is rotating at proper speed.

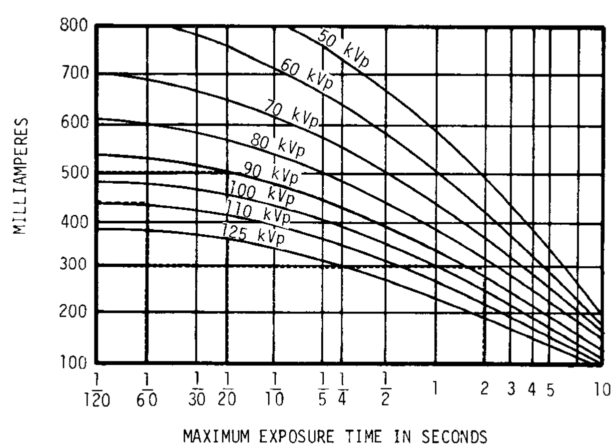
For your convenience, the rating charts applying to these tubes are arranged so that one may be selected for the particular type of X-ray generator and combination of focal spot sizes to be used and the other charts discarded to avoid confusion. Note that the charts apply to generators differing in the following characteristics:

- 50- or 60-Hz frequency,
- Single- or three-phase power supply.

## USE OF RADIOGRAPHIC RATING CHART

At the left of each page of rating charts, you will find graphs for the smaller focal spot—at the right graphs for the larger focal spot. For certain focal spot size, separate charts are provided for your convenience with different techniques: Radiography, Cineradiography, and Angiography.

To use the Radiographic Rating Charts, find the intersection of two of the three exposure factors and see that the third is less than the value which also intersects at that point. For example, suppose the chart like the one below (2mm spot, full-wave, 60-Hz, single-phase power) is being used.




If 300 mA for 2 seconds is selected, their point of intersection corresponds with 83 kVp, *the maximum kVp to be used with those* *factors.* On the other hand, if 500 mA at 90 kVp is to be used, *the maximum exposure time is slightly over 1/20 second.* Similarly, if 1/60 second at 110 kVp is to be used, *the maximum mA is 450.* (Usually 400 mA would be used and time adjusted accordingly.)

## SERIES OF EXPOSURES

When a number of exposures are to be made within 10 to 12 minutes, such as for cine, angiography, chest survey, stereo and spot-film techniques, the amount of heat that the anode can safely accumulate must be considered. This anode heat storage capacity, listed for Picker tubes, is defined in heat units: the product of kVp x mA x seconds.

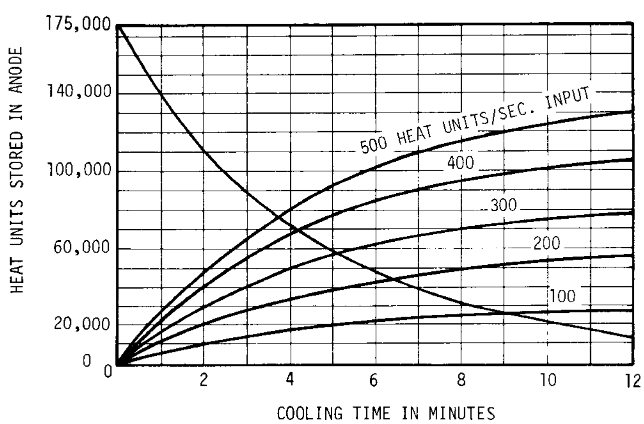
### NOTE

The heat units derived from the product of kVp x mA x seconds apply only to tubes operating from generators using single-phase power. For three-phase generators producing 6 pulses per cycle, the heat unit product must be multiplied by 1.35 (35 percent *more* heating is produced); for those producing 12 pulses per cycle, multiply by 1.40.



## USE OF ANODE COOLING CHART

The Anode Cooling Chart is used to determine whether a series of exposures are permissible within a certain time period. To illustrate, assume that there have been exposures totaling 100,000 heat units on a tube with 175,000 HU anode heat storage capacity. Two minutes later, a lateral lumbar spine exposure at 82 kVp and 300 mAs is made. What waiting time (if any) is required before making a posterior oblique lumbar spine exposure at 75 kVp and 150 mAs?




*Solution:* Refer to the anode cooling curve for the tube (above) and note that 100,000 HU is at a cooling time of 2-1/2 minutes.

Two minutes later (or 4-1/2 minutes total on the curve) the anode will have cooled to 64,000 units. The lateral lumbar exposure equals 24,600 heat units (82 kVp x 300 mAs), so that after this exposure the total anode heat will be 88,600 units (64,000 + 24,600).

The oblique exposure requires 11,250 heat units (75 kVp x 150 mAs), so that the total anode heat will be 99,850 units (88,600 + 11,250). Since this is less than the 175,000 heat-unit capacity of the tube, the exposure can be made without any waiting time.

## FLUOROSCOPY

Fluoroscopic exposure time is limited also in some instances by the total heat that can be safely absorbed by the anode of the X-ray tube. This limit and the cooling rate of the anode are shown on the Anode Cooling Charts.

Each curve shows three characteristics of the anodes:

1. The maximum heat storage capacity of the anode in heat units.
2. The time it takes for the anode to cool from one energy level to another.
3. The amount of heat that will accumulate during a fluoroscopic examination.

For your convenience, permissible fluoroscopic exposures are presented in terms of input energy curves which account for the cooling that occurs during exposure. Several typical values have been plotted on the Anode Cooling Charts. For others you will have to interpolate.

## USE OF ANODE COOLING CHARTS FOR FLUOROSCOPY

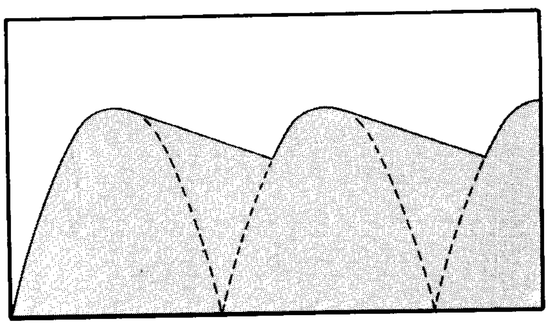
The heat to be dissipated by the tube is determined by multiplying the kVp and mA, then selecting the input energy curve corresponding to this value (or its approximate position) on the Anode Cooling Chart. Then by finding the point on the curve that corresponds with the estimated examination time (horizontal axis), the corresponding number of heat units accumulated in the anode can be found on the vertical axis.

For example, an examination at 100 kVp and 4 mA produces 400 heat units per second (100 x 4). From the corresponding curve on the Sample Anode Cooling Chart, it can be seen that this amount of exposure adds about 66,000 heat units to the anode after 4 minutes. Usually, this amount of heat is handled easily by the tube.

To find the time required for the anode to cool a given amount, locate the intersection of the original heat units on the cooling curve, then note the equivalent time. Repeat this procedure at the lower heat unit value and determine the time difference. *In effect, the input energy curves show you the rate heat is added to the anode during fluoroscopy, and the cooling curve shows you the rate that the heat is dissipated after the exposure is terminated.*

## EFFECT OF CABLE LENGTH

At the low mA levels used in fluoroscopy, the length of the shockproof cables effects the amount of input energy to the anode at various combinations of kVp and mA. This is because at low mA the wave shape changes from pulsed DC to a near constant potential form, which contains more energy. The Heat Input Cable Correction Factor table helps you determine how much more energy is applied to the tube, due to cable capacity, than is specified on the Anode Cooling Charts. Note that this factor increases with increasing cable length and kVp, but decreases with increasing mA.



CABLE CAPACITY AT LOW MA changes the waveshape of the energy reaching the X-ray tube from that shown by the dotted lines to a near constant potential form. The actual shape depends on cable length, kVp, and mA.

Where low mA, high kVp, and relatively long shockproof cables are used, the Heat Input Correction Factor will be as large as 1.4 (40% more energy reaching the X-ray tube). This means that the Anode Heat Storage Capacity will be reached more quickly for given factors than if cable capacity were not considered. However, the higher energy available at the tube due to the near constant potential wave-form enables the user to operate at lower kVp or mA while maintaining the same screen brightness. These lower factors may even reduce the heat unit input more than it is increased by the cable capacity.

## FLUOROSCOPY AND SPOTFILM

To illustrate the application of the factors involved in determining permissible exposures when fluoroscopy is combined with spotfilms, a hypothetical problem will be posed. Assume a stomach fluoroscopic examination for 5 minutes at 100 kVp and 4 mA combined with eight spotfilms at 90 kVp, 40 mAs, using a tube having the same anode cooling chart as the sample shown previously. The length of each shockproof cable is 36-feet. Is this technique permissible?

*Solution:*

The input energy is 100 kVp x 4 mA = 400 units per second. From the curve for 400 units per second on the Anode Cooling Chart, the anode heat storage for 5 minutes = 76,000 units. Referring to the Heat Input Cable Correction Factor table for 36-feet, 4 mA, and 100 kVp, the heat input ratio will be approximately 1.24. Multiplying the 76,000 fluoroscopic heat units x 1.24 = 94,240 units.

The total heat from the eight spotfilm exposures will be 28,800 units (8 x 90 x 40). Therefore, the total anode heat will be 123,040 units (94,240 + 28,800), which is within the anode heat storage capacity of the heavy duty tubes.

## TUBE HOUSING TEMPERATURE

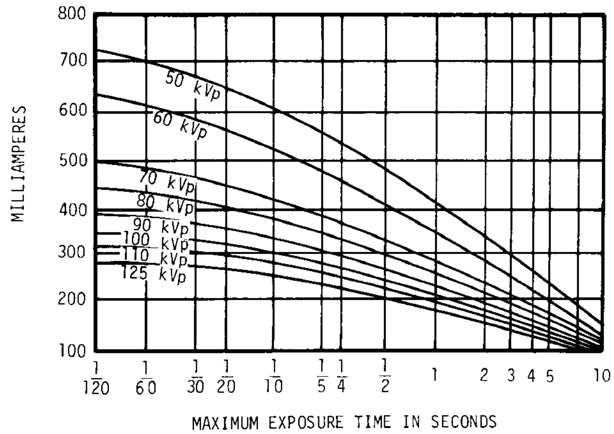
The third factor that may have to be considered in determining permissible exposure schedules is the total heat storage capacity of the housing (usually 1,250,000 units). This rating must be followed to prevent the oil, and so forth, in the housing from becoming too hot to remove the heat radiated from the anode, and to prevent damage to the interior parts of the tube such as the port, expansion diaphragm, and cable insulators.

HEAT INPUT CORRECTION FACTOR FOR SHOCKPROOF CABLE CAPACITY

| K V P | FOR 24-FT CABLES | | | FOR 36-FT CABLES | | | FOR 48-FT CABLES | | | FOR 60-FT CABLES | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 mA | 3 mA | 5 mA | 1 mA | 3 mA | 4 mA | 1 mA | 3 mA | 4 mA | 1 mA | 3 mA | 4 mA |
| 75 kVp | 1.32 | 1.17 | 1.06 | 1.35 | 1.24 | 1.18 | 1.36 | 1.27 | 1.24 | 1.37 | 1.30 | 1.27 |
| 100 kVp | 1.34 | 1.22 | 1.11 | 1.36 | 1.28 | 1.24 | 1.37 | 1.31 | 1.28 | 1.38 | 1.33 | 1.30 |
| 150 kVp | 1.36 | 1.28 | 1.18 | 1.37 | 1.32 | 1.29 | 1.38 | 1.34 | 1.32 | 1.39 | 1.35 | 1.33 |

## USE OF HOUSING COOLING CHART

To illustrate the use of the Housing Cooling Chart (heat storage capacity and cooling rate), assume that 70mm chest survey films will be made using an average exposure of 90 kVp, 200 mA, 2/5 second (80 mAs) at the rate of 4 per minute.

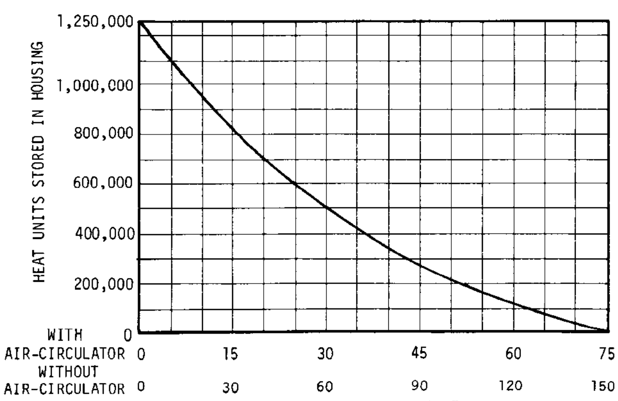



*Solution:*

From the radiographic rating chart above, it will be noted that the individual exposure is well within the rating (1-1/2 seconds). The total anode heat storage is 7,200 units per exposure (90 x 80), and 28,800 units per minute (7,200 x 4) at the 4 exposures per minute rate. Since the anode cooling rate is generally 40,000 units per minute (note thermal rating on tube data sheets), this technique is permissible.

However, after about 44 minutes (1,250,000 ÷ 28,800) a total housing heat storage in excess of 1,250,000 units would be reached.

When this maximum is reached, it is then necessary to reduce the rate of heat input to the maximum cooling rate of the housing (note thermal rating) or less, by adding air circulation, or by reducing the number of exposures. Assuming a maximum overall cooling rate of 15,000 units (which is correct for the tube housing without air circulation),




and since in this case the heat units per exposure is 7,200, therefore two exposures per minute (2 x 7,200 = 14,400 units) could be made safely.

Or assume that after operating for 44 minutes at the original rate the tube is permitted to cool for 30 minutes, which from the Housing Cooling Chart would reduce the heat still in the housing to about 800,000 units. It would then be possible to resume operation for 15 minutes [(1,250,000 - 800,000) ÷ 28,800 = 15]. After this time the housing heat would reach the maximum permissible, and it would be necessary to reduce the exposures to the rate described previously.

## SPECIAL TECHNIQUES:

Following are the special instructions for calculating the duration for cineradiography, angiography, and mammography exposures from a full-wave rating chart.

### NOTE

All mA values referred to are full-wave, single-phase values as indicated on the Tube Charts and mA meter during normal continuous exposure. They are not readings made during intermittent or pulsed exposures.

## CINERADIOGRAPHY

1. Determine the exposure (kVp and mAs) required for proper film density.
2. Using these factors (kVp and mA), refer to the appropriate Radiographic Rating Chart and determine the longest single exposure that is permissible.

### NOTE

For focal spots of 0.7mm and larger, the kVp and mA values selected will usually permit exposure times longer than the maximum time on the rating chart. If so, the following formula is used to determine the time of film run and steps 3 and 4 below do not apply.

MAXIMUM TIME FOR FILM RUN (IN SECONDS) =

$$\frac{\text{ANODE HEAT STORAGE CAPACITY (HEAT UNITS)}}{\text{(HEAT UNITS PER EXPO.) X (CINE FILM RATE)}}$$

## USE OF HOUSING COOLING CHART

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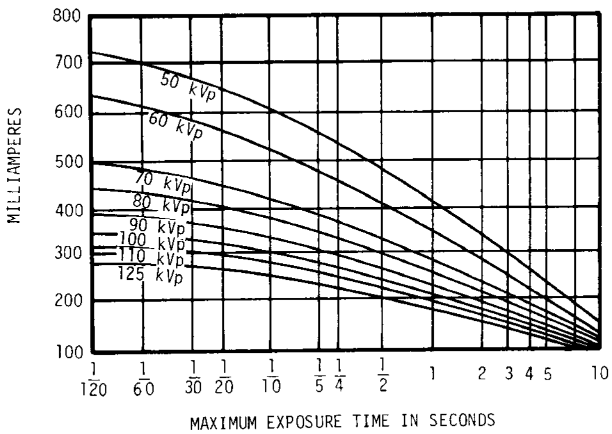


*Solution:*

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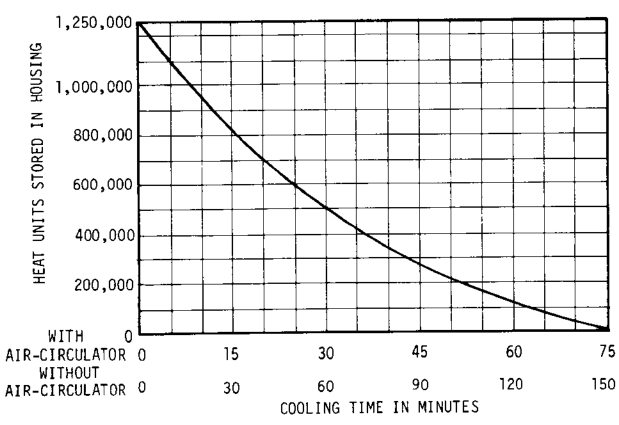


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**NOTE**

For focal spots of 0.7mm and larger, the kVp and mA values selected will usually permit exposure times longer than the maximum time on the rating chart. If so, the following formula is used to determine the time of film run and steps 3 and 4 below do not apply.

$$\text{MAXIMUM TIME FOR FILM RUN (IN SECONDS)} = \frac{\text{ANODE HEAT STORAGE CAPACITY (HEAT UNITS)}}{\text{(HEAT UNITS PER EXPO.) X (CINE FILM RATE)}}$$

3. Determine the Exposure Cycle Factor as related to a single continuous exposure (see Exposure Cycle Factor).

4. To obtain the maximum number of seconds of film run, multiply the longest permissible continuous exposure by the Exposure Cycle Factor.

5. If the film run time is too short, then recalculate on the basis of a slower frame rate or larger focal spot.

## EXPOSURE CYCLE FACTOR

For a given kVp and mA the full-wave rating chart will give the longest permissible continuous exposure time which would also be the film run time for a continuous exposure. However, the number of seconds of film run can be increased if the exposures are turned off between frames during film transport.

The Exposure Cycle Factor is a number which expresses the relationship between a continuous and an intermittent exposure sequence—the factor by which the film run can be increased for a sequence of *intermittent* exposures. It is expressed by the following formula:

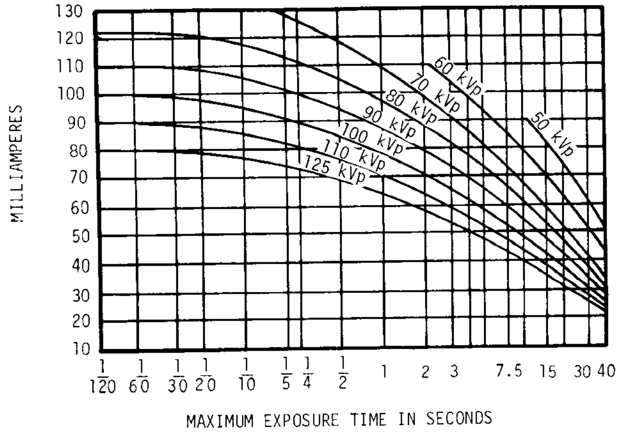
$$\text{EXPOSURE CYCLE FACTOR} = \frac{1}{(\text{EXPOSURE TIME}) \times (\text{EXPOSURE RATE})}$$

Exposure Cycle Factors for typical cine film runs are given below:

| EXPOSURE TIME | EXPOSURE RATE | EXPOSURE CYCLE FACTOR |
|---|---|---|
| 1/120 sec. | 60 per sec. | 2 |
| 1/120 sec. | 30 per sec. | 4 |
| 1/120 sec. | 15 per sec. | 8 |
| 1/120 sec. | 7-1/2 per " | 16 |
| 1/60 sec. | 30 per sec. | 2 |
| 1/30 sec. | 15 per sec. | 2 |
| 1/15 sec. | 7-1/2 per " | 2 |

(Does not apply for pulsed grid control operation.)

To illustrate, assume exposure factors of 100 kVp, 20 mA, 1/60 second, and 30 frames per second using a tube having the above Radiographic Rating Chart, and an anode heat storage capacity of 140,000 units. Calculate the maximum continuous film run.

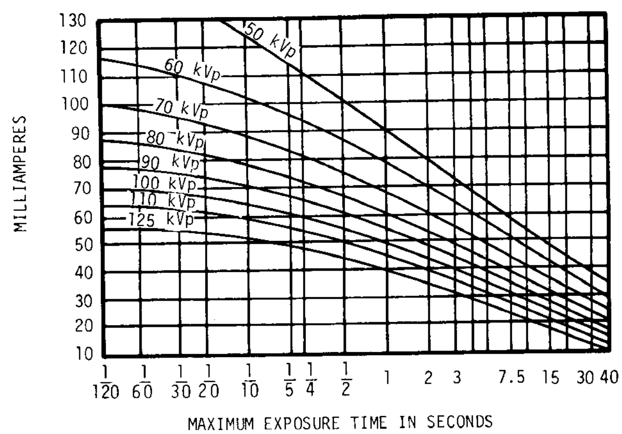



*Solution:*

1. Referring to the Radiographic Rating Chart, note that the permissible continuous exposure for the assumed factors is over 40 seconds. The heat units per exposure = 100 x 20 x 1/60 = 33-1/3 heat units. Therefore, the formula of paragraph 2 will apply.

$$\text{MAXIMUM TIME FOR FILM RUN} = \frac{140{,}000}{33\text{-}1/3 \times 30} =$$

140 Seconds of Continuous Film Run




2. To illustrate the use of the Exposure Cycle Factor, assume that a tube with a smaller focal spot having the above Radiographic Rating Chart is used. Referring to the rating chart for this size focal spot, the longest continuous exposure is 22 seconds (for 100 kVp, 20 mA).

3. Note from the table that the Exposure Cycle Factor is 2 for 30 frames per second and 1/60 second exposure. The maximum number of seconds of film run is thus 22 x 2 = 44 seconds.

The Cineradiographic Rating Charts included in this manual may be used to determine the maximum exposure time directly, if desired.

## ANGIOGRAPHY (RAPID-SEQUENCE RADIOGRAPHY)

As previously indicated, too many exposures within a limited period of time may overheat the tube in three different ways:

1. The surface of the target can be overheated by repeating exposures before the heat on the surface has had time to dissipate into the anode proper.
2. The entire anode can be overheated by repeating exposures before the anode heat can radiate into the surrounding oil and tube housing.
3. The tube housing can be overheated by making exposures more rapidly than the tube housing can dissipate its heat to the surrounding air.

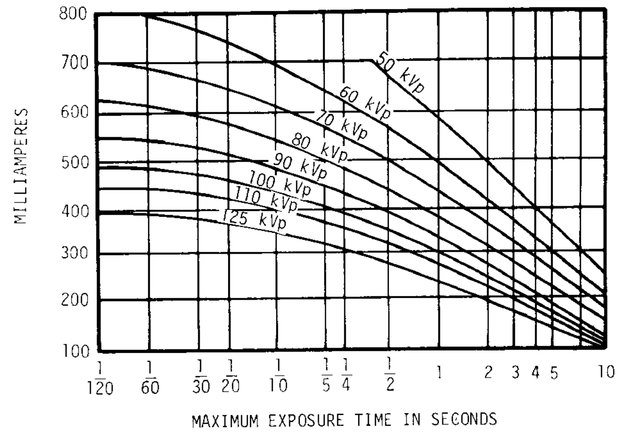
To prevent this dangerous overheating, the following condition must be met:

*The total heat units of a series of exposures made in rapid sequence must not exceed the heat units permissible, as indicated by the Radiographic Rating Chart, for a single exposure of a duration equal to the total elapsed time required to complete the series of exposures.*

This rule applies when each individual exposure is within the radiographic rating, is of the same number of heat units and is separated by the same time interval. When the time interval between individual exposures exceeds the maximum time range of the radiographic rating chart, it can be assumed that there will be no danger of overheating the target so only the anode or housing heat storage capacity need be considered.

Proceed as follows to determine whether the rapid-sequence technique is permissible:

1. Determine that the individual exposure factors are within the radiographic rating for the type of tube and focal spot employed.
2. Calculate the total number of heat units for the proposed series: (kVp x mA x exposure time x number of exposures per second x total time for series).
3. Referring to the radiographic rating chart, determine the maximum mA for the kVp and desired total time for the series.
4. Calculate the total permissible heat units for the series [kVp x mA (from 3 above) x total time for the series].
5. Compare the total number of heat units for the proposed series (from 2 above) against the total permissible heat units. If the total permissible heat units is greater than that of the proposed series, then the technique may be used.




To illustrate, assume a technique of 100 kVp, 400 mA, 1/10 second, at the rate of 6 exposures per second for a total time of 3 seconds; using a tube having the above radiographic rating chart.

*Solution:*

1. From the tube rating, the maximum exposure time at 100 kVp, 400 mA is over 3/20 second so that individual exposure is permissible.
2. The total number of heat units for the desired technique = 100 kVp x 400 mA x 1/10 second x 6 exposures per second x 3 seconds = 72,000 HU.
3. From the rating chart, the maximum mA at 100 kVp and 3 seconds total time = 210 mA.
4. Total permissible heat units = 100 kVp x 210 mA x 3 seconds = 63,000 HU. Since this is *less* than that of 2 above, the proposed technique *cannot* be used. It will be necessary to reduce the total number of heat units, perhaps by operating at the rate of 5 exposures per second. This would result in a total of 60,000 HU which is within the permissible range.

   The Angiographic Rating Charts included may be used to determine the maximum number of exposures directly if desired.

## MAMMOGRAPHY

When sequences of exposures are to be made over extended periods, the heating and cooling characteristics of the anode system and of the complete tube unit must be considered.

A simplified method of determining the minimum cooling time between exposures is as follows:

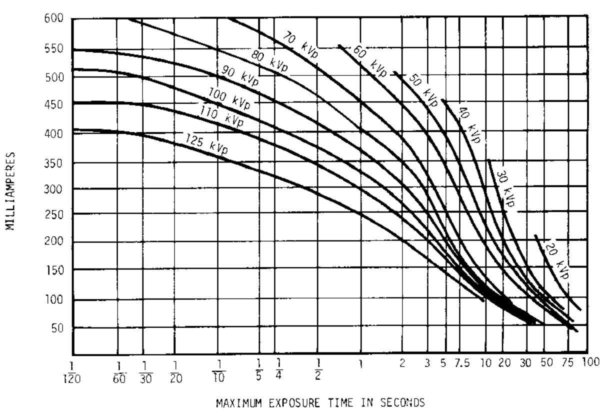
1. Determine that the individual exposure factors are within the radiographic ratings for the type of tube and focal spot.

2. See that none of the individual exposures exceeds the anode heat storage capacity of the tube.

3. Determine the waiting time between each exposure by selecting the exposure with the largest number of heat units and subtracting its heat unit value from the anode heat storage capacity.

4. Using the anode cooling curve, determine the cooling time equivalent to the heat unit remainder found in step 3.

To illustrate, assume a series of mammographic exposures with the greatest exposure 30

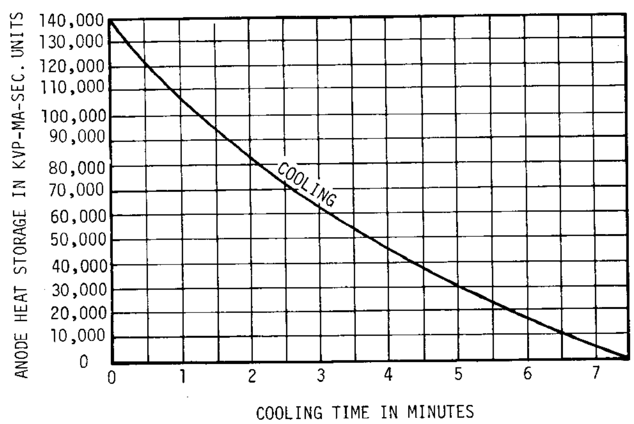



kVp, 300 mA, 6 seconds on a tube with an anode heat storage capacity of 140,000 units.

*Solution:*

1. The technique is within the rating of the tube—see above chart.

2. The heat units total = 30 kVp x 300 mA x 6 seconds = 54,000 units, which is within the anode heat storage capacity.




3. Anode heat storage equals 86,000 heat units (140,000 - 54,000 = 86,000).

4. 86,000 units on the anode cooling curve equals about 1.8 minutes, so exposures of 54,000 heat units or less can be made at time intervals of 1.8 minutes until the *housing* heat storage capacity is reached.