X-Ray Tube Rating

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RATING CHARTS & COOLING CURVES

Exposure factors that determine radiographic output:

1.Operating voltage (kV)

2.Tube current (mA)

3.Exposure time (sec)

- These factors determine radiographic output and heat generated on tube anode
- Anode should not be heated above the melting point of target material (about 3000 ^{0}C for tungsten)
- Rating charts & cooling curves help to avoid thermal damage to x-ray tube.

Thermal energy generated on anode will be proportional to exposure factors (kV, mA and sec.).

Thermal load is therefore proportional to the product of these factors and it is expressed in heat units (HU).

HU = Peak voltage (kVp) x Tube current (mA)

x Exposure time (sec) x Rectification factor

Rectification	Constant
Single-phase, Full-wave	1.0
3-phase, 6-pulse	1.35
3-phase, 12 pulse	1.41
High-Frequency	1.45

Q.1

How many heat units are generated by an exposure of 70 kVp, 200 mA and 0.2 sec on a single-phase full-wave rectified unit ?

Ans: 80 kVp x 200 mA x 0.2 sec. x 1.0 = 3200 HU

Q.2

How many heat units are generated by an exposure of 70 kVp, 300 mA and 0.15 sec on a three phase 6 pulse unit ?

Ans: 70 kVp x 300 mA x 0.15 sec x 1.35 = 4253 HU

Q.3

How many heat units are generated by two exposures of 65 kVp , 400 mA , 0.05 Sec on three phase 12 pulse unit?

Ans: 65 kV x 400 mA x 0.05 sec x 1.41 x 2 = 3666 HU

Three types of charts are mainly referred to avoid thermal damage to x-ray tube:

1. Radiographic/tube rating charge
2. Anode cooling charts
3. Housing cooling charts

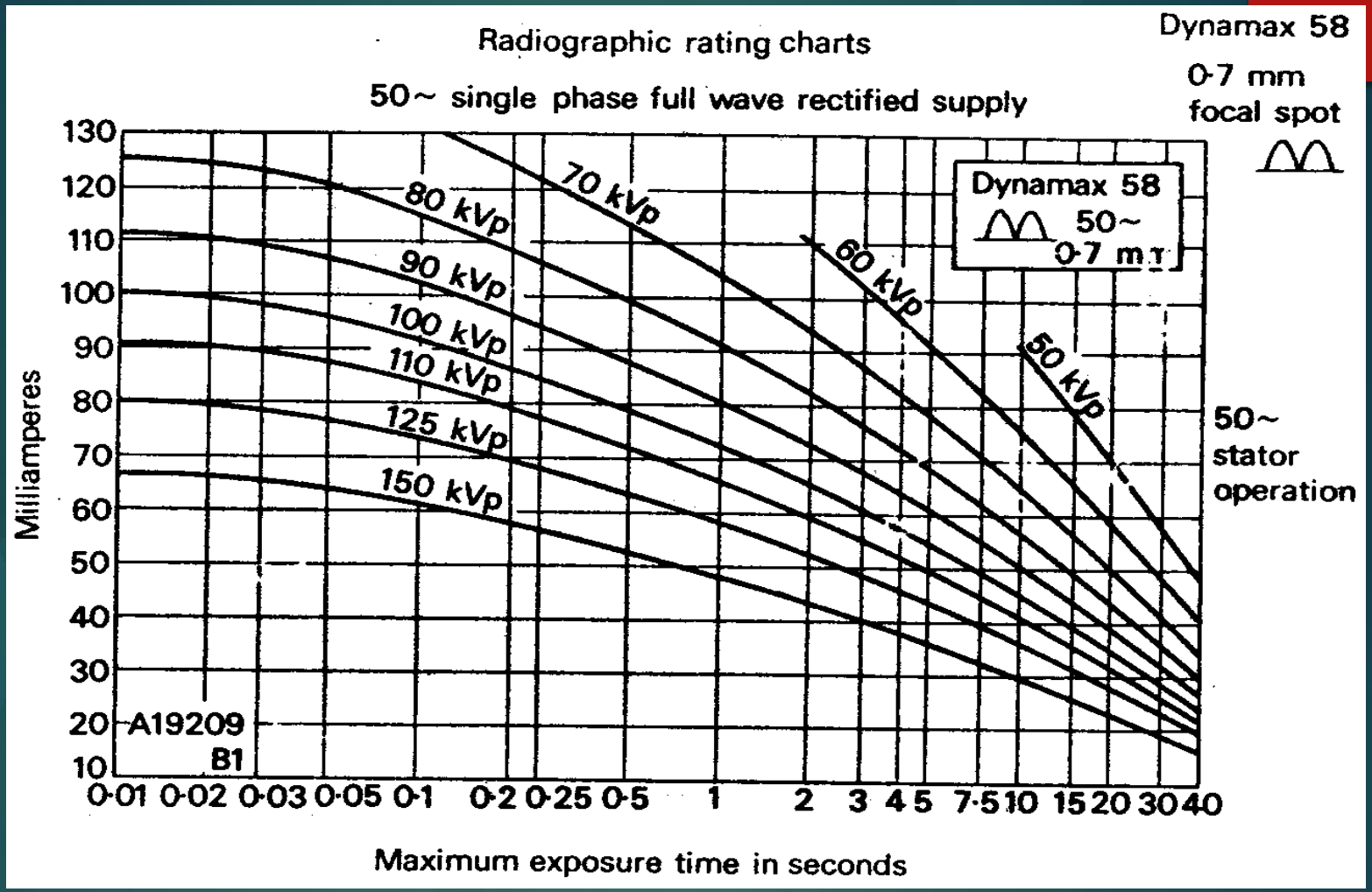
Radiographic rating charts/tube rating charts

- All rating chart plot mA, kV and time (sec)

- Serves as a guide for selecting maximum exposure factor combinations that can be used without overheating the tube.

- Each tube and each filament (Double focus) has a unique radiographic tube rating chart.

- Hence the radiographer must ensure that the correct chart is consulted.



Combination of factors at or under the curve is safe

Anode cooling charts

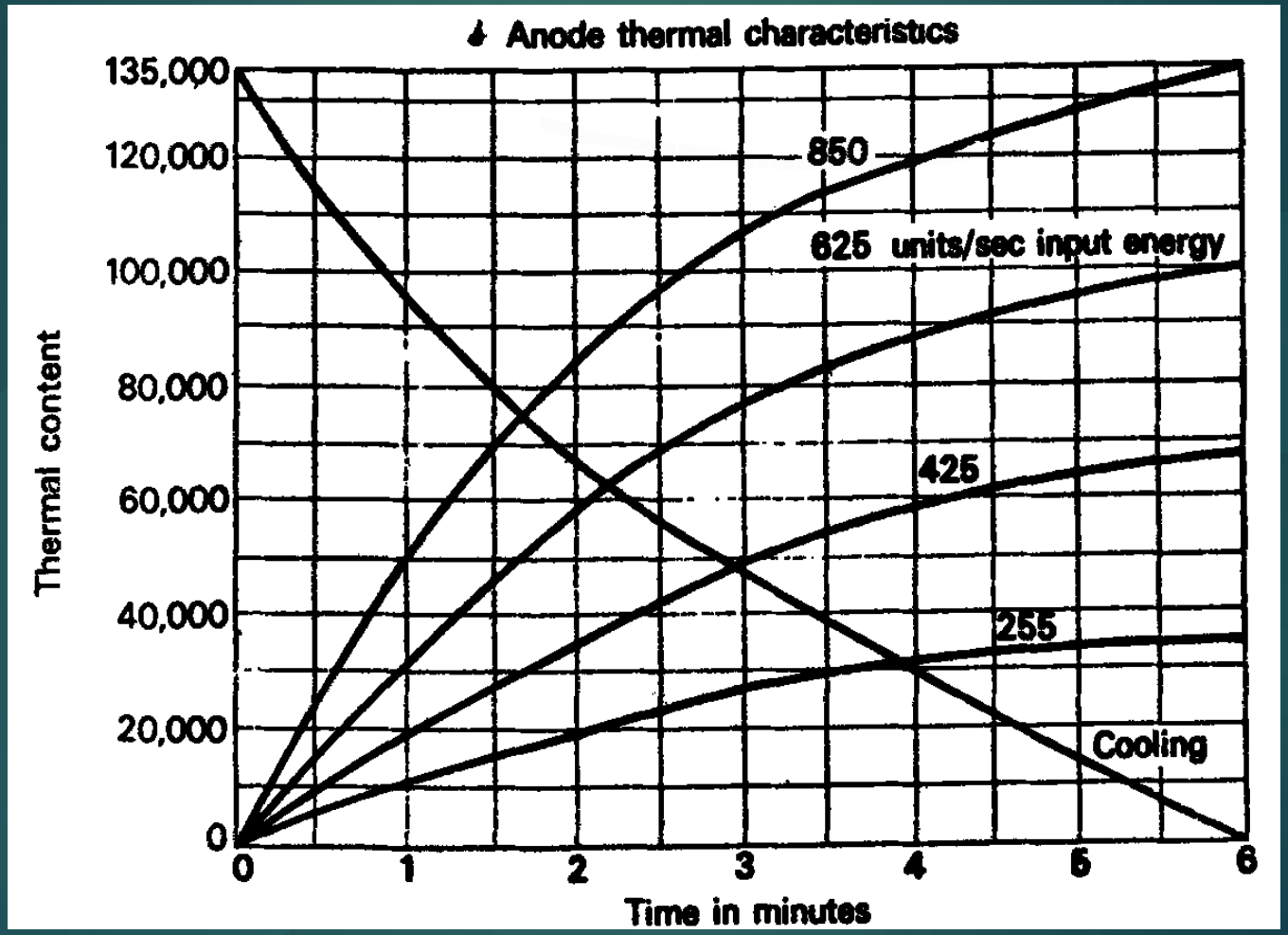
Rating charts are applicable only for cold anode (i.e anode at room temperature)

Rating chart cannot be applied for a tube which is already heated from the previous exposures.

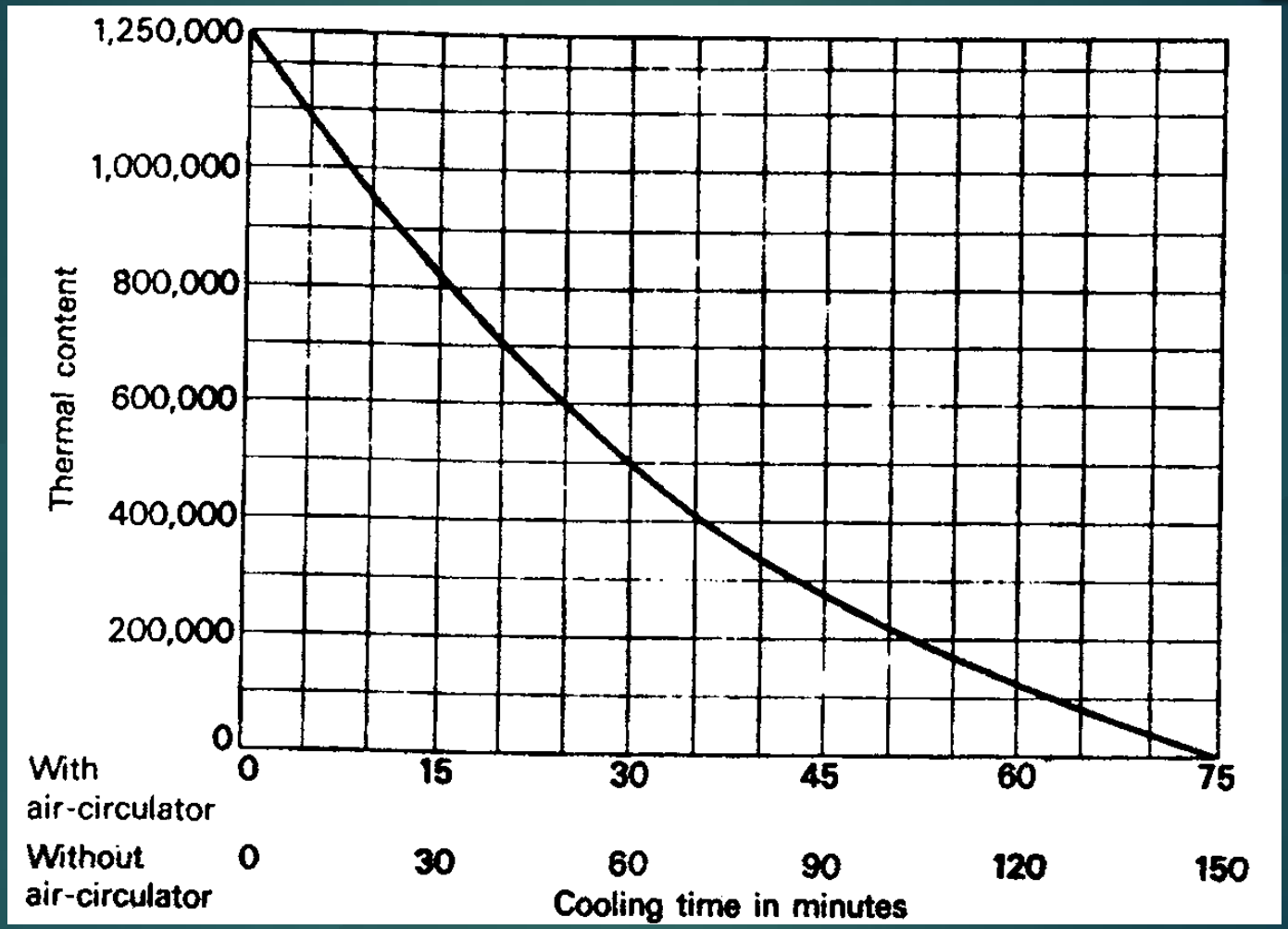
Hence cooling chart is provided to determine the cooling time that is required between exposures for loading the tube for the fresh exposure.

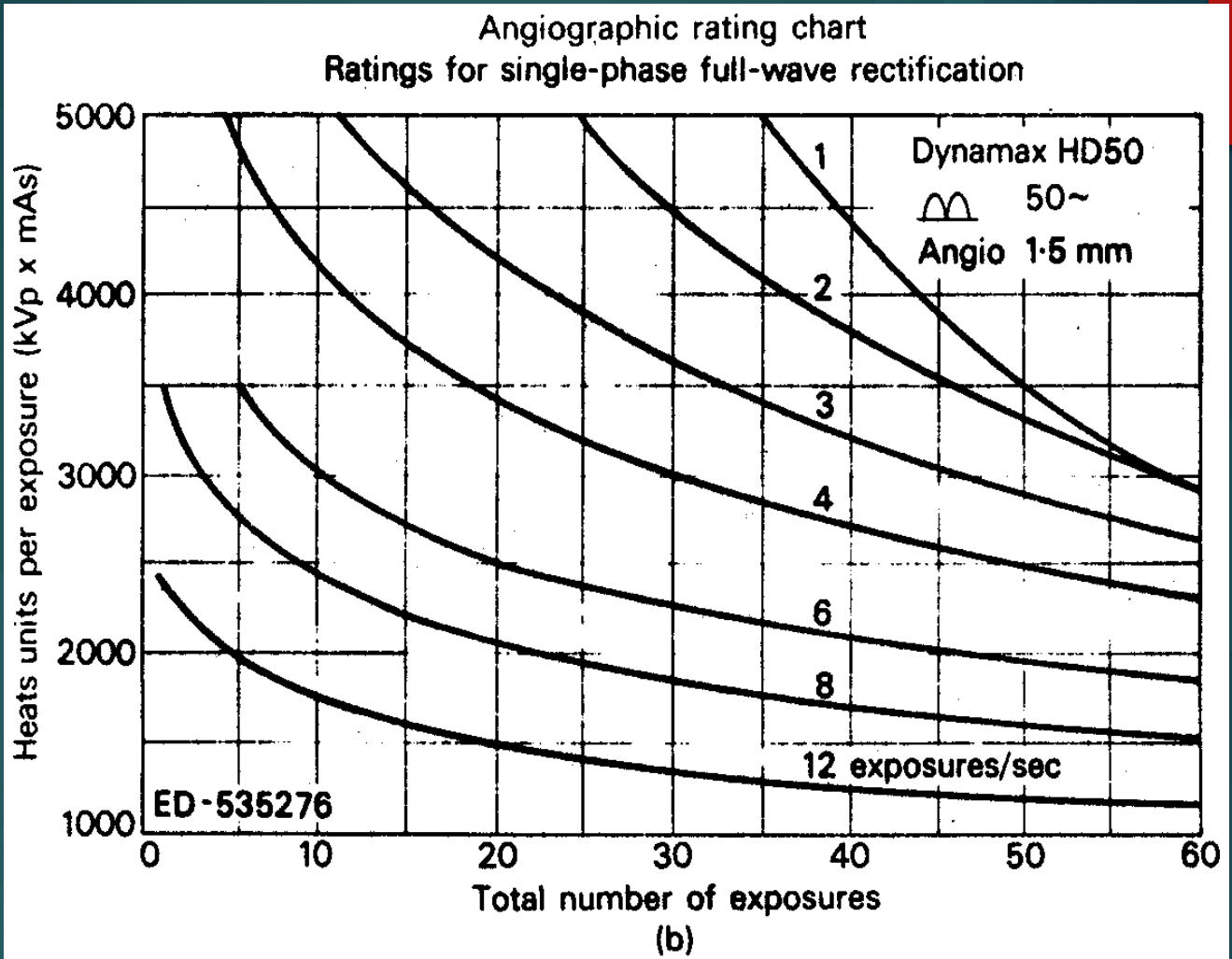
ANODE THERMAL CHARACTERISTICS

Without air circulator



COOLING CHART FOR TUBE UNIT





An exposure factors of 100 kV, 300 mA and 0.05 sec generate 1500 HU

For this much heat generation 20 exposures can be made at the rate of 12 exposures per second

RATING ON THE BASIS OF GENERATOR TYPE AND FOCAL SPOT SIZE AND EXPOSURE TIME

Large and small focal spot

- low rating for single phase generators
- Higher rating for all other generators

Exposure time

- Short exposure → Low rating for single phase system
- Difference in ratings for small and large focus will be prominent at short exposures and less prominent at longer exposures
- Single phase generators can have more ratings at very longer exposures compared to other generators

FAULTS IN X-RAY TUBES

The glass envelope

Vapourization of tungsten filament & anode→ Filament formation on the inner side of glass envelope→ Additional filtration for x-ray beam→Reduces the insulation of x-ray tube

The anode

Over loading the tube→ Roughening of smooth target→ Affect the resolution of radiograph→ Less uniformity in the useful x-ray beam

Heavy load on cold target→ cracking of anode→ Imbalance in the rotation of anode→ stress on ball bearings → electron beam through the crack can puncture the glass tube

Warming up is necessary before first exposure for non-stress relieved anodes

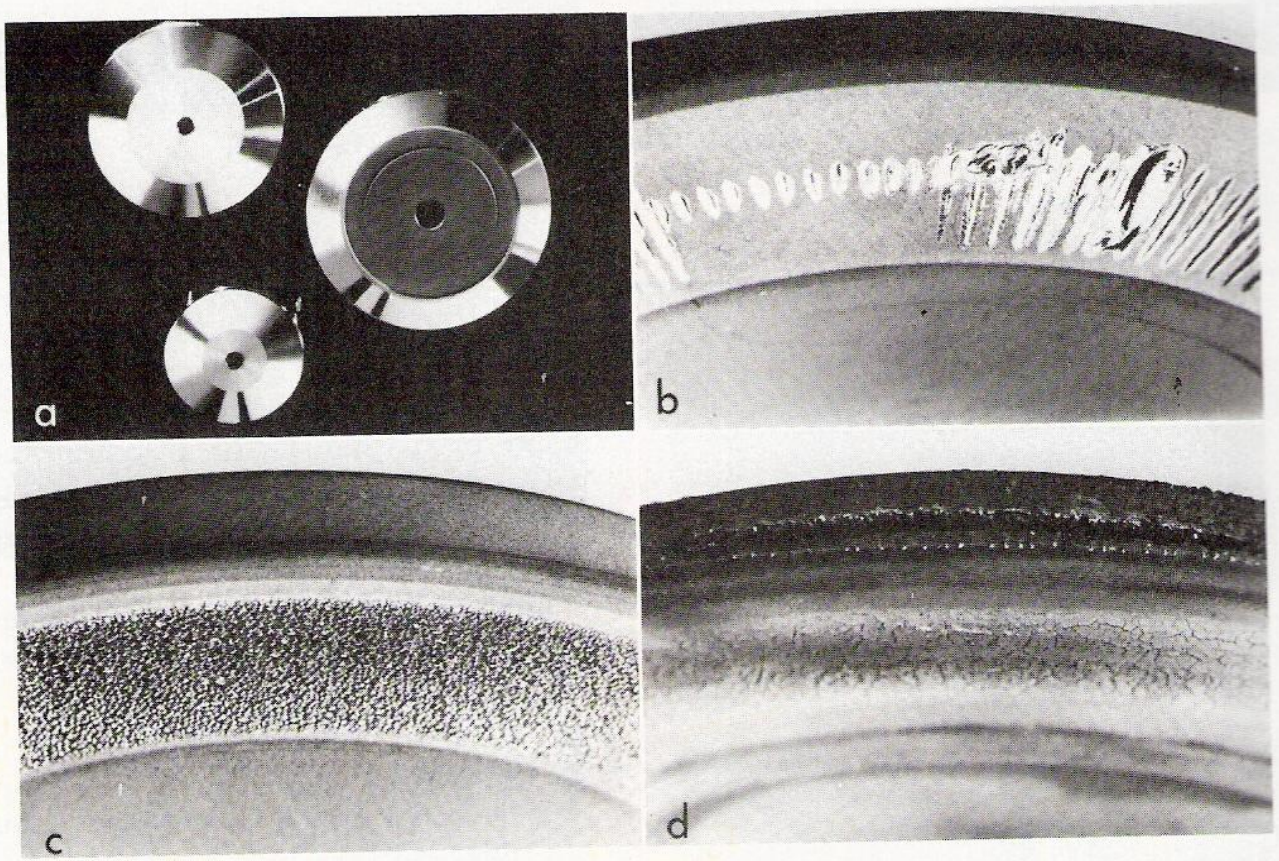


FIGURE 10-14 Comparison of smooth, shiny appearances of rotating anodes when new, **A,** and their appearance after failure, **B** to **D.** Examples of anode separation and surface melting shown were caused by slow rotation caused by bearing damage **(B),** repeated overload **(C),** and exceeding of maximum heat storage capacity **(D).** *(Courtesy The Machlett Laboratories.)*

FAULTS IN X-RAY TUBES (Contd..)

Over heating of anode → distortion of focal spot/ anode angle→ geometric un-sharpness in the radiograph

The Rotor and its Bearing

Wear in the bearings is a deteriorating process effected by → unnecessary rotation of anode→ speed of anode rotation→ Loading of the tube when anode is cold→ inefficiency of dry lubricants as compared to oil and greases→ the heat to which ball bearings are subjected to

The Stator Winding

Fault in winding → No power supply for anode rotation

Circuit arrangements in newer x-ray units to prevent exposure if stator is without its power supply.

Filament

Failure of filament to heat

Reasons → Break in the filament → Fault in the filament circuit

Safe loading of the machine reduces filament vapourisation and avoids the filament to become thinner.

Failure of filament heating will not produce filament current and x-ray exposure → This can be checked from mA meter→ No tube current→ No meter reading

Unsteady tube current→ Unsteady meter reading

Filament break during the exposure → Meter reading goes to zero indication amidst the exposure

Faults in vacuum

Gassy tube → ionization of gas molecules→ additional electrons→ meter reading will indicate the increasing current

Positive ions→ Bombardment of filament

The tube life can be increased by:

Rating it only with safe operating parameters as recommended by the rating & cooling charts

Operating it after necessary warming exposures before the first exposure of the day

Preparing it with the delay switch only for the optimum time