SAWA UNIVERSITY

اساسيات الفيزياء الشعاعية/ الكورس الاول

HEAT UNITS



Sawa University	جامعـــــــة ســـــــاوة الاهلية
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Second Stage	المرحلـــــــــــــة الثانية

الجانب العملي

Practical

محاضرة رقم (2)

Lecture No. (2)

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(INTRODUCTION)

In diagnostic radiology, the X-ray tube operates under strict physical and thermal limitations. Each exposure produces not only useful X-rays but also significant heat. To prevent tube damage and prolong its life, radiographers must understand the concept of heat units (HU), interpret tube rating charts, and apply anode cooling charts effectively.

(HEAT UNITS (HU))

Heat Units (HU) are a standardized measure of thermal energy generated in the X-ray tube during exposure. They allow radiographers to quantify the thermal stress placed on the anode.

Formula:

$$HU = kVp \times mA \times time \times constant$$

Where:

kVp = tube voltage

mA = tube current

time = exposure time (s)

constant = correction factor for generator type

(GENERATOR CONSTANTS)

- Single-phase: 1.0.
- Three-phase, 6-pulse: 1.35.
- Three-phase, 12-pulse: 1.41.
- High-frequency generator: 1.45

These constants reflect waveform efficiency, since high-frequency systems deliver more consistent voltage and higher heat loads.

(EXAMPLE CALCULATION OF HU)

- Exposure: 80 kVp, 200 mA, 0.2 sec, 3-phase, 12-pulse system.

$HU = 80 \times 200 \times 0.2 \times 1.41 = 4512\ HU$

This means the anode absorbed 4512 heat units during this exposure.

(CLINICAL IMPORTANCE OF HEAT UNITS)

- Prevents thermal overloading of the tube.
- Helps select safe exposure parameters.
- Guides radiographers in sequential imaging (e.g., fluoroscopy, CT scans).
- Reduces risk of tube failure and costly downtime.

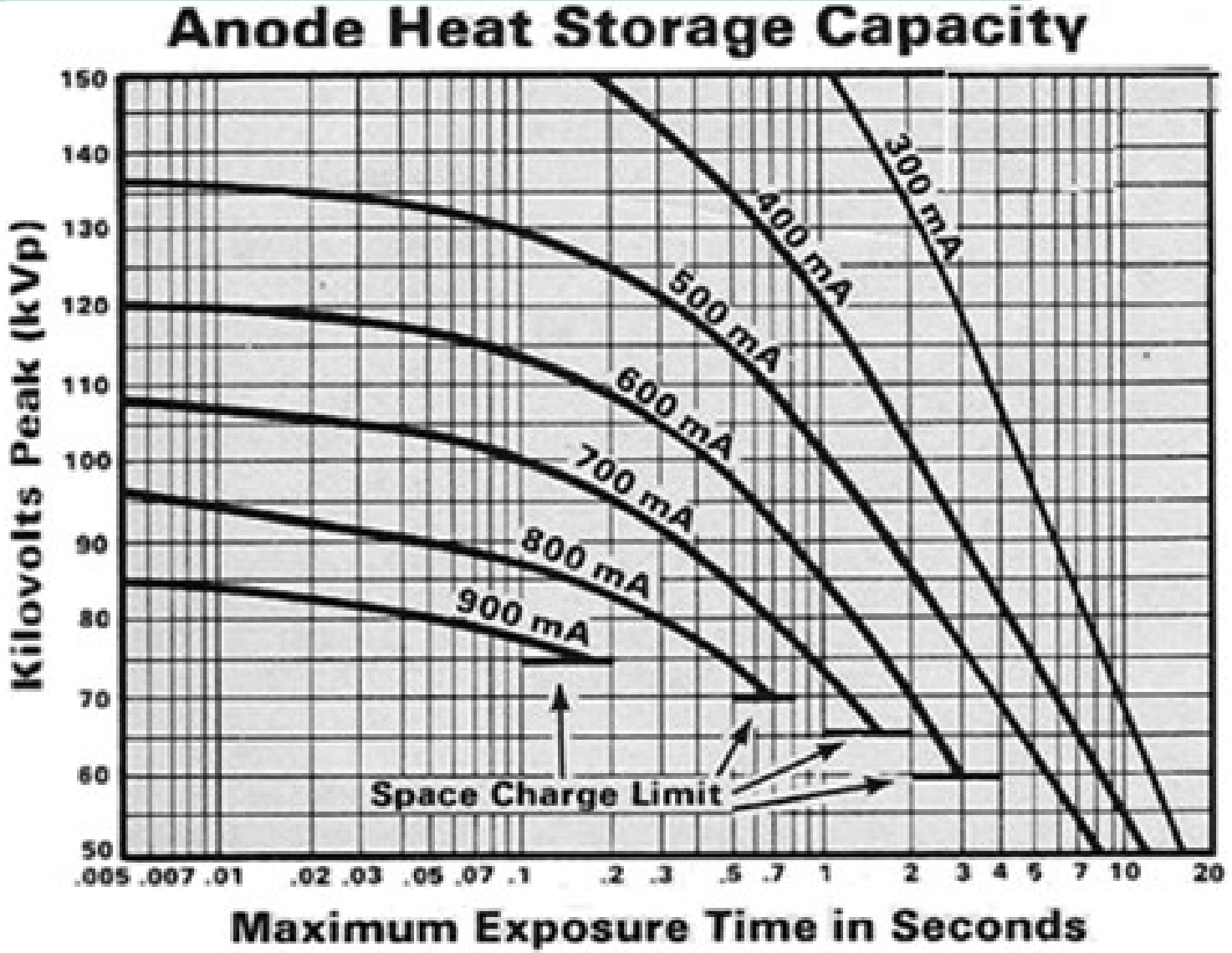
(TUBE RATING CHART)

Tube rating charts are manufacturer-provided graphs that show safe combinations of kVp, mA, and exposure time for a specific X-ray tube. Any exposure above the curve is unsafe and risks tube damage.

(READING A TUBE RATING CHART)

- X-axis = exposure time (ms or s).
- Y-axis = tube current (mA).
- Curves plotted at various kVp values.To use: locate the chosen kVp, then cross-check the exposure time and mA. If the point lies **below the curve**, the exposure is safe; if **above**, it exceeds tube capacity.

(READING A TUBE RATING CHART)



(IMPORTANCE OF TUBE RATING CHARTS)

- Prevents accidental tube burnout.
- Helps in protocol design (e.g., chest radiography vs CT scan).
- Ensures longer lifespan of X-ray equipment.
- A teaching tool for students to understand safe limits.

(ANODE COOLING CHART)

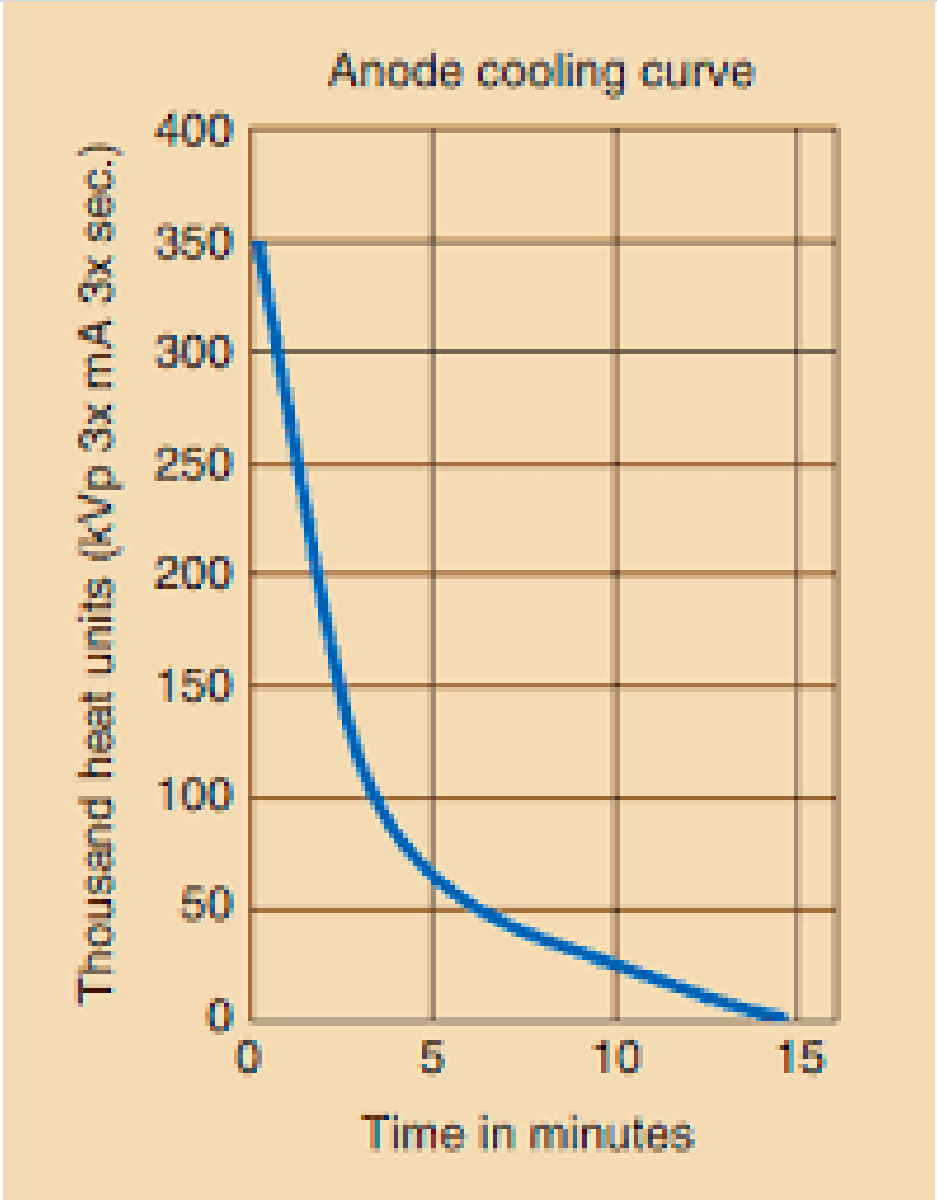
Even when operated within safe limits, anodes heat up with repeated exposures. Anode cooling charts graphically represent how quickly the anode loses heat between exposures.

(STRUCTURE OF ANODE COOLING CHART)

- Y-axis = anode heat units (HU).
- X-axis = time (minutes).

The curve shows the natural exponential cooling of the anode. Radiographers can use this chart to determine how long they must wait before making another high-load exposure.

(STRUCTURE OF ANODE COOLING CHART)



(EXAMPLE: COOLING REQUIREMENT)

After a series of exposures, the anode has accumulated 200,000 HU. If the chart shows that the anode cools to 100,000 HU in 2 minutes, then the radiographer must wait at least 2 minutes before the next full exposure.

(PRACTICAL APPLICATIONS)

- Fluoroscopy & Interventional Radiology: Multiple high-dose exposures require cooling management.
- CT Scanning: Continuous rotation generates significant heat; charts prevent overheating.
- Trauma Imaging: Fast sequences must balance patient needs with safe tube operation.

(SUMMERY)

- Heat management in X-ray tubes is critical to safe and efficient radiology.
- Heat Units quantify exposure-related heat.
- Tube Rating Charts guide safe combinations of kVp, mA, and time.
- Anode Cooling Charts ensure adequate waiting times between exposures.
- Mastery of these tools allows radiographers to operate within safe limits, protect expensive equipment, and deliver reliable diagnostic imaging.

(QUIZ)

Q1 . Which of the following generator types produces the highest heat units (HU) for the same exposure factors?

A) Single-phase. B) Three-phase, 6-pulse. C) Three-phase, 12-pulse. D) High-frequency.

Q2 –An exposure is made at 90 kVp, 300 mA, and 0.1 sec using a 3-phase, 12-pulse generator. Calculate the heat units (HU) produced.

Q3 –Explain how a tube rating chart is used to determine whether an exposure is safe. Provide an example with parameters (kVp, mA, and exposure time).

Q4 –An anode cooling chart shows that after reaching 150,000 HU, the anode requires 3 minutes to cool to 75,000 HU.If another exposure of 50,000 HU is needed, how long must the radiographer wait before it can be safely performed?

Q5 –Why is heat management in X-ray tubes especially important in CT scanning and interventional radiology compared to routine chest radiography?

Any questions?



Lecture 2 | Practical review: 10 MCQs

One correct answer per question. Correct answers appear in green.

1. What does the generator factor modify in HU calculation?
A. Waveform-dependent heat ✓ B. Patient distance
C. Anode angle D. Detector size
E. Field area

2. At 80 kVp, 200 mA, 0.2 s, factor 1.41, HU =
A. 3,200 **B. 4,512 ✓**
C. 5,120 D. 11,280
E. 45,120

3. Which generator factor is largest in this lecture?
A. 1.00 B. 1.10
C. 1.35 D. 1.41
E. 1.45 ✓

4. Which variables appear on a typical tube rating chart?
A. Time and mA ✓ B. Time and SID
C. Filtration and kVp D. Dose and contrast
E. Temperature and SID

5. For a specified kVp, a point above the tube rating curve is:
A. Unsafe ✓ B. Always safe
C. A cooling interval D. The target angle
E. Zero heat

6. What does an anode cooling chart relate?
A. Stored HU and time ✓ B. mA and field size
C. kVp and contrast D. Distance and kerma
E. Time and image size

7. Why check cooling after repeated exposures?
A. Heat accumulates ✓ B. kVp rises automatically
C. Z changes D. SID decreases
E. mA becomes negative

8. If 200,000 HU cools to 100,000 HU in 2 min on a chart, wait:
A. 0 s B. 30 s
C. 1 min **D. At least 2 min ✓**
E. 10 min exactly

9. A tube rating chart must be selected for the:
A. Specific tube and focal spot ✓ B. Any department tube
C. Patient weight only D. Monitor type
E. Film cassette

10. At fixed kVp and factor, doubling mAs approximately:
A. Doubles HU ✓ B. Halves HU
C. Changes target Z D. Doubles peak energy
E. Leaves HU unchanged