

READING
HOSPITAL
SCHOOL OF
HEALTH
SCIENCES

MEDICAL
IMAGING
PROGRAM

UNIT 3 – THE X-RAY TUBE

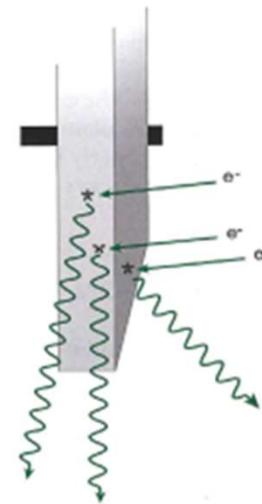
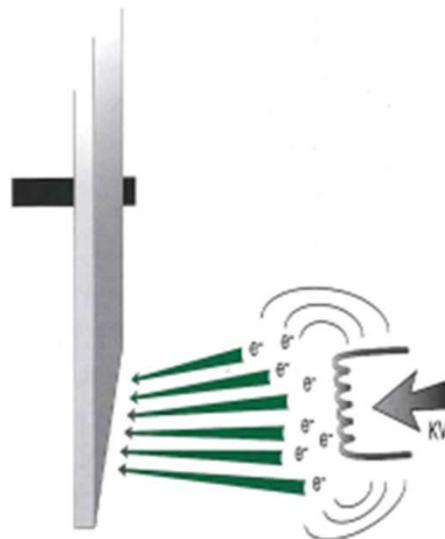
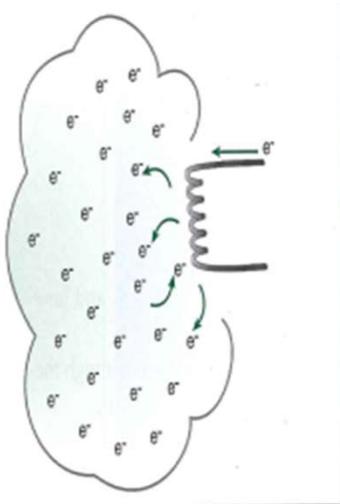
MI 132
2022-2023

LEARNING OBJECTIVES

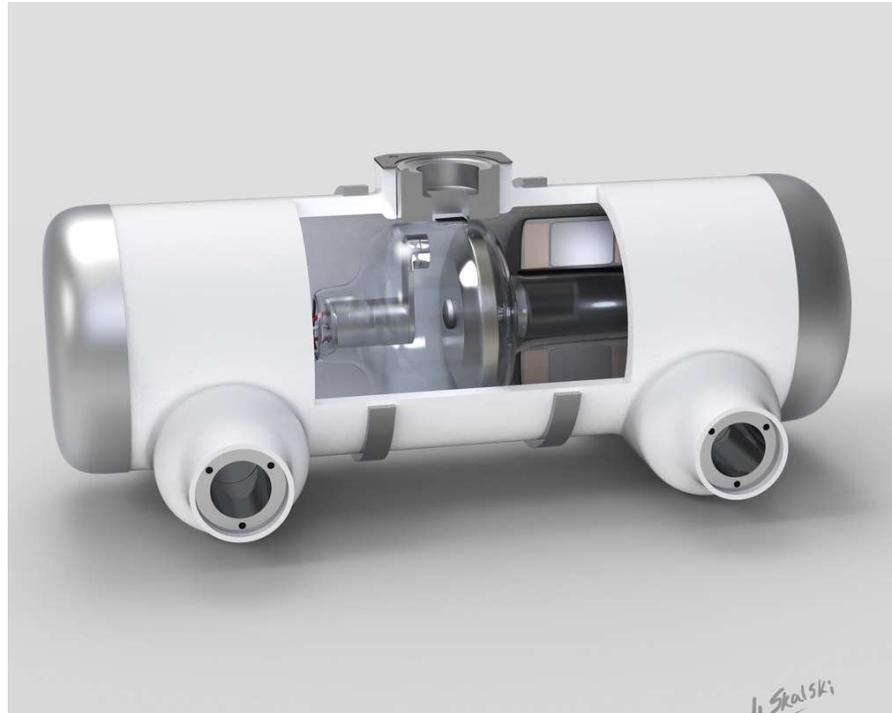
- List the four essential conditions for the production of x-rays to occur and how each is met.
- Identify and describe the components and function of diagnostic x-ray tubes.
- Discuss the construction and identify the purpose of the envelope and the protective housing.
- Discuss characteristics of the anode and anode targets in terms of materials used and construction.
- Identify the components and describe the function of a rotating anode and induction motor
- Explain the line focus principle
- Explain the anode heel effect

4 CONDITIONS NECESSARY FOR X-RAY PRODUCTION

1. **Source** of electrons
2. **Acceleration** of electrons
3. **Focusing** of electrons
4. **Deceleration** of electrons



WHAT IS THE PURPOSE OF THE PROTECTIVE HOUSING:

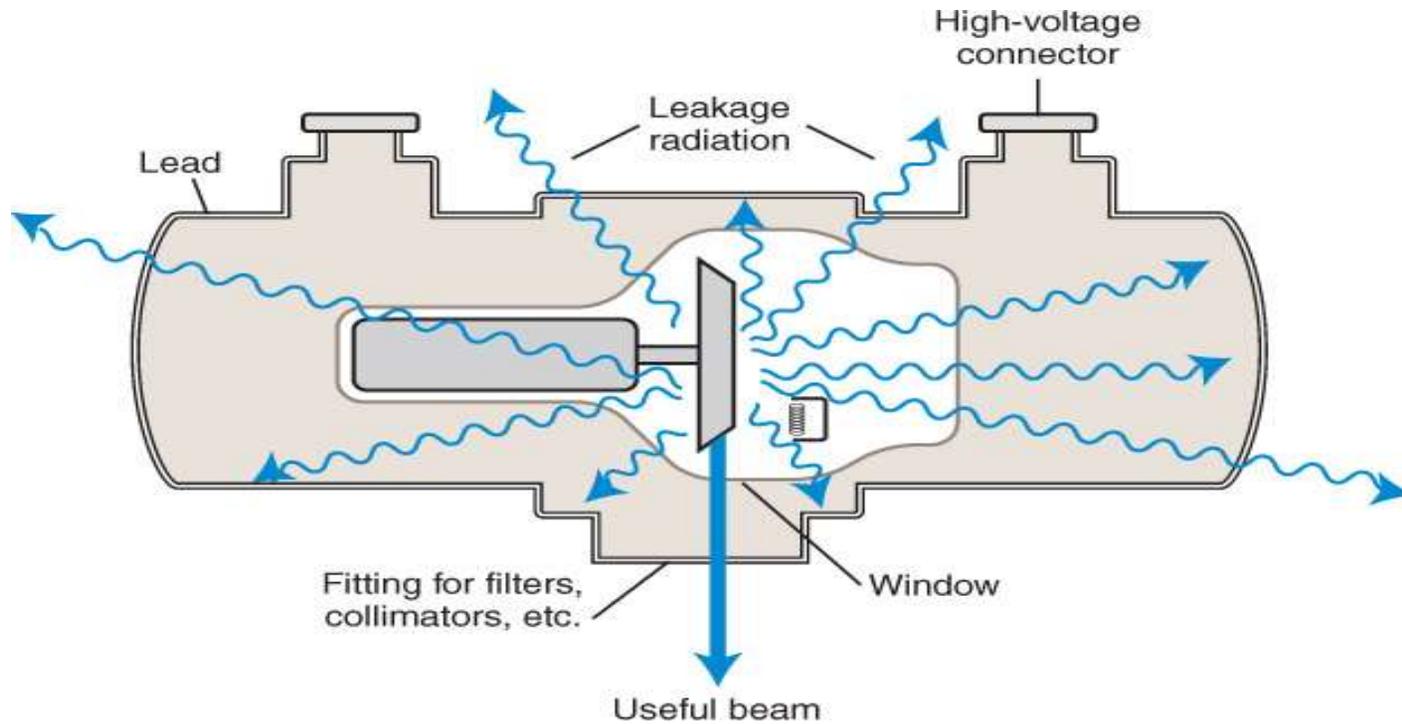


WHAT ARE THE COMPONENTS OF THE PROTECTIVE HOUSING AND WHAT DOES EACH DO?

- Get into groups of 2 and identify the components of the protective housing including the purpose for each component

1. Oil bath - dissipate heat
2. Cooling fans - circulate air, dissipates heat
3. Electrical cables -
4. Lead lining - reduces leakage radiation
5. High voltage receptacles - prevent electrical shock

WHAT IS LEAKAGE RADIATION?

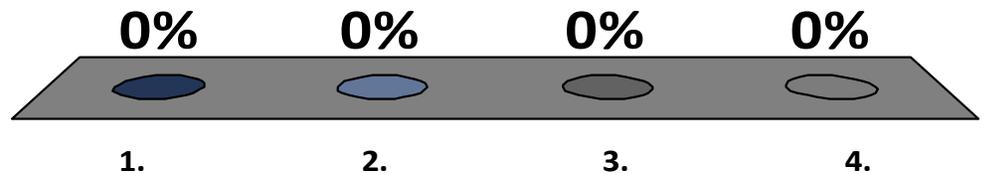


WHAT ARE THE 3 COMPONENTS OF THE X-RAY TUBE AND WHAT ARE THEY ENCASED IN?

- Anode, cathode, induction motor
- Encased in envelope

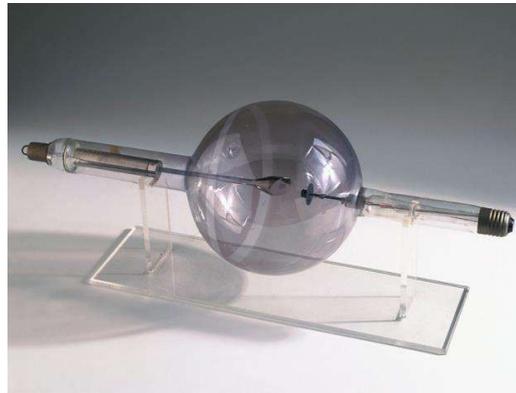
THE MAIN PURPOSE OF THE ENVELOPE IS TO:

1. Focus electrons
2. Provide thermionic emission
3. Create x-rays
4. Provide a vacuum





Crookes Tube

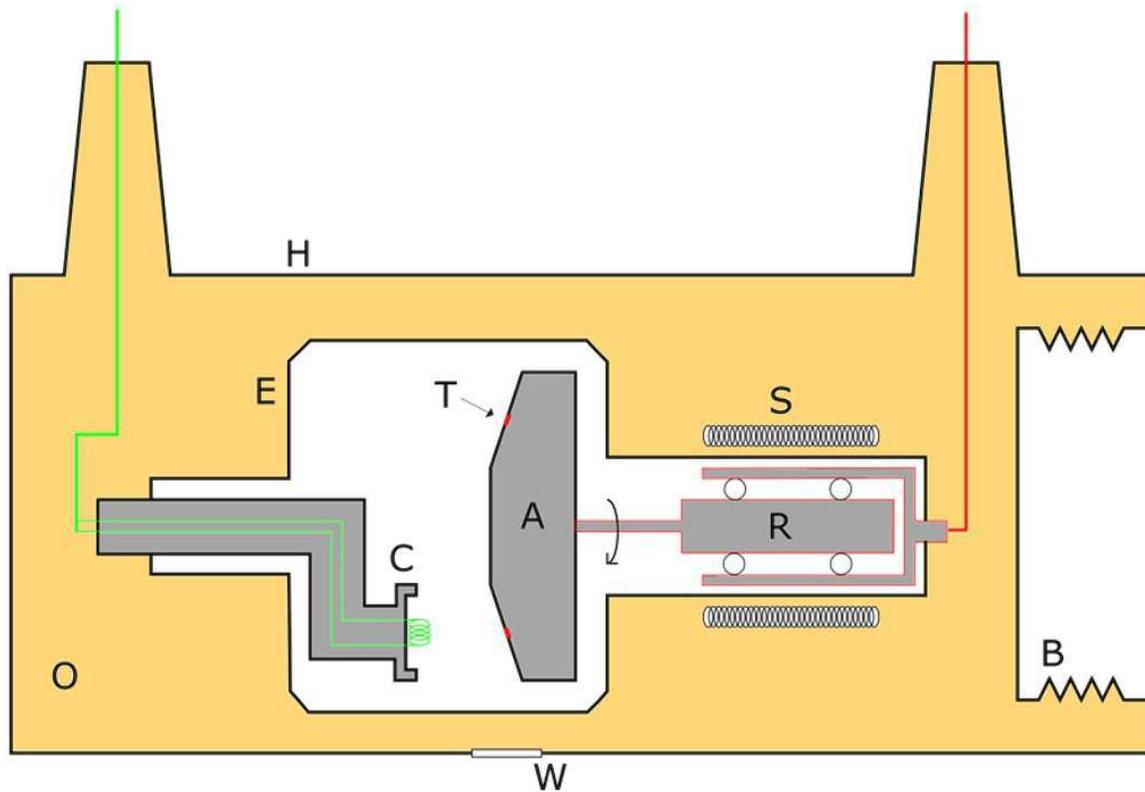


Coolidge Tube



Modern Tube

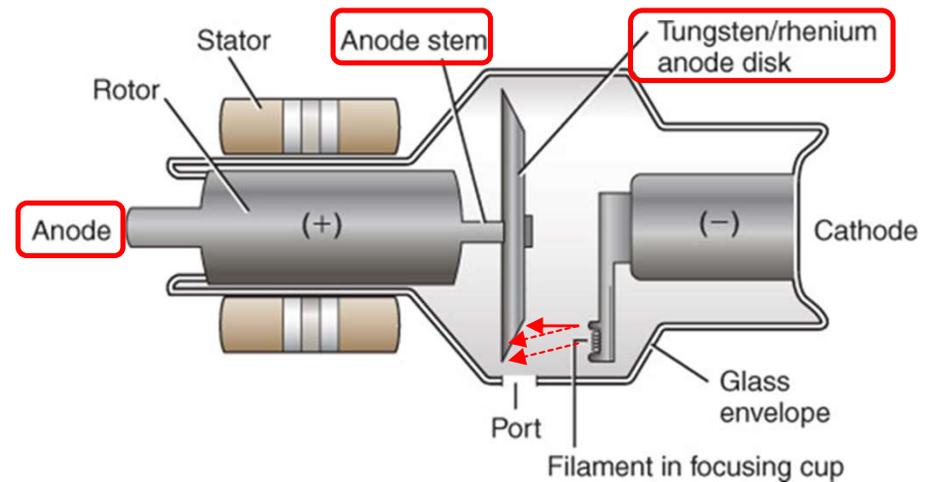
WHAT TYPE OF ENVELOPE BEST EXTEND
TUBE LIFE AND WHY?



WHAT AREA ON THE ENVELOPE IS THE DESIRED EXIT POINT FOR X-RAY PHOTONS?

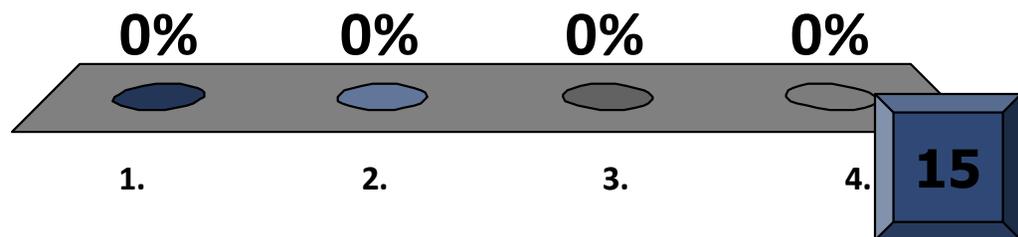
ANODE

- Positive (+)
- Purpose
 - Provides a target
 - Serves as an electrical and thermal conductor



THE ANODE DISC AND STEM ARE MADE OF:

1. Tungsten
2. Molybdenum
3. Rhenium
4. Thorium



WHAT MATERIAL IS ADDED TO THE TUNGSTEN TARGET FOR MECHANICAL STABILITY?

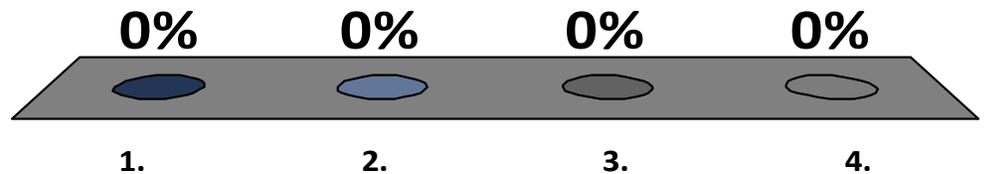
1. Thorium



2. Rhenium

3. Molybdenum

4. Steel



ANODE MATERIALS

- Molybdenum
- Tungsten
- Rhenium
- Copper

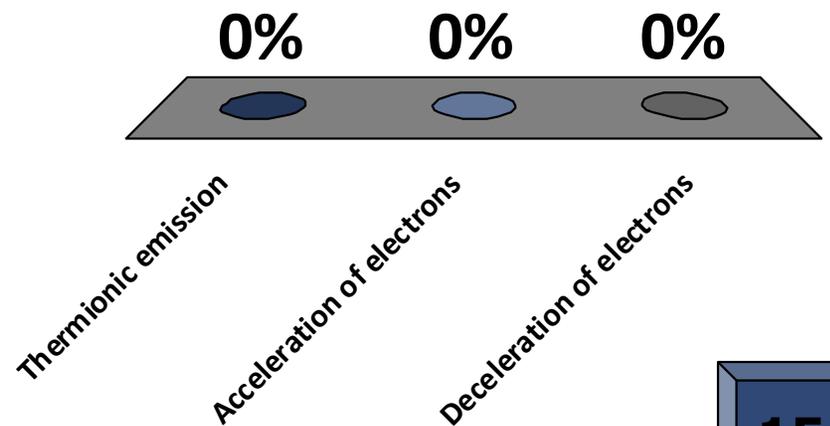


STATIONARY v. ROTATING ANODES



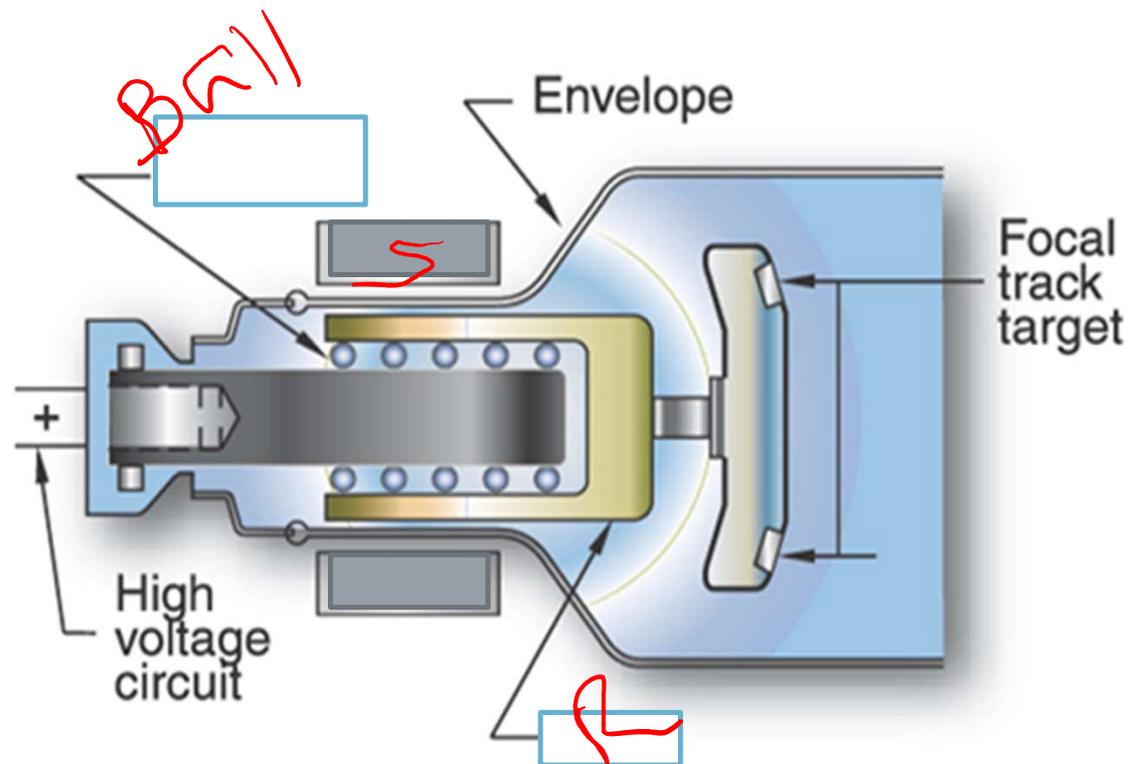
THE ANODE IS RESPONSIBLE FOR:

1. Thermionic emission
2. Acceleration of electrons
3. Deceleration of electrons

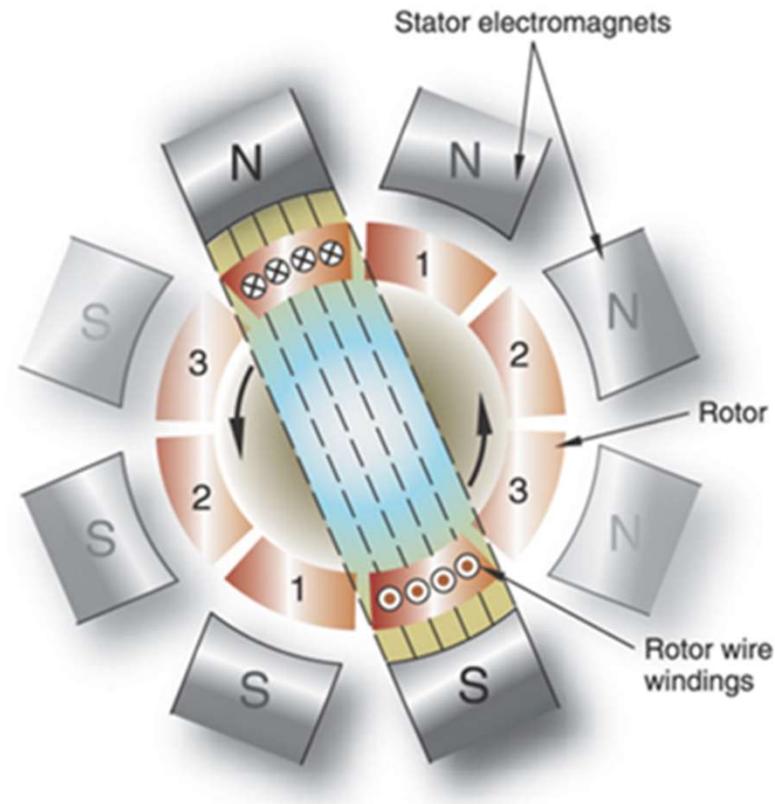


INDUCTION MOTOR

- Describe the components of the induction motor



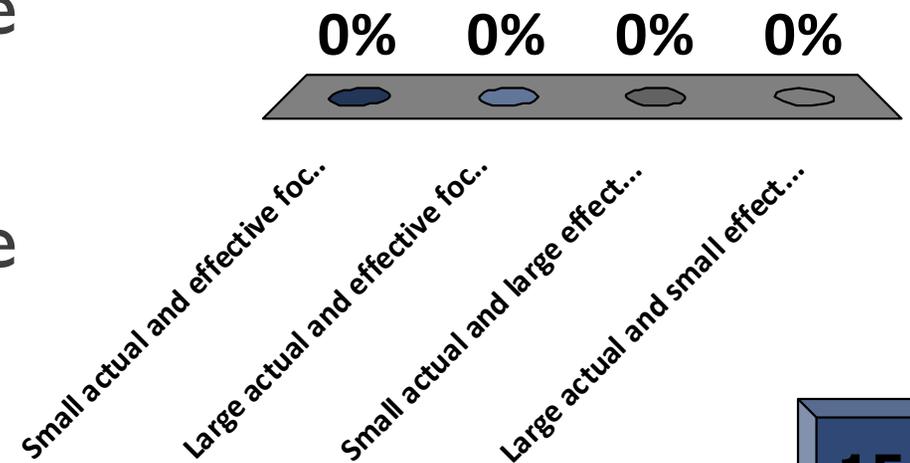
OPERATION OF INDUCTION MOTOR



- Capable of speeds of 3400 rpm for general-purpose tubes and 10,000 rpms for specialty tubes

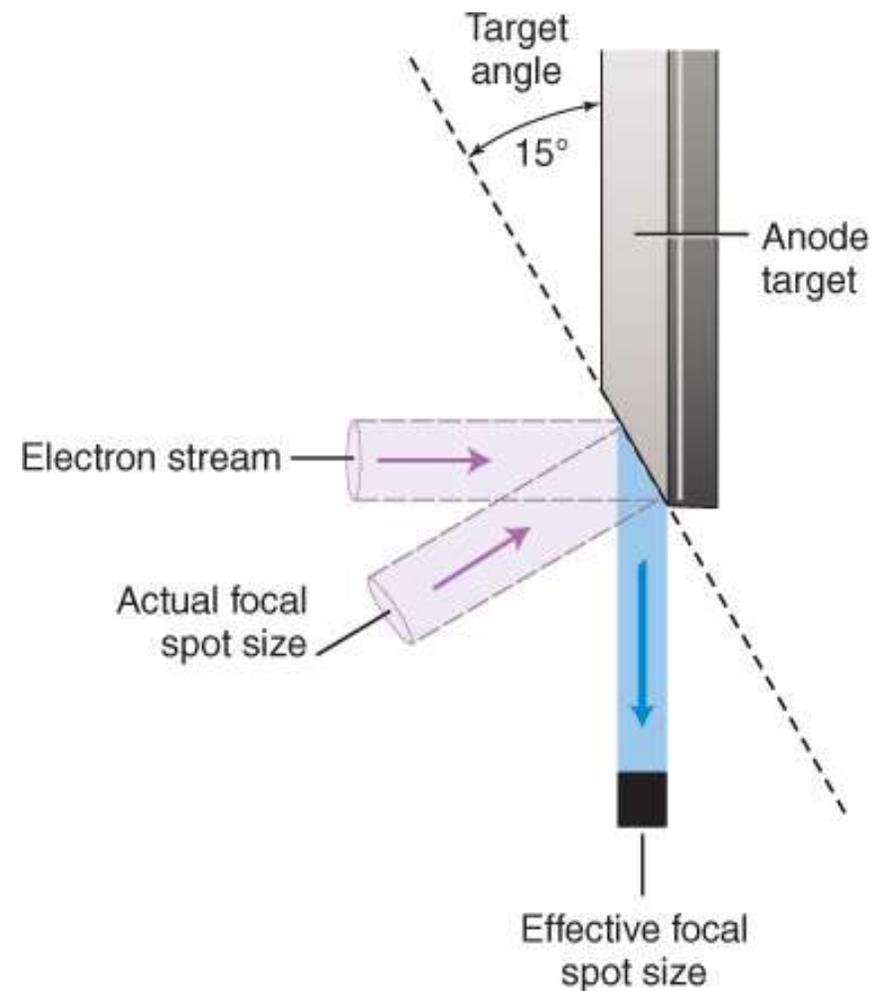
THE PURPOSE OF THE LINE FOCUS PRINCIPLE IS TO CREATE WHICH OF THE FOLLOWING?

- A. Small actual and effective focal spot size
- B. Large actual and effective focal spot size
- C. Small actual and large effective focal spot size
-  D. Large actual and small effective focal spot size

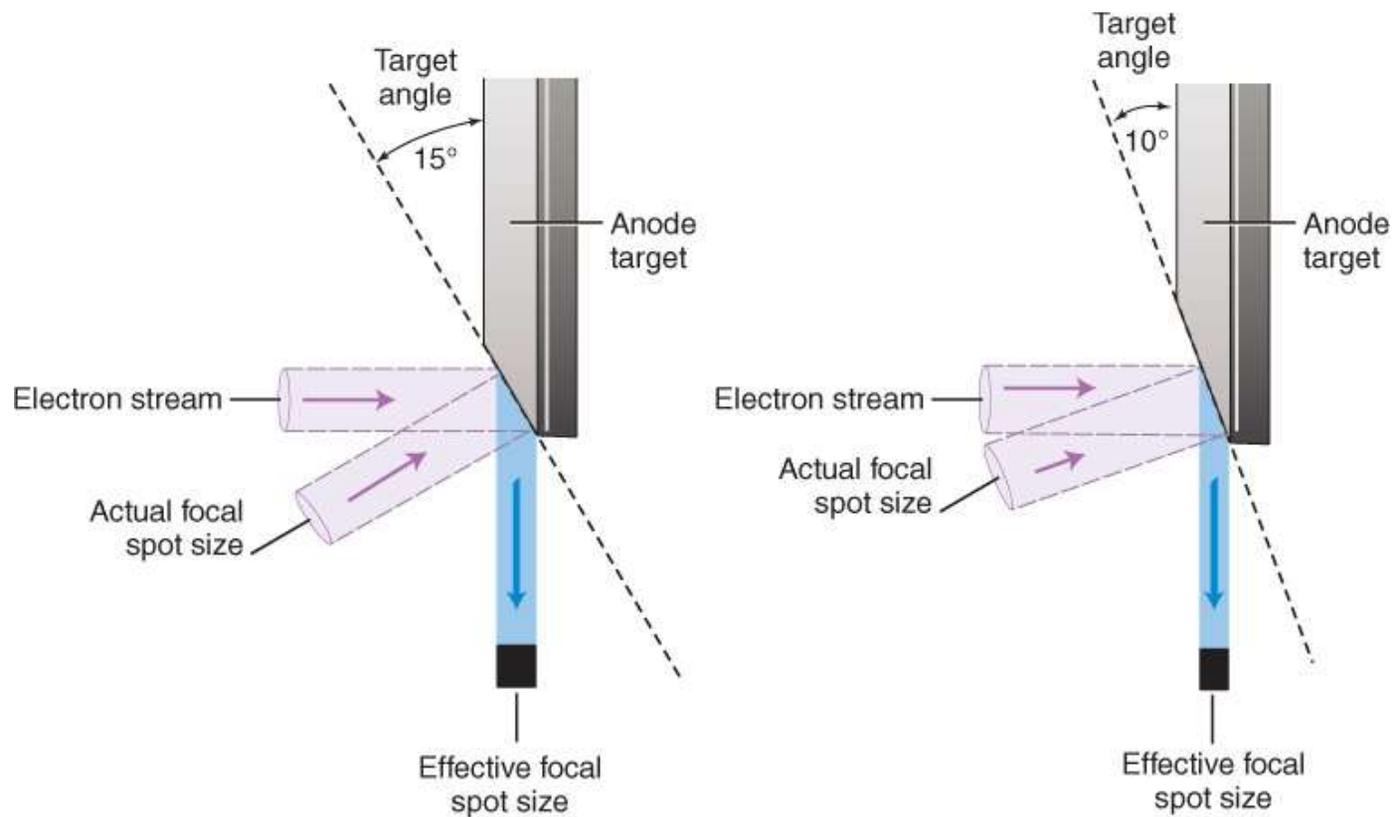


LINE FOCUS PRINCIPLE

- Explain what is meant by effective focal spot size and actual focal spot size.

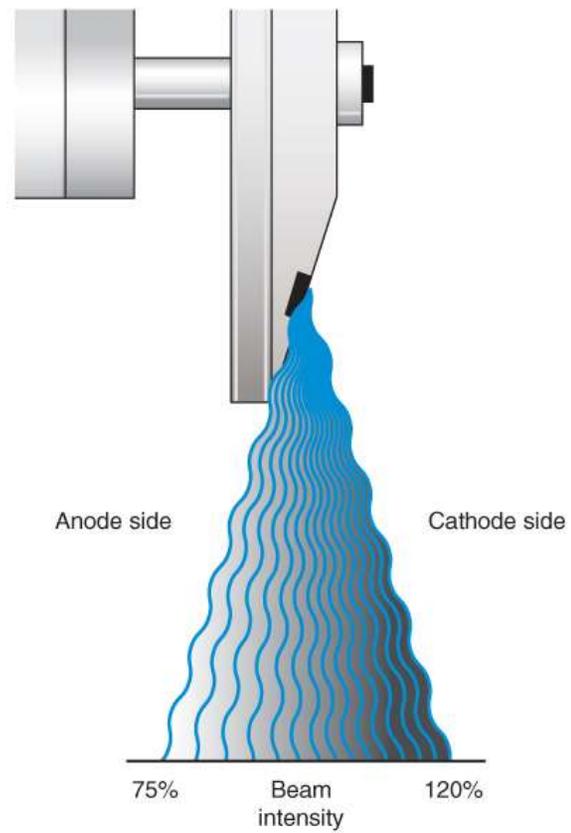


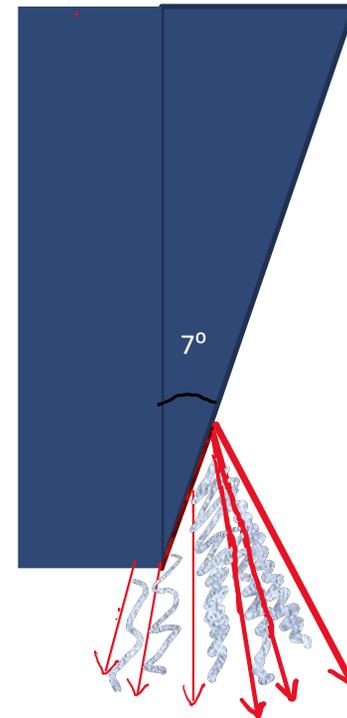
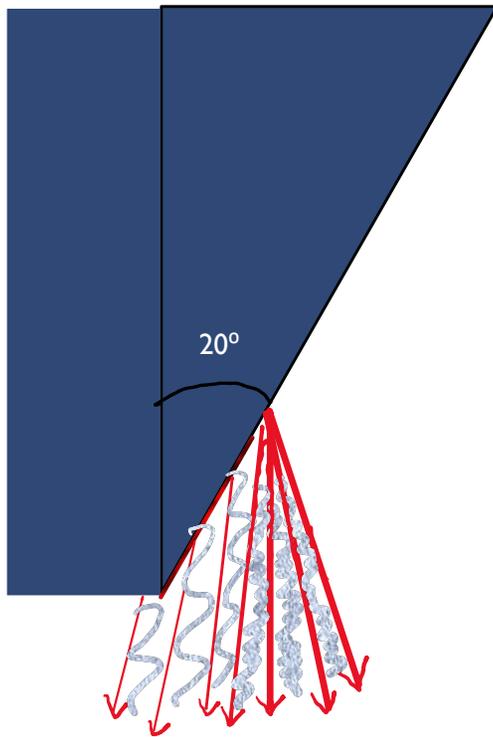
WHICH TARGET ANGLE WOULD WE PREFER?



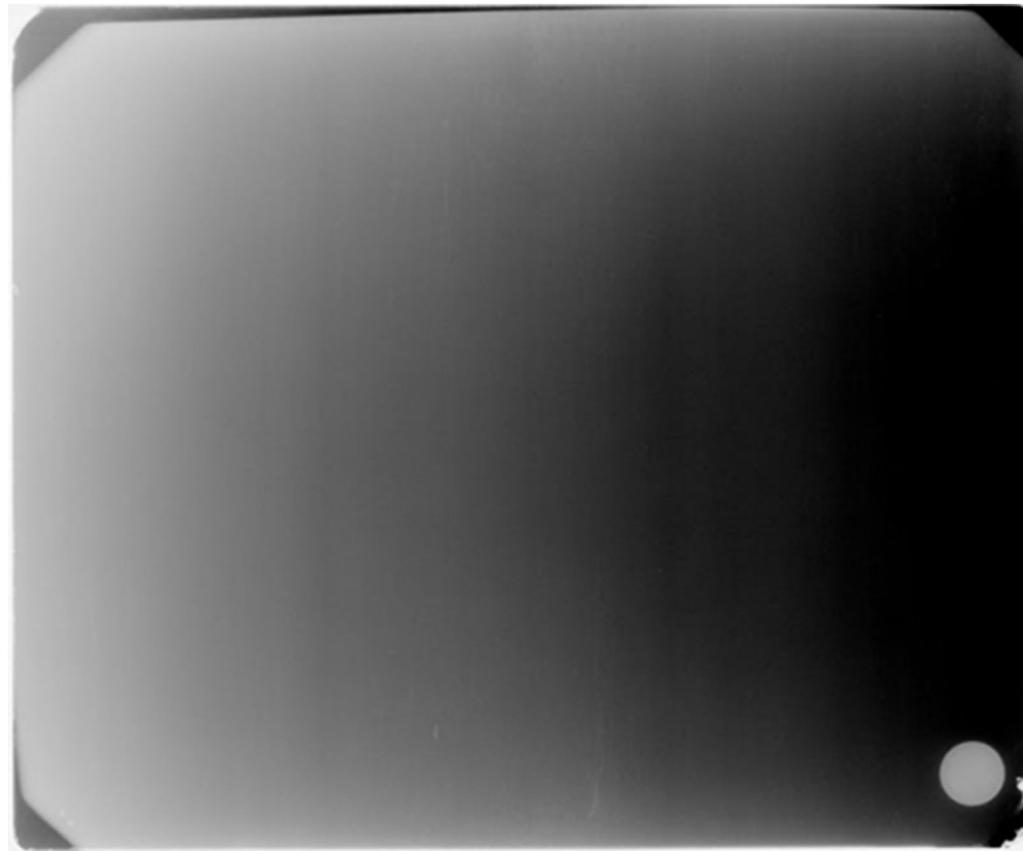
[Focal Spot & Line Focus Principle - YouTube](#)

ANODE HEEL EFFECT



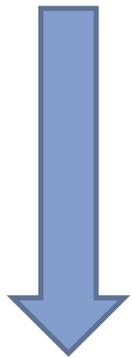


Which target angle will cause an increase in anode heel effect?

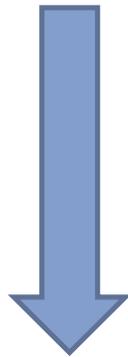


[Anode Heel Effect \(X-Ray Tube\) - YouTube](#)

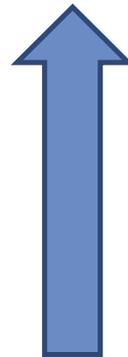
WHAT IMPACT DOES THE ANODE ANGLE, SID, AND FIELD SIZE HAVE ON THE ANODE HEEL EFFECT?



Anode
Angle



SID



Field
Size

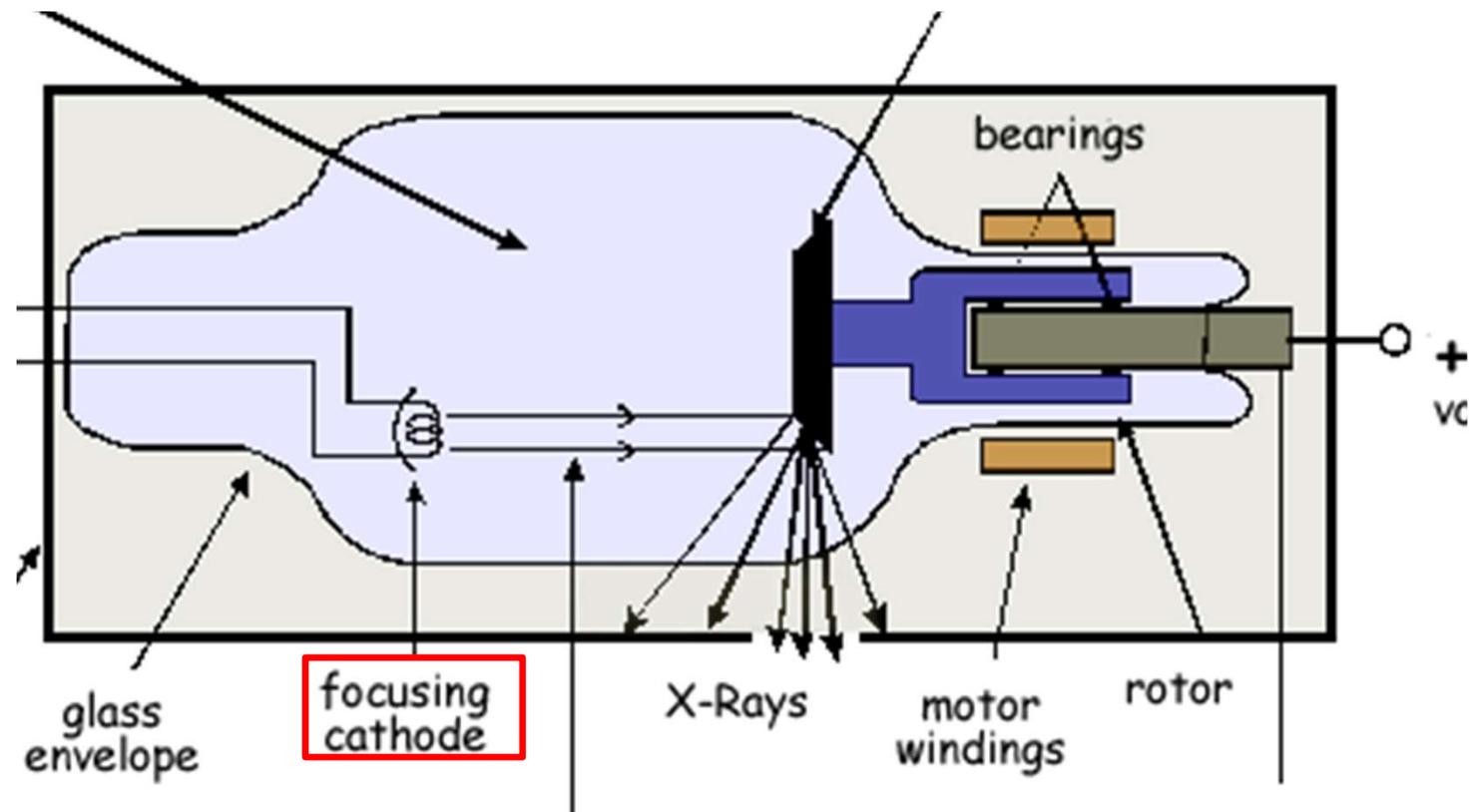


Anode
Heel
Effect

LEARNING OBJECTIVES

- Describe the function of the filament and focusing cup.
- Describe the control of thermionic emission from the filament.
- Discuss the necessary characteristics of filament metals and construction.
- Calculate heat units as specified for specific generator types.
- Use tube rating charts, anode cooling charts and housing cooling charts.
- Employ methods of safe x-ray tube operation and extending x-ray tube life.

WHAT FUNCTION DOES THE CATHODE HAVE IN THE PRODUCTION OF X-RAYS?

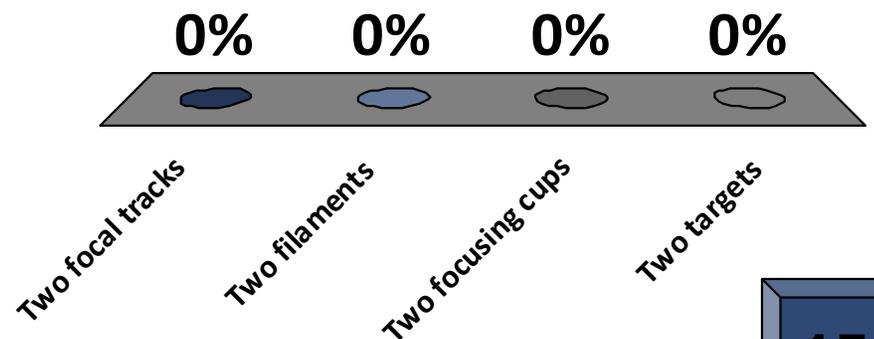


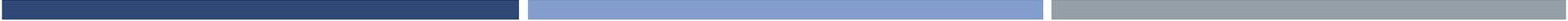
WHAT ARE THE 2 COMPONENTS OF THE CATHODE AND WHAT ARE THEY MADE OF?



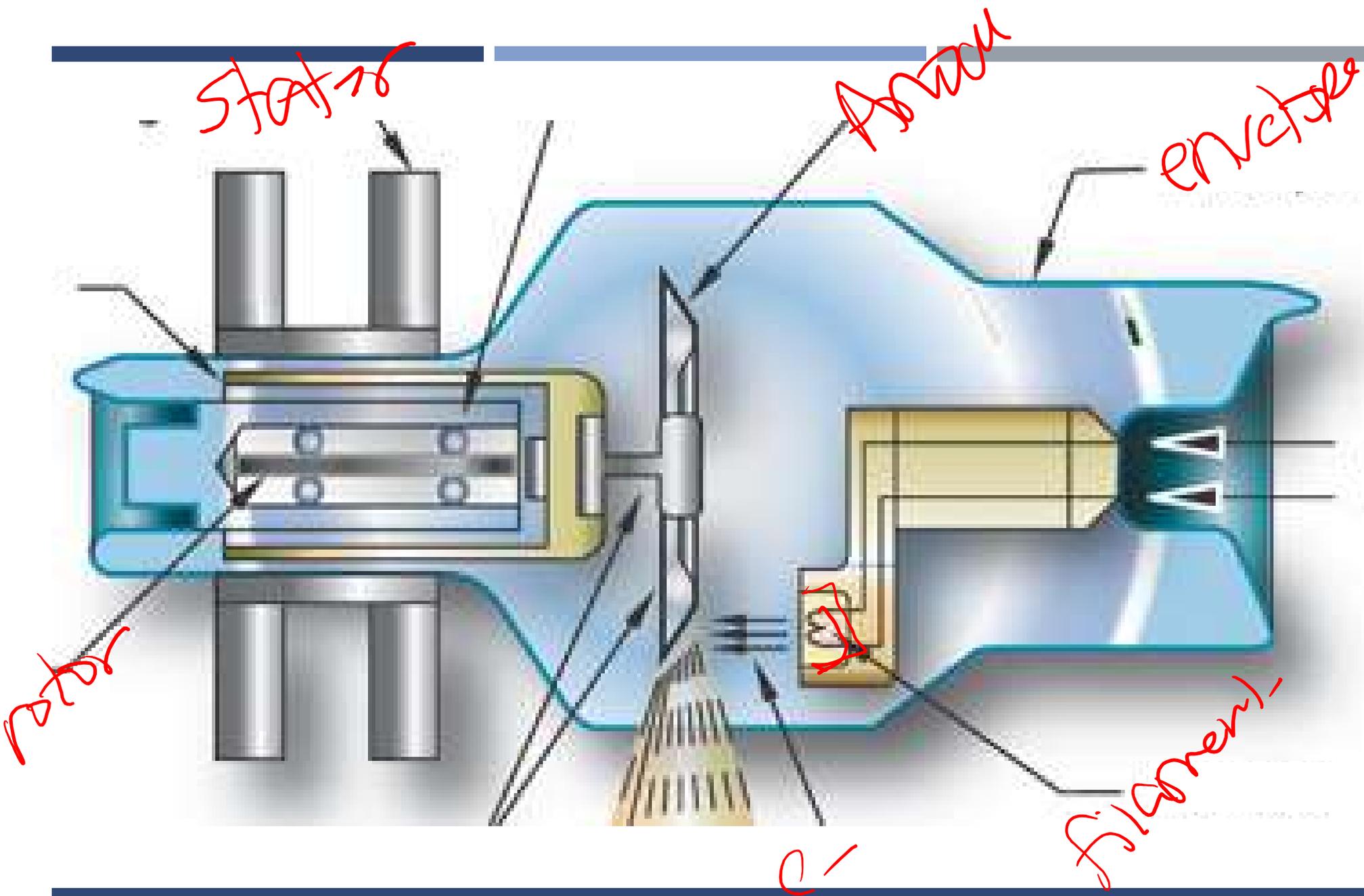
A DUAL FOCUS TUBE REFERS TO A TUBE WITH:

- A. Two focal tracks
- ★ B. Two filaments
- C. Two focusing cups
- D. Two targets





**SPLIT INTO GROUPS AND DRAW AND LABEL
THE DIFFERENT PARTS OF THE X-RAY TUBE**



PRINCIPLES OF OPERATION

- Radiographer selects the desired exposure factors
- When the exposure switch is first pressed, some of the electricity is diverted to the STATOR of the x-ray tube to bring the rotor up to speed
 - Induction motor turns the anode at approximately 3400 rpm
- FILAMENT is energized until the desired thermionic emission is achieved.
- Current heats filament so THERMIONIC EMISSION occurs
- Focusing cup forms them into a cloud called a SPACE CHARGE

PRINCIPLES OF OPERATION (CONT.)

- When the exposure switch is pressed, the voltage from the AUTOTRANSFORMER passes to the STEP-UP GENERATOR.
- The voltage then passes through a rectifier bank before passing to the anode and cathode of the x-ray tube.
- Creating a POTENTIAL DIFFERENCE between the cathode and anode.
- E- then strike the anode producing HEAT and X-RAY PHOTONS.

REVIEW: 4 CONDITION FOR X-RAY PRODUCTION

- [How does X Ray Work \(X-Ray Production\) - YouTube](#)

- Source of e⁻ - filament
- Acceleration of e⁻ - potential difference
- Focusing of e⁻ - focusing cup
- Deceleration of e⁻ - anode target

WHEN INCREASING THE MA STATION ON THE OPERATING CONSOLE, WHICH OF THE FOLLOWING IS OCCURRING?

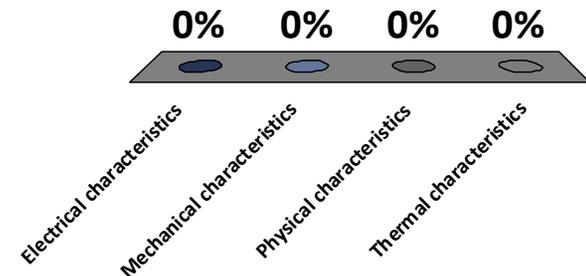
1. Increasing filament current
2. Increasing thermionic emission
3. Increasing potential difference



4. 1 and 2 only
5. 1, 2 and 3

CAUSES OF TUBE FAILURE ARE MOST OFTEN RELATED TO WHICH OF THE FOLLOWING:

- A. Electrical characteristics
- B. Mechanical characteristics
- C. Physical characteristics
- D. Thermal characteristics

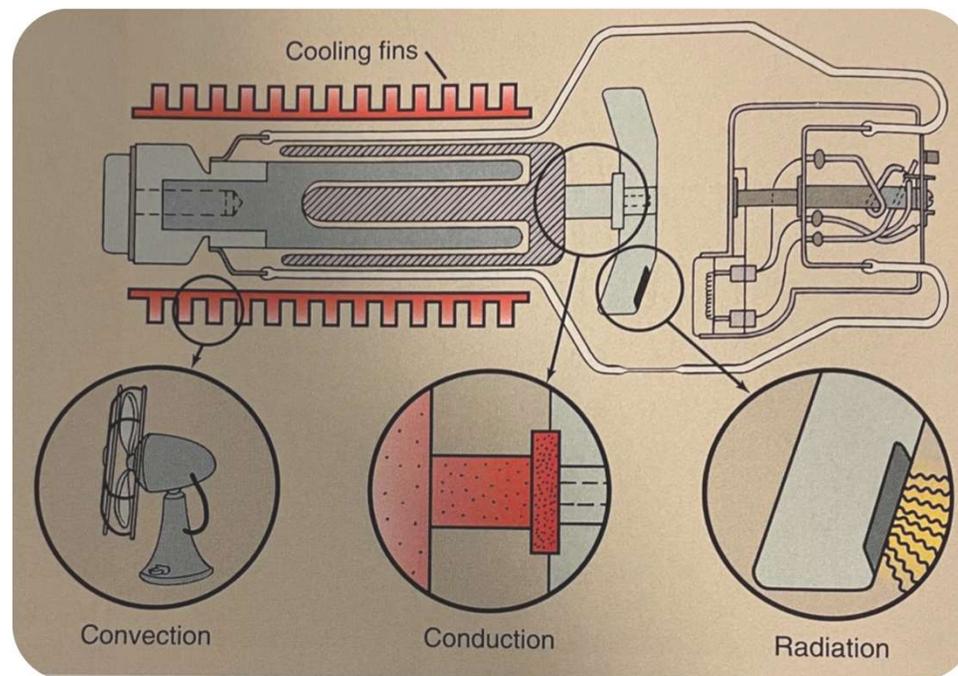


WHAT FACTORS CAN DAMAGE OR SHORTEN THE LIFE OF THE X-RAY TUBE?

- Frequent use of high exposure factors
- Overloading filament
- Filament burnout
- Slow leaks
- Tungsten vaporization
- Anode cracking/ pitting
- Mechanical damage

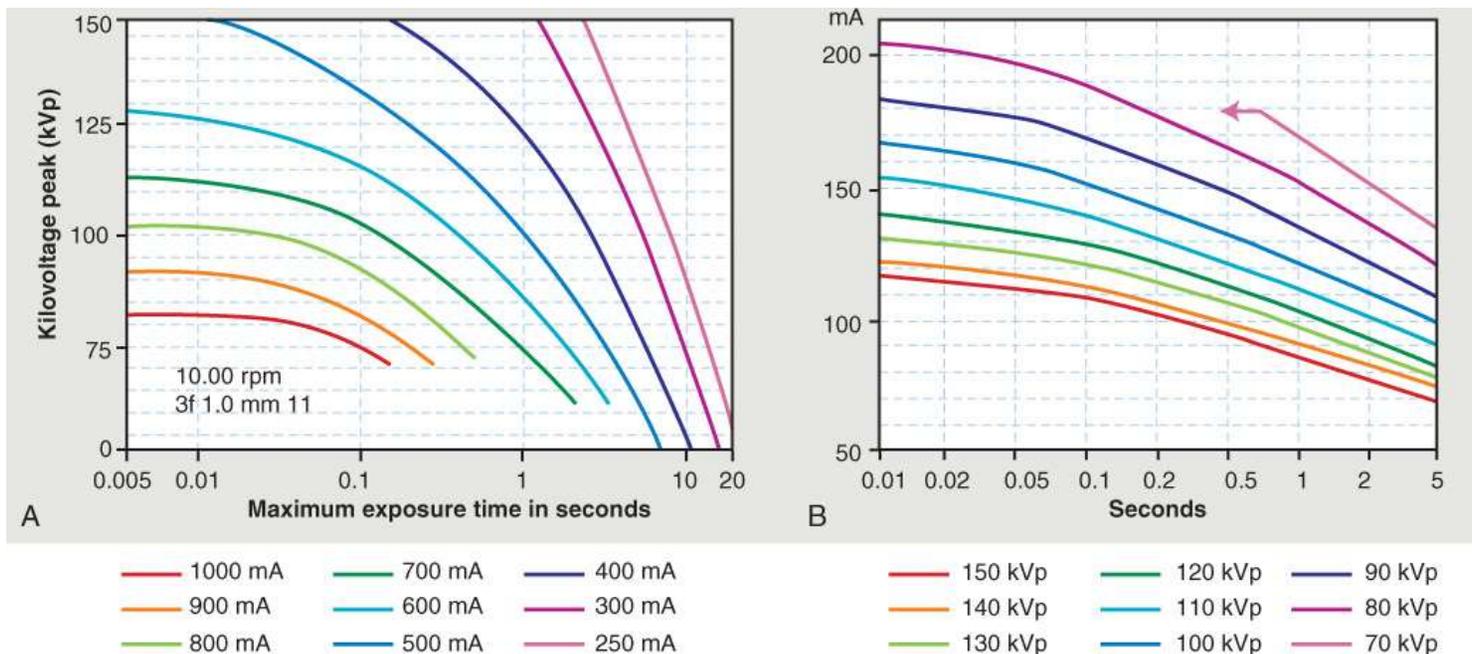
TUBE FAILURE AND PREVENTION

- Three processes of heat transfer:



- Protective circuits prevent the use of unsafe exposure techniques and heat overloads.

TUBE RATING CHART



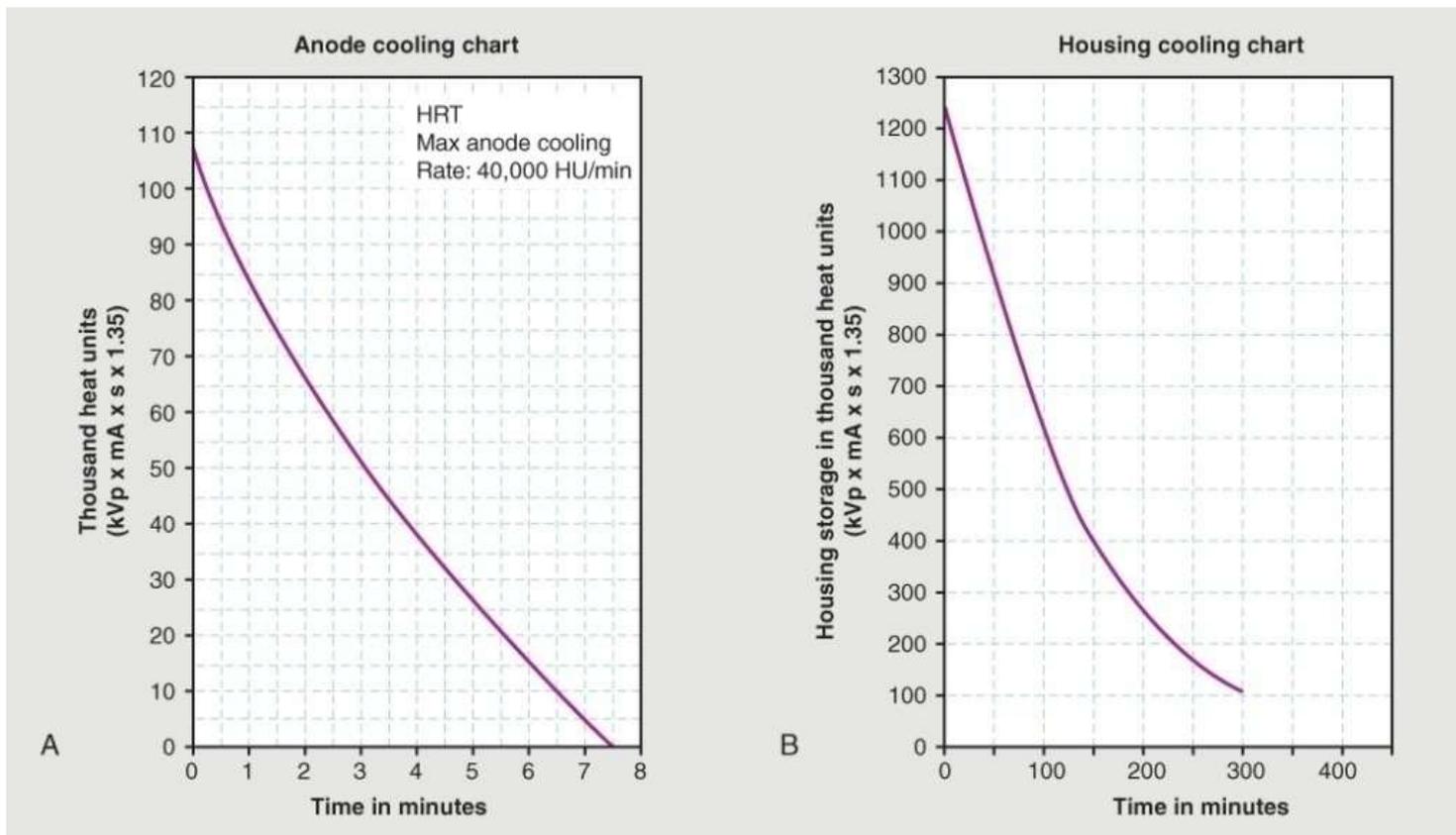
HEAT UNITS

- What do heat units measure?
- Calculated by multiplying $kVp \times mA \times s \times c$
 - Single-phase = 1.0
 - Three-phase, 6-pulse = 1.35
 - Three-phase, 12 pulse = 1.41
 - High-frequency = 1.45

Ex. 80 kVp, 120 mA, .2 s, three-phase 12 pulse generator

$$80 \times 120 \times .2 \times 1.41 = 2707$$

COOLING CHARTS



WHAT PROCEDURES AND GUIDELINES SHOULD BE FOLLOWED TO EXTEND TUBE LIFE?

- Follow equipment specific warm-ups
- Do not prep rotor excessively
- Do not routinely use extreme exposure factors