

RADIATION SAFETY

Analytical X-Ray Systems

Indiana University - Bloomington



USER TRAINING REQUIREMENTS

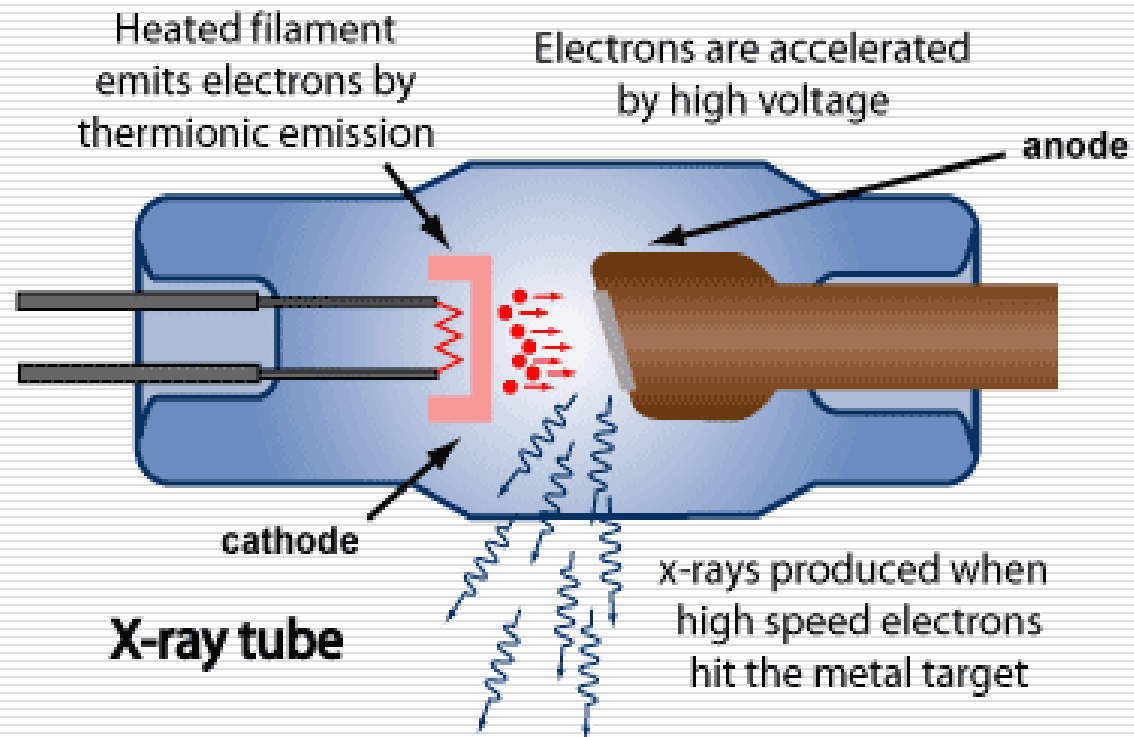
Analytical X-Ray Systems

- Complete online training and read associated “Radiation Safety Guide”.
- Review safe operating procedures with Principal Investigator (or Lab Manager).
- Forward to Radiation Safety Office a completed Radiation Safety Exam and Form XS-2 (Documentation of Training).

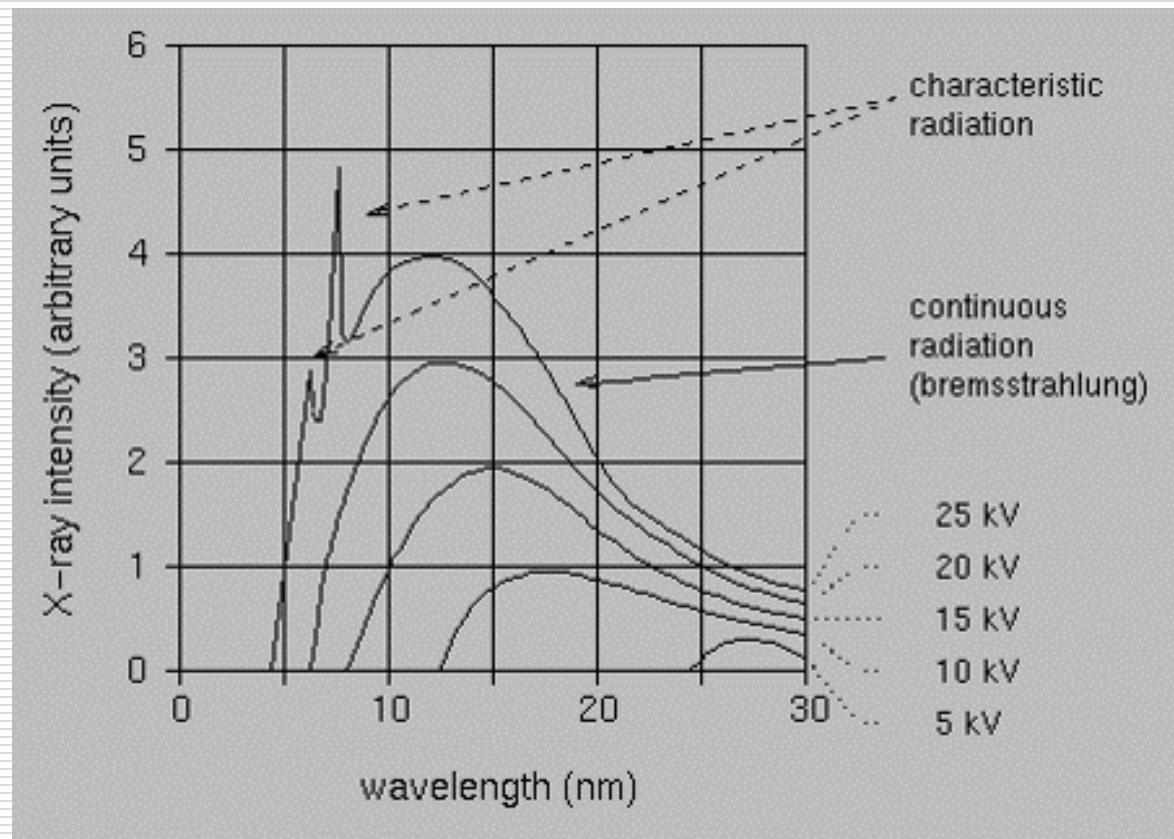
For users of open beam systems:

- Complete an onsite review of safety procedures with the Radiation Safety Officer.
 - Obtain ring dosimeter.
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X-RAY PRODUCTION



Analytical x-ray systems (unlike diagnostic x-ray systems) make use of “characteristic” x-rays.

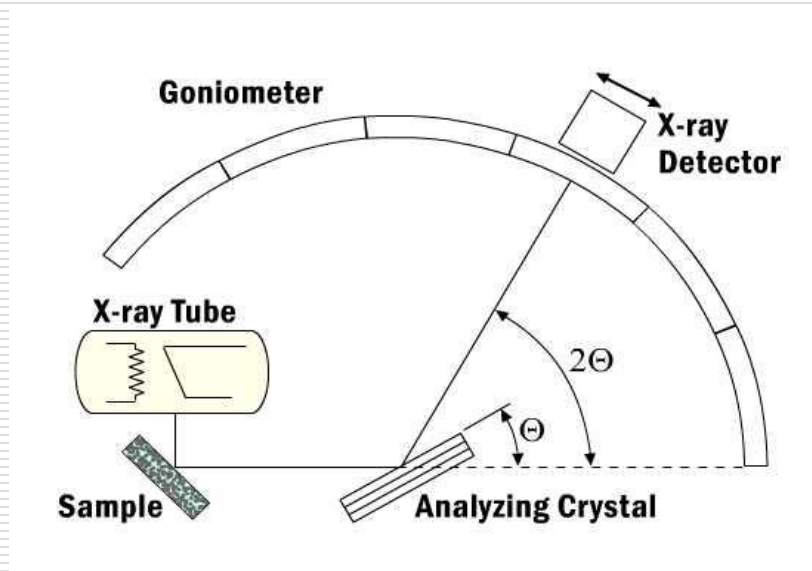


OPERATING PARAMETERS ANALYTICAL X-RAY SYSTEMS (kVp and mA)

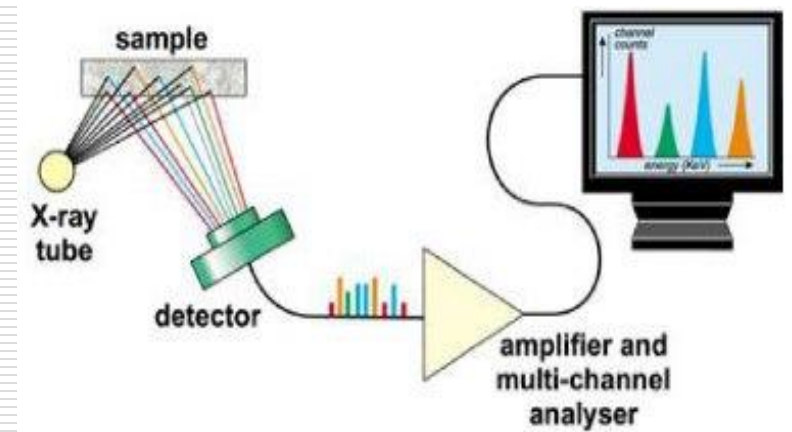
- The energy of x-rays (and their penetration ability) increases with kVp.
 - The quantity of x-rays (beam intensity) increases with mA.
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OPERATION MODES OF ANALYTICAL X-RAY SYSTEMS

X-Ray Diffraction (XRD)



X-Ray Fluorescence (XRF)



RADIATION HAZARDS OF ANALYTICAL X-RAY SYSTEMS

In general, XRD systems pose more significant potential radiation hazards than do XRF systems because:

- ❑ XRD systems operate at higher mA producing more intense x-rays; and
 - ❑ The primary beam of an XRD system emerges from the collimator to strike the sample, whereas for most stationary XRF systems, the primary beam strikes the sample inside a shielded enclosure.
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ANALYTICAL X-RAY SYSTEMS

Enclosed

Interlocked enclosure which eliminates radiation hazards.



Open

No enclosure; radiation hazards controlled by strict procedures.



RADIATION HAZARDS OF ANALYTICAL X-RAY SYSTEMS

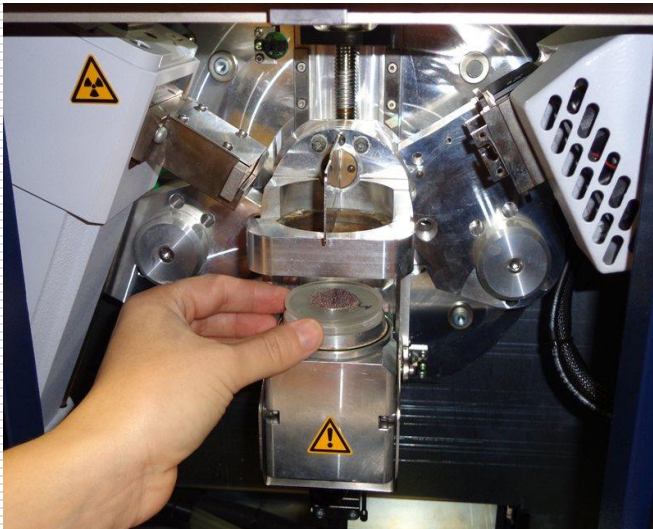
Primary Beam (XRD) – intense, narrow (< 1 cm diameter), and capable of producing skin burn doses in only seconds within 30 cm of tube housing port).

Diffacted Beam (XRD) – much less intense (than primary beam) but still narrow and capable of producing overexposures to the hands (though not burns) in a few minutes within 30 cm of sample.

Scattered and Secondary X-rays – undetectable at outer surface of enclosure (for enclosed systems); for open systems at 1 meter, well below occupational dose limits.

RADIATION HAZARDS OF ANALYTICAL X-RAY SYSTEMS

The greatest potential radiation hazard for analytical x-ray systems is the accidental exposure of the hands to the **primary beam** during the placement of the sample in an **open beam** system.



RADIATION DOSE

Quantities and Units

ABSORBED DOSE – Amount of energy imparted by ionizing radiation to a given mass of matter.

Units: rad = 100 ergs/gram
 gray = 100 rad

DOSE EQUIVALENT – Absorbed dose adjusted for biological significance by a Quality Factor (QF).

Units: rem = rad x QF
 sievert = gray x QF

BIOLOGICAL EFFECTS OF ACCIDENTAL EXPOSURE TO PRIMARY X-RAY BEAM

Acute (prompt) Effects –

- Erythema (skin reddening) within 24 hours with accompanying pain; > 300 Rad (3 Gray)
- Blood flow problems leading to atrophy and ulcerations; > 5000 Rad (50 Gray)

Chronic (late) Effects

- Skin sensitivity to UV and dermatitis
 - Skin Cancer
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OCCUPATIONAL DOSE LIMITS

Indiana (410 IAC Section 5-4-2)

Whole Body	5 rem (50 mSv) per year
Hands	75 rem (750 mSv) per year

Current dose limits have been established to:

- Prevent all acute effects (such as skin burns); and to
- Limit the risk of any late effects such as cancer to very low “acceptable” levels.

However, dose limits are “upper” limits. All personnel doses are required to be maintained:

As Low As Reasonably Achievable (**ALARA**).

X-RAY REGULATORY REQUIREMENTS

INDIANA STATE DEPARTMENT OF HEALTH

(410 IAC Section 5-8)

- Status lights for x-ray tube and shutter
 - “Caution” label on tube housing and near “on” switch
 - Area radiation levels < 2 mrem in any one hour
 - “Caution” posting of door to area
 - Written Standard Operating Procedures
 - Ring dosimeters for open beam XRD users
 - Prohibition against altering system safety features
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ANALYTICAL X-RAY SYSTEMS

User Safety Rules

- ❑ Understand the function of all safety features (status lights, interlocks, and shielding).
 - ❑ Immediately notify the Principal Investigator (or Lab Manager) of any problems with a safety feature.
 - ❑ Never by-pass an interlock or alter a safety feature without prior written approval from the Radiation Safety Officer.
 - ❑ Confirm proper function of safety features by surveys with “thin crystal” NaI detector (required for users of open beam systems).
 - ❑ Monitor any “external” exposure to your hand by always wearing your ring dosimeter (required for users of open beam systems).
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