SAWA UNIVERSITY

تقنيات أجهزة التصوير التقليدية/ الكورس الاول

X-RAY MACHINE SYSTEM

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الجانب النظري محاضرة رقم (1)

Theoretical Lecture No. (1)

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(OVERVIEW)

Four main subsystems:

- **Operating Console (control interface).**
- **High-Voltage Generator (modifies incoming power).**
- **X-Ray Tube (produces X-rays).**
- **Image Receptor (captures image).**

An X-ray machine works by converting electrical energy → X-rays → image. The operating console controls how electricity flows into the generator, which steps it up or down to the required levels. The X-ray tube converts this into X-rays, and the image receptor records the transmitted radiation.

(OPERATING CONSOLE INTRODUCTION)

Central command system.

Adjusts:

- **kVp (beam energy).**
- **mA (beam quantity).**
- **Time (exposure duration).**
- **Includes indicators: “Power On,” “Ready,” “Exposure.”**

The radiographer communicates with the system only through the operating console. Modern consoles are digital with touch screens, while older ones have analog dials. Regardless of design, the functions are the same: select kVp, mA, and exposure time.

(LINE COMPENSATION)

- **Incoming electricity from wall supply fluctuates ±5–10%.**
- **Such variations affect X-ray beam energy.**
- **Line compensator stabilizes the voltage before it reaches the autotransformer.**

Power supply instability is a common issue, particularly in older hospitals or rural areas. A 230 V supply may vary between 215–245 V. This fluctuation can result in inconsistent beam energy, leading to variability in image contrast and patient dose. The line compensator corrects for these variations to provide a stable input.

(LINE COMPENSATION)

- **Located on the primary side of the autotransformer.**
- **Works manually (older units) or automatically (modern units).**
- **Ensures consistent exposures across patients.**

By ensuring constant input voltage, the compensator guarantees that a 70 kVp setting on the console actually delivers 70 kVp to the tube. Without it, repeat exposures and increased dose would result.

(AUTOTRANSFORMER CIRCUIT)

- **Voltage adjustment = selecting taps.**
- **Determines kVp range available.**
- **Connected to the kVp dial at the console.**

When the radiographer selects a specific kVp on the console, they are essentially choosing which taps of the autotransformer are connected. The generator then boosts this to the final kilovoltage supplied to the X-ray tube.

(KVP ADJUSTMENT)

- **kVp = peak voltage across the tube.**
- **Determines beam quality (penetration power).**
- **Higher kVp → stronger, more penetrating X-rays.**

The kilovoltage peak is one of the most important factors in radiography. A low kVp beam produces high subject contrast (black/white images), while high kVp beams reduce contrast but allow better penetration. The correct balance depends on clinical need.

(KVP AND IMAGE QUALITY)

- ↑ kVp → lower contrast, higher penetration.
- ↓ kVp → higher contrast, lower penetration.
- Clinical examples:
- - Chest → 110–120 kVp.
- - Hand → 50–60 kVp.

In chest imaging, high kVp ensures the beam penetrates the lungs, heart, and mediastinum. In extremities, low kVp highlights bone detail with high contrast. Incorrect selection leads to either “washed out” images or overly dark films.

(MA CONTROL)

- mA = tube current (electrons crossing tube per second).
- Controls number of X-ray photons.
- Directly proportional to image receptor exposure.

mA doesn’t change beam energy. It only changes the number of photons produced. This makes it directly responsible for image density and patient dose.

(MA AND IMAGE QUALITY)

- **mAs = mA × time.**
- **Controls total radiation output.**
- **↑ mAs → darker image, ↑ dose.**
- **↓ mAs → lighter image, risk of noise.**

A proper balance must be maintained: too little mAs → underexposed, noisy images. Too much mAs → unnecessary radiation exposure without diagnostic benefit.

(EXPOSURE TIMER)

Controls exposure duration.

- **Types:**
- **Mechanical (obsolete).**
- **Electronic (common).**
- **AEC (modern).**

Exposure time is especially critical in moving organs (chest, heart). Short times freeze motion, while long times increase blur. Automatic exposure controls terminate exposure once a sufficient dose reaches the detector.

(EXPOSURE TIMER ACCURACY)

- **Accuracy essential for patient safety.**
- **Inaccuracy → repeat exams → double dose.**
- **Quality control requires ±5% accuracy.**

Regulatory agencies require periodic testing of timer accuracy using test tools like the spinning top test. Any drift beyond ±5% makes the system unsafe.

(INTEGRATION OF CONSOLE FUNCTIONS)

- **Line compensator → stable input.**
- **Autotransformer → kVp selection.**
- **kVp → beam quality.**
- **mA → beam intensity.**
- **Timer → exposure length.**

All components are interlinked. A stable supply (line compensator) feeds the autotransformer, which sets the kVp. The radiographer then selects mA and time to balance exposure and image quality.

(SUMMARY)

- **Console = central control of X-ray system.**
- **Five key functions: line compensation, autotransformer, kVp, mA, timer.**
- **Determines diagnostic quality + radiation safety.**

Understanding the console enables radiographers to produce consistent, high-quality radiographs with minimal dose.

QUIZ

Q1. PURPOSE OF THE LINE COMPENSATOR IN AN X-RAY MACHINE IS TO:

A) INCREASE THE FILAMENT TEMPERATURE FOR HIGHER MA. B) CORRECT FLUCTUATIONS IN THE INCOMING POWER SUPPLY.

C) CONVERT LOW VOLTAGE TO HIGH VOLTAGE FOR THE TUBE. D) REGULATE EXPOSURE TIME.

Q2. WHICH OF THE FOLLOWING BEST DESCRIBES THE FUNCTION OF THE AUTOTRANSFORMER IN THE X-RAY OPERATING CONSOLE?

A) CONVERTS AC TO DC CURRENT. B) PROVIDES VOLTAGE ADJUSTMENT FOR KVP SELECTION.

C) CONTROLS EXPOSURE DURATION. D) DIRECTLY CONTROLS THE X-RAY PHOTON QUANTITY.

Q3. THE SELECTED KVP WILL PRIMARILY:

A) INCREASE BEAM QUANTITY ONLY. B) DECREASE BEAM PENETRATION.

C) INCREASE BEAM PENETRATION AND REDUCE IMAGE CONTRAST.. D) INCREASE EXPOSURE TIME.

Q4. IN THE OPERATING CONSOLE, THE MA CONTROL IS RESPONSIBLE FOR:

A) REGULATING THE EXPOSURE DURATION. B) ADJUSTING THE FILAMENT CURRENT TO CONTROL THE ELECTRON NUMBER.

C) INCREASING THE MAXIMUM TUBE POTENTIAL. D) COMPENSATING FOR POWER SUPPLY FLUCTUATIONS.

Q5. WHY IS THE EXPOSURE TIMER AN ESSENTIAL COMPONENT IN X-RAY SYSTEMS?

A) IT CONTROLS X-RAY BEAM FILTRATION B) IT DETERMINES THE DURATION OF ELECTRON FLOW ACROSS THE TUBE.

C) IT SELECTS THE SIZE OF THE FOCAL SPOT. D) IT STABILIZES INPUT VOLTAGE

Any questions?