OHIO DEPARTMENT OF HEALTH

GUIDANCE FOR DEVELOPING AN ACCEPTABLE DIDACTIC SYLLABUS FOR THE GENERAL X-RAY MACHINE OPERATOR (GXMO) EDUCATIONAL PROGRAM

RTS-GXMO-700

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TABLE OF CONTENTS

1. INTRODUCTION

Consolidated guidance documents have been developed by the Ohio Department of Health's Bureau of Environmental Health and Radiation Protection to provide guidance to licensees, registrants and applicants on implementing specific parts of the department's rules published in the Ohio Administrative Code (OAC); and guidance on the specific data and information needed, at a minimum, by the bureau in its review of applications for Department of Health licenses, registrations and education program approvals.

These guides are not substitutes for rules, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a license, registration or approval by the department.

This guide describes a didactic educational syllabus that is acceptable to the Bureau of Environmental Health and Radiation Protection for a GXMO educational program meeting the curriculum requirements outlined in OAC 3701-72-03.

This consolidated guidance was issued by the bureau and is based on the effort and input of the Radiation Advisory Council's Radiation-Generating Equipment Committee. Comments and suggestions for improvements in any of the bureau's consolidated guidance documents are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or techniques, evolving technology and experience or lessons learned.

2. PROGRAM GOALS

As permitted by OAC 3701-72, GXMOs will take radiographs using only predetermined techniques. A GXMO educational program should allow students to acquire and demonstrate a basic knowledge and practical understanding of the fundamentals requisite for radiation safety and daily operation of diagnostic x-ray equipment within the GXMO scope of limited practice. Therefore, at a minimum, the curriculum of the didactic educational section of a GXMO program shall include the following:

- Radiographic equipment and often-used terms and terminology;
- The nature of x-rays, their relative energy spectrum and their fundamental properties when traveling in space and interacting with matter;
- The components of the x-ray tube and their basic functions;
- How x-rays are produced by the x-ray machine;
- The essential factors controlling the quality and quantity of x-ray beam intensity, and specifically how kilovoltage peak (kVp), milliamperes (mA), time, and source-to-image receptor distance affect the x-ray beam;

- The functions of the x-ray tube, control panel, table, and grid devices;

- The three potential interactions of x-rays with matter, how these interactions combine to produce a useful image along with their potential negative effects on both image clarity and radiation safety;
  Note: The student is not required to conceptualize how these interactions occur using atomic models.

- X-ray image formation and the different processing techniques for digital image receptors;

- Major factors that control and affect image quality;

- The applicable units of measurement used in dosimetry, methods to monitor occupational exposure and when to do so;

- The long-term biologic effects of x-rays as a foundation to understanding the principles of safe practice; and the limited relevance of acute biologic effects;

- The cardinal rules of safety, along with standard safe practices in protecting both patients and operators from ionizing radiation;

- The initial clinical approach to the patient: identifying and verifying the correct patient, correct medical order, procedure, and patient confidentiality; and

- The proper patient assessment and patient care skills when performing radiographic procedures.

3. DIDACTIC EDUCATION: COURSE SYLLABUS

3.1 Introduction to GXMO Licensure

A. Brief overview of course content

B. GXMO responsibilities

C. Ohio Department of Health rules

D. GXMO licensure process (See Table 3.1)

Table 3.1 GXMO Licensure Process

Process for Obtaining an Initial GXMO License	
Step 1	Complete GXMO education course OR complete first year of accredited radiography program. Educators will supply students with exam registration form.
Step 2	Submit examination registration for to Diversified Technology, an affiliate of RadEd, LLC to schedule the exam.
Step 3	Complete one or as many approved clinical module course(s), specific to the procedures to be performed when licensed, OR be a student enrolled in an accredited radiography program. The GXMO program director will provide a clinical course certificate, OR for radiography students, the radiography program director will provide an affidavit of clinical competency.
Step 4	Submit complete application to ODH via online or by mail. Complete application means: • $65 application fee • GXMO examination score • GXMO course certificate or college transcript • Clinical course certificate(s) or clinical course affidavit Online: http://www.odh.ohio.gov/licenseapplication

3.2 Introduction to Radiographic Equipment and Basic Terms

A. Collimator and the Light Field - Definition and Purpose

B. Image Receptor (IR) System

- Computed Radiography (CR)-based cassette
- Digital Radiography (DR)

C. Patient Positioning Aids

- Sponges
- Immobilization devices

D. Positioning of the X-ray Tube

- Ceiling mount vs tube hanger
- Tube motions: transverse, longitudinal, vertical, angle, tilt
- Detent

E. Primary X-ray Beam

- Definition
- X-ray Source – tube

- Central ray

F. Radiographic Table/Upright Image Receptor

- Table movement
- Trendelenburg position
- Under-table bucky (grid)

G. Control Panel Components

- Timer
- kVp
- AEC
- mA

H. Remnant Radiation – Definition

3.3 X-rays, Ionization and Matter

A. Atomic Structure – Atomic structure should be covered but can be very basic and discuss the fundamental particles and introduce the nomenclature

B. Electromagnetic Spectrum

- Energies and photons – no wavelength models; emphasis should be on relative energies of x-rays vs. visible light
- Ionizing vs. non-ionizing radiation

C. Fundamental X-ray Interactions with Matter

- General information only, not as the atomic models
- Absorbed – radiopaque
- Scattered
- Penetrates through unaltered - radiolucent

D. Ionization

- Definition and Implication
- Cause of patient dose
- Cause of image formation

E. Properties of X-ray

- Travel in a straight line
- High Constant Speed
- Wide Variety of Energies
- Ionization of Matter
- Produce Secondary and Scatter Radiations
- Cause Certain Materials to Fluoresce
- Cannot Be Focused with a Lens

3.4 Basic X-ray Tube Design and the Controlled Formation of X-rays

A. Tube Construction and Schematic

- Protective housing
- Glass or metal enclosure
- Cathode and anode
- Port or window
- Added filtration
- Collimating shutters

B. Beam Limiting Devices

- Positive beam limitation (PBL)

C. X-ray Tube Components

- Collimator or variable aperture
- Cathode filament
- Focusing cup
- Anode target
- Rotating vs stationary anode

D. Process of X-ray Production

- Thermionic emission
- Kilovoltage
- Milliamperage and tube current

- Anode interactions – inefficient process; >99% heat vs <1% x-rays (no detailed atomic models)
- Bremsstrahlung radiation spectrum of photon energies in beam
- Characteristic radiation

E. Tube Filtration – definition, purpose, types (inherent, added, total)

3.5 The X-ray Beam

A. Definition of X-ray Beam Intensity – units of output/beam intensity – C/kg (R or mR)

B. X-ray Beam Quantity

- Definition
- Key factors affecting x-ray quantity
  - mA
  - sec (time)
  - kVp
  - distance – Inverse Square Law

C. X-ray Beam Quality

- Definition
- Key factors effecting x-ray beam quality
  - kVp
  - HVL – definition

3.6 Primary Radiologic Image

A. Basic Interactions with Matter

- Penetrate
- Absorb – photoelectric absorption
- Scatter – Compton scattering

B. Differential Attenuation/Absorption

- Basis for subject contrast
- Effects of air, bone, muscle, and fat (No Z numbers)

C. Intensity/Exposure

- Effects on intensity/exposure of the x-ray beam on the radiographic image

3.7 Digital Imaging

- Analog signal “waveform” vs. digital signal “string” of binary numbers
- Analog to digital conversion (ADC) – information sent to computer for processing
- Matrix – pixels, pixel size, matrix size, spatial resolution measure in line pairs/mm (lp/mm)

A. Digital Basics

- Digital Imaging and Communications in Medicine (DICOM) definition and importance
- Medical Image Management and Processing System (MIMPS – formerly PACS) – definition and importance
- Teleradiography
- Hospital Information System (HIS)
- Radiology Information System (RIS)

B. Computed Radiography (CR) – overview of photostimulable phosphor (PSP) imaging plates

- Less expensive than Direct Conversion
- Construction – cassette and PSP imaging plate
- X-ray exposure interacts with PSP with latent image formation
- Image degradation over time – regulatory limit of 8 hours before erasure
- Sensitivity to scatter radiation
- Maintenance, cleaning, and inspection
- Plate scanned by laser light, trapped energy released as light and read to produce the manifest image
- Exposure to plate by intense light erases any remaining trapped energy to ready plate to be used again

C. Direct Radiography (DR)

- Indirect conversion DR – converts x-rays to light prior to detection

- Scintillators convert x-rays to light (therefore indirect), with emitted light read by photodetector (CCD)

- Direct conversion DR – utilizes crystals which directly convert x-rays into a charge that is stored and ready to read

- Costs increase with size

D. Display Qualities

- Post-processing
  - Window level – affects brightness/luminance
  - Edge enhancement
  - Smoothing
- Define spatial resolution and contrast resolution
- Window width – the range of the gray scale displayed on the monitor – affects contrast
  - Inverse relationship between window width and image display contrast

E. Exposure Indicator/Index

- Definition
- Vendor specific
- Ethical and regulatory responsibility regarding overexposure and underexposure

3.8 Optimal Techniques

A. Primary and Secondary Factors Affecting Image Quality

- Primary
  - Kilovoltage (kVp) – adequate penetration
  - Milliamperage (mA) – adequate intensity/exposure
  - Time – adequate intensity/exposure
  - SID – definition and intensity/exposure
- Secondary
  - Signal-to-noise ratio (SNR)
  - Beam restriction (Controls Field Size)
  - Contrast
  - Intensity/Exposure

- Scatter
- Grid ratio
- Contrast
- Intensity/exposure
- Scatter and patient dose

B. Image Spatial Resolution

- SID – definition and the effects on spatial resolution, distortion, and magnification
- OID – definition and the effects on spatial resolution, distortion, and magnification
- Distortion and positioning
- Focal spot size, pixel size, pixel pitch, matrix size, fill factor
- Time – patient motion

C. Image Contrast Resolution

- Optimization of image contrast (contrast resolution)
- Effects of scatter on image quality – grids and collimation
- Bit depth
- Detector quantum efficiency (DQE)
- Motion
    - Types of motion
    - Common methods to reduce motion

D. Automatic Exposure Control (AEC) – definition and proper use

E. Radiographic Grids

- Definition and purpose
- Scatter and patient dose
- Focus range/tube alignment
- Types: linear/parallel and focused

F. Technique Charts – definition

3.9 Image Evaluation

A. Optimal Image Quality – motion

B. Common Image Artifacts – definition

- Periodic CR cassette cleaning – required and documented
- Digital
- Moire effect
- Ghost or phantom
- Quantum mottle/noise
- Dead pixel
- Image compression
- Histogram selection/algorithm error

3.10 Radiation Safety Basics

A. Sources of Radiation

- Sources of average annual dose
  - Natural sources
  - Man-made sources
  - Average annual doses
  - General public
  - Operator

B. Dosimetry, Units of Radiation Safety

- $Gray_t$ – rad: absorbed dose
- $Gray_a$ – rad: radiation in air
- Seivert – rem: equivalent dose

C. Basic Biologic Effects of Radiation Exposure

- Human radiation response
- Key biologic factors affecting radiosensitivity
  - Age
  - Radiosensitive tissue
  - Oxygen Enhancement Ratio
  - Late Effects
- Law of Bergonie and Tribondeau – relative radiosensitivity of cells

- Deterministic vs Stochastic Effects
    - Definition
    - Dose-response relationships
- Early effects – to show that high dose effects are relevant to diagnostic imaging
    - Erythema – definition
    - Epilation – definition
    - Desquamation
- Late effects – background information should develop understanding as to why certain shielding precautions are taken
    - Cataract formation
    - Radiation-induced malignancies – general concepts
    - Thyroid Effects
- Direct vs. indirect effect
    - Radiolysis of water – indirect effect
    - DNA as critical target molecule – direct effect
- Somatic vs. Genetic effects – definitions
- Radiation and pregnancy
    - Effects on fertility
    - Irradiation in utero – 1st trimester – fetal effects
    - Relative risk of childhood leukemia
- Dose Response
    - Linear, Non-Linear, Threshold, Non-Threshold

D. GXMO Scope of Practice

3.11 Methods of Patient Safety

A. General Safety Principles

- Optimization of Technical Factors
- Cardinal Principles – time, distance, shielding
    - Minimize time – optimize mAs

- Maximize distance – Inverse Square Law

B. Reduction of Unnecessary Patient Dose

- Unnecessary examinations
- Avoid repeat examinations
- Proper collimation
- Positioning

C. Kilovoltage - optimize kVp: high kVp, low mAs

D. Scatter Control – beam restriction

E. Grids – Image scatter reduction (contrast improvement) vs. patient dose

- Increase dose to patient with technique compensation
- Grid Ratio

F. The Pregnant Patient

- Methods of screening
- Methods of documentation
- Risk vs benefit – physician consultation before procedure

3.12 Methods of Operator Safety

A. Relative Safety of Radiologic Occupation

- ALARA Principle
- Cardinal Principles

B. Rule 3701:1-66-12 of the Ohio Administrative Code: Occupational Dose Limits

- Annual dose limits
  - Whole body
  - Lens of eye
  - Skin, hands, and feet
- Cumulative occupational dose
- Embryo or fetal dose limits

C. Rule 3701:1-38-13 of the Ohio Administrative Code: Dose Limits for Individual Members of the Public – non-occupational dose limits

D. Rule 3701:1-38-14 of the Ohio Administrative Code: Survey and Monitoring Requirements

- Who should be monitored?
- Types of personal dosimeters – sensitivity levels
- Wearing and handling of monitors
- Interpreting personnel dosimetry reports

E. Personnel Shielding and Protective Barriers

- Reduction of Occupational exposure – lead aprons
- Primary radiation – definition
- Secondary radiation – definition
- Minimize time – optimize mAs
- Secondary Scatter
- Secondary Leakage
- Secondary Off-Focused
- Elimination of Secondary Radiations
- Controlled work area – definition
- Uncontrolled work area – definition

F. The Pregnant Worker

- Effects on fertility
- Irradiation in utero
- Declaration of pregnancy

3.13 Patient Assessment, Clinical History, Confidentiality and Image Labeling

A. Identifying the Correct Patient

- Methods of correct patient identification: verbal name, date of birth, and identification bracelet

- Patient communication regarding radiographic studies, explaining procedures to your patient

B. Patient Clinical History

- Verifying and taking a clinical history
- Importance of prior radiographic studies

C. Confidentiality of Medical Information

- Release of records
- Health Insurance Portability and Accountability Act (HIPAA)
- Other institutional policies

D. Proper Image Labeling and Documentation

- Facility name
- Date
- Patient name
- Anatomical markers (left/right)

4. RESOURCES

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