



# California Radiography Supervisor and Operator Examination

The American Registry of Radiologic Technologists (ARRT) develops and administers the *Radiography Supervisor and Operator Examination* on behalf of the State of California. The purpose of the examination as established by the State is to assess the knowledge and cognitive skills expected of licentiates who supervise operators of radiographic equipment or who operate radiographic equipment themselves.

A practice analysis was conducted on a nationwide sample of radiographers to identify the tasks typically associated with the performance of imaging procedures using radiographic equipment. The State of California Radiologic Health Branch selected a subset of these tasks as relevant to radiography supervisors and operators. The content of the examination reflects the knowledge and cognitive skills required to safely and effectively perform the selected tasks. The *Task Inventory* for the *Radiography Supervisor and Operator Examination* appears in *Attachment B* of this document. The *Content Specifications for the Radiography Supervisor and Operator Examination* identify the content areas covered on the examination and the number of questions for each area. Every content category can be linked to one or more activities on the task inventory.

The table below presents the major content categories and the number of test questions appearing in each category. The remaining pages provide a detailed listing of topics addressed within each major content category.

	Number of Scored Questions	Testing Time
Patient Care	18	
Safety <sup>1</sup>	40	
Image Production	42	
<b>Total</b>	<b>100</b>	<b>1 hr, 45 min</b>

<sup>1</sup>: SI units are the primary (principal) units of radiation measurement used on this examination.



## Patient Care

### 1. Patient Interactions and Management

#### A. Ethical and Legal Aspects

1. patient's rights
  - a. informed consent (\*e.g., written, oral, implied)
  - b. confidentiality (HIPAA)
  - c. American Hospital Association (AHA) Patient Care Partnership (Patient's Bill of Rights)
    1. privacy
    2. extent of care (e.g., DNR)
    3. access to information
    4. living will, health care proxy, advanced directives
    5. research participation
2. legal issues
  - a. verification (e.g., patient identification, compare order to clinical indication)
  - b. common terminology (e.g., battery, negligence, malpractice, beneficence)
  - c. legal doctrines (e.g., respondeat superior, res ipsa loquitur)
  - d. restraints versus immobilization
  - e. manipulation of electronic data (e.g., exposure indicator, processing algorithm, brightness and contrast, cropping or masking off anatomy)

#### 3. Professional Ethics

#### B. Interpersonal Communication

1. modes of communication
  - a. verbal/written
  - b. nonverbal (e.g., eye contact, touching)
2. challenges in communication
  - a. interactions with others
    1. language barriers
    2. cultural and social factors
    3. physical or sensory impairments
    4. age
    5. emotional status, acceptance of condition
  - b. explanation of medical terms
  - c. strategies to improve understanding
3. patient education (e.g., explanation of current procedure purpose, exam length)

#### C. Physical Assistance and Monitoring

1. patient transfer and movement
  - a. body mechanics (e.g., balance, alignment, movement)
  - b. patient transfer techniques
2. assisting patients with medical equipment (e.g., oxygen delivery systems, urinary catheters)
3. routine monitoring
  - a. vital signs
  - b. physical signs and symptoms (e.g., motor control, severity of injury)
  - c. fall prevention
  - d. documentation

#### D. Medical Emergencies

1. allergic reactions (e.g., contrast media, latex)
2. cardiac or respiratory arrest (e.g., CPR)
3. physical injury or trauma
4. other medical disorders (e.g., seizures, diabetic reactions)

\* The abbreviation "e.g.," is used to indicate that examples are listed in parentheses, but that it is not a complete list of all possibilities.

(Patient Care continues on the following page.)



## Patient Care (continued)

### E. Infection Control

1. cycle of infection
  - a. pathogen
  - b. reservoir
  - c. portal of exit
  - d. mode of transmission
    1. direct
      - a. droplet
      - b. direct contact
    2. indirect
      - a. airborne
      - b. vehicle borne–fomite
      - c. vector borne–mechanical or biological
  - e. portal of entry
  - f. susceptible host
2. asepsis
  - a. equipment disinfection
  - b. equipment sterilization
  - c. medical aseptic technique
  - d. sterile technique

### 3. CDC Standard Precautions

- a. hand hygiene
  - b. use of personal protective equipment (e.g., gloves, gowns, masks)
  - c. safe injection practices
  - d. safe handling of contaminated equipment/surfaces
  - e. disposal of contaminated materials
    1. linens
    2. needles
    3. patient supplies
    4. blood and body fluids
- ### 4. transmission-based precautions
- a. contact
  - b. droplet
  - c. airborne
- ### 5. additional precautions
- a. neutropenic precautions (reverse isolation)
  - b. healthcare associated (nosocomial) infections

### F. Handling and Disposal of Toxic or Hazardous Material

1. chemicals
2. safety data sheet (e.g., material safety data sheets)



## Safety

### 1. Radiation Physics and Radiobiology

#### A. Principles of Radiation Physics

1. x-ray production
  - a. source of free electrons (e.g., thermionic emission)
  - b. acceleration of electrons
  - c. focusing of electrons
  - d. deceleration of electrons
2. target interactions
  - a. bremsstrahlung
  - b. characteristic
3. x-ray beam
  - a. frequency and wavelength
  - b. beam characteristics
    1. quality
    2. quantity
    3. primary versus remnant (exit)
  - c. inverse square law
  - d. fundamental properties (e.g., travel in straight lines, ionize matter)
4. photon interactions with matter
  - a. Compton effect
  - b. photoelectric absorption
  - c. coherent (classical) scatter
  - d. attenuation by various tissues
    1. thickness of body part
    2. type of tissue (atomic number)

#### B. Biological Aspects of Radiation

1. SI units of measurement
  - a. absorbed dose
  - b. dose equivalent
  - c. exposure
  - d. effective dose
2. radiosensitivity
  - a. dose-response relationships
  - b. relative tissue radiosensitivities (e.g., LET, RBE)
  - c. cell survival and recovery (LD50)
  - d. oxygen effect
3. somatic effects
  - a. short-term versus long-term effects
  - b. acute versus chronic effects
  - c. carcinogenesis
  - d. organ and tissue response (e.g., eye, thyroid, breast, bone marrow, skin, gonadal)
4. acute radiation syndromes
  - a. hemopoietic
  - b. gastrointestinal (GI)
  - c. central nervous system (CNS)
5. embryonic and fetal risks
6. genetic impact
  - a. genetically significant dose
  - b. goals of gonadal shielding

(Safety continues on the following page.)



## Safety (continued)

### 2. Radiation Protection

#### A. Minimizing Patient Exposure

1. exposure factors
  - a. kVp
  - b. mAs
2. shielding
  - a. rationale for use
  - b. types
  - c. placement
3. beam restriction
  - a. purpose of primary beam restriction
  - b. types (e.g., collimators)
4. filtration
  - a. effect on skin and organ exposure
  - b. effect on average beam energy
  - c. NCRP recommendations (NCRP #102, minimum filtration in useful beam)
5. patient considerations
  - a. positioning
  - b. communication
  - c. pediatric
  - d. morbid obesity
6. radiographic dose documentation
7. image receptors
8. dose area product (DAP) meter

#### B. Personnel Protection (ALARA)\*

1. sources of radiation exposure
  - a. primary x-ray beam
  - b. secondary radiation
    1. scatter
    2. leakage
  - c. patient as source
2. basic methods of protection
  - a. time
  - b. distance
  - c. shielding
3. protective devices
  - a. types
  - b. attenuation properties
  - c. minimum lead equivalent (NCRP #102)
4. radiation exposure and monitoring
  - a. dosimeters
    1. types
    2. proper use
  - b. NCRP recommendations for personnel monitoring (NCRP #116)
    1. occupational exposure
    2. public exposure
    3. embryo/fetus exposure
    4. dose equivalent limits
    5. evaluation and maintenance of personnel dosimetry records

\* Note: Although it is the responsibility of the individual with this permit to apply radiation protection principles to minimize bioeffects for both patients and personnel, the ALARA concept is specific to personnel protection and is listed only for that section.



## Image Production

### 1. Image Acquisition and Technical Evaluation

#### A. Selection of Technical Factors Affecting Radiographic Quality

Refer to *Attachment A* to clarify terms that may occur on the exam. (X indicates topics covered on the examination.)

	1. Receptor Exposure	2. Contrast	3. Spatial Resolution	4. Distortion
a. mAs	X			
b. kVp	X	X		
c. OID		X (air gap)	X	X
d. SID	X		X	X
e. focal spot size			X	
f. tube filtration	X	X		
g. beam restriction	X	X		
h. motion			X	
i. anode heel effect	X			
j. patient factors (size, pathology)	X	X	X	X
k. angle (tube, part, or receptor)			X	X

#### B. Technique Charts

1. anatomically programmed technique
2. caliper measurement
3. fixed versus variable kVp
4. special considerations
  - a. pathologic factors
  - b. age (e.g., pediatric, geriatric)
  - c. body mass index (BMI)

#### C. Digital Imaging Characteristics

1. spatial resolution (equipment related)
  - a. pixel characteristics (e.g., size, pitch)
  - b. detector element (DEL) (e.g., size, pitch, fill factor)
  - c. matrix size
  - d. sampling frequency

#### 2. contrast resolution (equipment related)

- a. bit depth
- b. modulation transfer function (MTF)
- c. detective quantum efficiency (DQE)
3. image signal (exposure related)
  - a. dynamic range
  - b. quantum noise (quantum mottle)
  - c. signal to noise ratio (SNR)
  - d. contrast to noise ratio (CNR)

#### D. Image Identification

1. methods (e.g., radiographic, electronic)
2. legal considerations (e.g., patient data, examination data)

(Image Production continues on the following page.)



## Image Production (continued)

### 2. Equipment Operation and Quality Assurance

#### A. Imaging Equipment

1. components of radiographic unit (fixed or mobile)
  - a. operating console
  - b. x-ray tube construction
    1. electron source
    2. target materials
    3. induction motor
  - c. manual exposure controls
  - d. beam restriction
2. x-ray generator, transformers and rectification system
  - a. basic principles
  - b. tube loading
3. components of digital imaging
  - a. CR components
    1. plate (e.g., photo-stimulable phosphor [PSP])
    2. plate reader
  - b. DR image receptors
    1. flat panel
    2. charge coupled device (CCD)
    3. complementary metal oxide semiconductor (CMOS)

#### B. Image Processing and Display

1. raw data (pre-processing)
  - a. analog-to-digital converter (ADC)
  - b. quantization
  - c. corrections (e.g., rescaling, flat fielding, dead pixel correction)
  - d. histogram
2. corrected data for processing
  - a. grayscale
  - b. edge enhancement
  - c. equalization
  - d. smoothing
3. data for display
  - a. values of interest (VOI)
  - b. look-up table (LUT)
4. post-processing
  - a. brightness
  - b. contrast
  - c. region of interest (ROI)
  - d. electronic cropping or masking
  - e. stitching
5. display monitors
  - a. viewing conditions (e.g., viewing angle, ambient lighting)
  - b. spatial resolution (e.g., pixel size, pixel pitch)
  - c. brightness and contrast
6. imaging informatics
  - a. DICOM
  - b. PACS
  - c. RIS (modality work list)
  - d. HIS
  - e. EMR or EHR

(Image Production continues on the following page.)



## Image Production (continued)

### C. Criteria for Image Evaluation of Technical Factors

1. exposure indicator
2. quantum noise (quantum mottle)
3. gross exposure error (e.g., loss of contrast, saturation)
4. contrast
5. spatial resolution
6. distortion (e.g., size, shape)
7. identification markers (e.g., anatomical side, patient, date)
8. image artifacts
9. radiation fog

### D. Quality Control of Imaging Equipment and Accessories

1. beam restriction
  - a. light field to radiation field alignment
  - b. central ray alignment
2. recognition and reporting of malfunctions
3. digital imaging receptor systems
  - a. maintenance (e.g., detector calibration, plate reader calibration)
  - b. QC tests (e.g., erasure thoroughness, plate uniformity, spatial resolution)
  - c. display monitor quality assurance (e.g., grayscale standard display function, luminance)
4. shielding accessories (e.g., lead apron, glove testing)



## Attachment A ARRT Standard Definitions

Digital Radiography	Digital Radiography includes both computed radiography and direct radiography. <u>Computed Radiography (CR)</u> systems use storage phosphors to temporarily store energy representing the image signal. The phosphor then undergoes a process to extract the latent image. <u>Direct Radiography (DR)</u> systems have detectors that directly capture and readout an electronic image signal.
Spatial Resolution	The sharpness of the structural edges recorded in the image.
Receptor Exposure	The amount of radiation striking the image receptor.
Brightness	Brightness is the measurement of the luminance of an area in a radiographic image displayed on a monitor. It is calibrated in units of candela (cd) per square meter.
Contrast	Contrast is the visible difference between any two selected areas of brightness levels within the displayed radiographic image. It is determined primarily by the processing algorithm (mathematical codes used by the software to provide the desired image appearance). The default algorithm determines the initial processing codes applied to the image data. <u>Grayscale</u> refers to the number of brightness levels (or gray shades) visible on an image and is linked to the bit depth of the system. <u>Long Scale</u> is the term used when slight differences between gray shades are present (low contrast) but the total number of gray shades is great. <u>Short Scale</u> is the term used when considerable or major differences between gray shades are present (high contrast) but the total number of gray shades is small.
Dynamic Range	The range of exposures that may be captured by a detector.
Receptor Contrast	The fixed characteristic of the receptor. Most digital receptors have an essentially linear response to exposure. This is impacted by <b>contrast resolution</b> (the smallest exposure change or signal difference that can be detected). Ultimately, contrast resolution is limited by the <b>quantization</b> (number of bits per pixel) of the analog-to-digital convertor.
Exposure Latitude	The range of exposures which produces quality images at appropriate patient dose.
Subject Contrast	The magnitude of the signal difference in the remnant beam as a result of the different absorption characteristics of the tissues and structures making up that part.



## Attachment B

### Task Inventory for the California Radiography Supervisor and Operator Examination

Activity	Content Categories
1. Confirm patient's identity.	PC.1.A.2.A., PC.1.B., IP.1.D.
2. Evaluate patient's ability to understand and comply with requirements for the requested examination.	PC.1.B.
3. Obtain pertinent medical history.	PC.1.A.2.A., PC.1.B.
4. Manage complex interpersonal interactions within the workplace in an effective manner.	PC.1.B.2.
5. Review imaging examination request to verify accuracy and completeness of information (e.g., patient history, clinical diagnosis, physician's orders).	PC.1.A.2.A.
6. Respond as appropriate to imaging study inquiries from patients.	PC.1.B.
7. Assume responsibility for medical equipment attached to patients (e.g., IVs, oxygen) during the imaging procedures.	PC.1.C.2.
8. Follow environmental protection standards for handling and disposing of bio-hazardous materials (e.g., sharps, blood, and body fluids).	PC.1.E.3.E.
9. Provide for patient safety, comfort, and modesty.	PC.1.A., PC.1.C.
10. Notify appropriate personnel of adverse events or incidents (e.g., patient fall, wrong patient imaged).	PC.1.A.2.A., PC.1.C.3., IP.1.D.
11. Communicate scheduling delays to waiting patients.	PC.1.B.
12. Demonstrate and promote professional and ethical behavior.	PC.1.A., PC.1.B.
13. Verify informed consent as necessary.	PC.1.A.1.A., PC.1.B.
14. Communicate relevant information to others (e.g., M.D.s, RNs, other radiology personnel).	PC.1.A., PC.1.B., PC.1.C.3.D.
15. Explain procedure instructions to patient or patient's family.	PC.1.B.3.
16. Practice Standard Precautions.	PC.1.E.3.
17. Follow appropriate procedures when caring for patients with communicable diseases.	PC.1.E.3., PC.1.E.4., PC.1.E.5.
18. Use immobilization devices, as needed, to prevent patient movement and/or ensure patient safety.	PC.1.A.2.D.
19. Use proper body mechanics when assisting a patient.	PC.1.C.1.A.
20. Use patient transfer devices when needed.	PC.1.C.1.B.
21. Use sterile or aseptic technique when indicated.	PC.1.E.2.
22. Follow environmental protection standards for handling hazardous materials.	PC.1.F.
23. Obtain vital signs.	PC.1.C.3.A.
24. Recognize and communicate the need for prompt medical attention.	PC.1.C.3., PC.1.D.
25. Administer emergency care.	PC.1.C.2., PC.1.C.3., PC.1.D.
26. Explain post-procedural instructions to patient or patient's family.	PC.1.B.3.
27. Maintain confidentiality of patient information.	PC.1.A.1.B., PC.1.A.3.



<b>Activity</b>	<b>Content Categories</b>
28. Clean, disinfect, or sterilize facilities and equipment, and dispose of contaminated items in preparation for next examination.	PC.1.E.2., PC.1.E.3.
29. Document required information on patient's medical record (e.g., imaging procedure documentation, images). a. On paper b. Electronically	PC.1.B.1.A., PC.1.C.3.D., IP.1.D., IP.2.B.6.
30. Evaluate the need for and use of protective shielding.	S.2.A.2., S.2.B.3.
31. Take appropriate precautions to minimize radiation exposure to the patient.	S.2.A.
32. Question female patient of child-bearing age about date of last menstrual period or possible pregnancy and take appropriate action (e.g., document response, contact physician).	PC.1.B., S.1.B.5., S.1.B.6.
33. Restrict beam to the anatomical area of interest.	S.2.A.3., IP.1.A.1.G., IP.1.A.2.G.
34. Set technical factors to produce diagnostic images and adhere to ALARA.	S.2.A., IP.1.A., IP.1.B.
35. Document radiographic procedure dose.	S.2.A.6., IP.2.B.6.E.
36. Prevent all unnecessary persons from remaining in area during x-ray exposure.	S.2.B.4.B.
37. Take appropriate precautions to minimize occupational radiation exposure.	S.2.B.
38. Advocate radiation safety and protection.	S.1.B., S.2.A., S.2.B.4.B.
39. Describe the potential risk of radiation exposure when asked.	PC.1.B.3., S.1.B.
40. Wear a personnel monitoring device while on duty.	S.2.B.4.A.
41. Evaluate individual occupational exposure reports to determine if values for the reporting period are within established limits.	S.2.B.4.B.
42. Determine appropriate exposure factors using the following: a. Fixed kVp technique chart b. Variable kVp technique chart c. Calipers (to determine patient thickness for exposure) d. Anatomically programmed technique*	IP.1.A., IP.1.B.
43. Select radiographic exposure factors. a. Automatic Exposure Control (AEC)* b. kVp and mAs (manual)	IP.1.A., IP.1.B., IP.1.C.
44. Operate radiographic unit and accessories including: a. Fixed unit b. Mobile unit (portable)	IP.2.A.1., IP.2.A.2., IP.2.A.3.
45. Operate electronic imaging and record keeping devices including: a. Computed radiography (CR) with photostimulable storage phosphor (PSP) plates b. Direct radiography (DR) c. Picture archiving and communication system (PACS) d. Hospital information system (HIS) e. Radiology information system (RIS) f. Electronic medical record (EMR) system	IP.2.A.3., IP.2.B.

\* Applies to specific modules



Activity	Content Categories
46. Modify technical factors to correct for noise in a digital image.	IP.1.D.3.B., IP.2.C.
47. Remove all radiopaque materials from patient or table that could interfere with the image (e.g., clothing removal, jewelry removal).	PC.1.B.3.A., IP.2.C.8.
48. Perform post-processing on digital images in preparation for interpretation.	IP.2.B.4.
49. Use radiopaque anatomical side markers at the time of image acquisition.	IP.1.E., IP.2.C.7.
50. Add electronic annotations on digital images to indicate position or other relevant information (e.g., time, upright, decubitus, post-void).	PC.1.A.2.E., IP.1.E., IP.2.C.7.
51. Select equipment and accessories (e.g., grid*, compensating filter*, shielding) for the examination requested.	S.2.A.2.
52. Explain breathing instructions prior to making the exposure.*	PC.1.B.3.A., IP.1.A.3.H.
53. Modify exposure factors for circumstances such as involuntary motion, casts and splints*, pathological conditions, or patient's inability to cooperate.	IP.1.A.3.H., IP.1.A.3.J., IP.1.B.
54. Verify accuracy of patient identification on image.	IP.1.E., IP.2.C.7.
55. Evaluate images for diagnostic quality.	IP.2.C., IP.2.D.
56. Respond appropriately to digital exposure indicator values.	IP.2.C.1.
57. Determine corrective measures if image is not of diagnostic quality and take appropriate action.	IP.2.C.
58. Identify image artifacts and make appropriate corrections as needed.	IP.2.C.8.
59. Store and handle image receptor in a manner which will reduce the possibility of artifact production.	IP.2.C.8., IP.2.C.9., IP.2.D.3.
60. Visually inspect, recognize, and report malfunctions in the imaging unit and accessories.	IP.2.C.8., IP.2.D.2.
61. Recognize the need for periodic maintenance and evaluation of radiographic equipment affecting image quality and radiation safety (e.g., shielding, image display monitor, light field, central ray detector calibration).	IP.2.D.
62. Perform routine maintenance on digital equipment including: a. Detector calibration b. CR plate erasure c. Equipment cleanliness d. Test images	IP.2.D.3.
63. Adapt radiographic procedures for patient condition (e.g., age, size, trauma, pathology) and location (e.g., mobile, surgical, isolation).	PC.1.C., PC.1.E., S.2.A.5., IP.1.
64. Select appropriate geometric factors (e.g., SID, OID, focal spot size, tube angle).	IP.1.A.

\* Applies to specific modules