

Diagnostic Medical Physics Support and Services

The Contractor shall furnish all labor, material, supplies, equipment, and qualified personnel to provide on-site diagnostic medical physics support or services for the Veterans Health Administration (VHA), under the terms and conditions stated herein and must adhere to VHA Handbook 1105.04, Fluoroscopy Safety, dated July 6, 2012, http://vaww.va.gov/vhapublications/ViewPublications.asp?pub_ID=2764.

The Contractor shall comply with radiation protection standards in 29 CFR 1910.1096 and immediately report any unsafe conditions with the potential to adversely impact the facility radiation workers or patients to the Radiation Safety Officer (RSO).

General Requirements

1. Performance

All work shall be performed by a qualified diagnostic medical physicist. A qualified diagnostic medical physicist is a person who is certified by the American Board of Radiology, American Board of Medical Physics, or the Canadian College of Physicists in Medicine. For mammography, a qualified medical physicist can have state licensure to perform mammography inspections in lieu of board certification. For diagnostic computed tomography (CT), nuclear medicine, PET, or MRI, a qualified medical physicist can meet the following requirements in lieu of board certification:

- A graduate degree in physics, medical physics, biophysics, radiologic physics, medical health physics, or a closely related science or engineering discipline from an accredited college or university
- Documented 3 years of clinical experience in CT, nuclear medicine, PET, or MRI. The physicist must document the 3 years of experience for the modality being inspected.

2. Mandatory Services to be Performed

- a. The qualified diagnostic medical physicist shall perform imaging equipment (x-ray equipment, nuclear medicine cameras, PET/CT cameras, ultrasound units, and MRIs) inspections to ensure compliance with the current American College of Radiology (ACR) and Mammography Quality Standards Act (MQSA) requirements. Any deficiencies or non-conformances discovered during the inspection shall be verbally communicated to the service supervisor or RSO prior to the qualified diagnostic medical physicist leaving the facility. Deficiencies or non-conformances which represent unsafe conditions with the potential to adversely impact the facility radiation workers or patients shall be reported to the RSO immediately upon discovery. A written report of the results shall be provided to the service supervisor or RSO within 5 working days after completion of the inspection. All imaging equipment (except ultrasound which is semi-annually, nuclear medicine cameras, and PET which are quarterly) shall be inspected at least annually.

- b. The qualified diagnostic medical physicist shall perform acceptance testing of all new or relocated imaging equipment prior to first clinical use. The acceptance testing shall comply with ACR or MQSA requirements. Any deficiencies or non-conformances discovered during the inspection shall be verbally communicated to the service supervisor or RSO prior to the qualified diagnostic medical physicist leaving the facility. Deficiencies or non-conformances which represent unsafe conditions with the potential to adversely impact the facility radiation workers or patients shall be reported to the RSO immediately upon discovery. A written report of the results shall be provided to the service supervisor or RSO within 5 working days after completion of the inspection.
- c. The qualified diagnostic medical physicist shall perform a full inspection of imaging equipment after repairs or modifications that may affect the radiation output or image quality. The inspection shall be completed within 48 hours after the facility contacts the contractor. Any deficiencies or non-conformances discovered during the inspection shall be verbally communicated to the service supervisor or RSO prior to the qualified diagnostic medical physicist leaving the facility. Deficiencies or non-conformances which represent unsafe conditions with the potential to adversely impact the facility radiation workers or patients shall be reported to the RSO immediately upon discovery. A written report of the results shall be provided to the service supervisor or RSO within 5 working days after performing of the inspection.
- d. The qualified diagnostic medical physicist shall provide consultation for additional services as needed, i.e., safety training.
- e. The qualified diagnostic medical physicist shall review CT protocols at least annually.
- f. The qualified diagnostic medical physicist shall provide shielding design calculations for each new, replaced, or relocated x-ray imaging system. The calculations for each shall comply with the National Council for Radiation Protection and Measurements (NCRP) Report No. 147, and, for dental units, NCRP Report No. 145, and shall be documented in a written report which includes a diagram showing adjacent areas. The qualified diagnostic medical physicist shall perform a shielding survey to verify the structural shielding was installed per the shielding design report and complies with the design goals. A written report of the shielding survey shall be provided to the RSO within 5 working days after the shielding survey has been completed.
- g. The qualified diagnostic medical physicist shall assist in the development of a comprehensive technical quality assurance (QA) program (e.g., technique charts, repeat/reject analysis monitoring, monitoring of exposure indices to radiographic image receptors, QA program for display monitors, QA for CT, monitoring of dose metrics from fluoroscopy studies), which complies with ACR recommendations, for all modalities. The qualified diagnostic medical physicist shall review at least annually the QA program. A written report of the results shall be provided to the service supervisor or RSO within 5 working days after performing of the inspection.

- h. The qualified diagnostic medical physicist shall perform a follow-up inspection to verify compliance of any necessary corrective action performed to correct deficiencies found.

3. Equipment Inspections

The Contractor shall conduct equipment inspections or quality control surveys of the imaging equipment listed below. The Contractor shall ensure the imaging equipment's compliance with applicable Federal regulations and ACR recommendations, and shall include, but not be limited to, monitoring the following basic performance characteristics.

A. Radiographic and Fluoroscopic Equipment

Physics inspections of radiographic and fluoroscopic equipment shall comply with the ACR Technical Standard for Diagnostic Medical Physics Performance Monitoring of Radiographic and Fluoroscopic Equipment. The performance of each radiographic and fluoroscopic unit must be evaluated at least annually. This evaluation should include, but not be limited to, the following tests (as applicable).

- (1) Integrity of unit assembly.
- (2) Collimation and radiation beam alignment.
- (3) Fluoroscopic system spatial resolution.
- (4) Automatic exposure control system performance.
- (5) Fluoroscopic automatic brightness control performance (high-dose-rate, pulsed modes, field-of-view [FOV] variation).
- (6) Image artifacts.
- (7) Fluoroscopic phantom image quality.
- (8) kVp accuracy and reproducibility.
- (9) Linearity of exposure versus mA or mAs.
- (10) Exposure reproducibility.
- (11) Timer accuracy.
- (12) Beam quality assessment (half-value layer).
- (13) Fluoroscopic entrance exposure rate (or air kerma rate). Maximum output and output using a phantom representing a standard size patient for all clinically used settings. [The mode of operation [e.g., magnification mode, frame rate, and any other mode selected) must be documented for each measurement.]
- (14) Fluorographic (image recording) entrance exposure rate (or air kerma rate) for cine imaging, if performed and entrance exposure (or air kerma) for spot images (if performed). Maximum output and output using a phantom representing a standard size patient for all clinically used settings. [The mode of operation (e.g., magnification mode, frame rate, etc.) must be documented for each measurement.]
- (15) Image receptor entrance exposure.
- (16) Equipment radiation safety functions.
- (17) Patient dose monitoring system calibration. This includes, for radiographic systems, the metric of dose to the image receptor (IEC Exposure Index or proprietary index) and, for fluoroscopy systems, the displays of cumulative air kerma and, if available, DAP.
- (18) Display monitor performance.

- (19) Digital image receptor performance.
- (20) Grids used with portable x-ray units shall be imaged for uniformity.
- (21) For radiographic units, measurement of entrance skin exposure (or air kerma) for a standard size patient for common radiographic projections and comparison to published diagnostic reference levels and achievable doses (e.g., ACR practice parameter).

Note: The information on entrance exposure rates (or air kerma rates) from fluoroscopy and from fluorography, in Items (13) and (14) above, for each fluoroscope, shall be in a format suitable for providing to the physicians who operate the fluoroscope.

B. Computed Radiography (CR) and Digital Radiography (DR)

Physics inspections of CR and DR equipment shall comply with the American Association of Physicist in Medicine (AAPM) Report Number 93, Acceptance Testing and Quality Control of Photostimulable Storage Phosphor Imaging Systems. The performance of CR and DR must be evaluated at least annually. This evaluation should include, but not be limited to, the following tests (as applicable).

- (1) Component and Imaging Plate Physical Inspection and Inventory.
- (2) Imaging Plate Dark Noise and Uniformity.
- (3) Exposure Indicator Calibration.
- (4) Linearity and Auto-ranging Response.
- (5) Laser Beam Function.
- (6) Limiting Resolution and Resolution Uniformity.
- (7) Noise and Low-Contrast Resolution.
- (8) Spatial Accuracy.
- (9) Erasure Thoroughness.
- (10) Aliasing/Grid Response.
- (11) IP Throughput.
- (12) Positioning and Collimation Errors.

C. CT Scanners

The physics inspection shall conform to the 2012 ACR Computed Tomography Quality Control Manual. The performance of each CT scanner shall be evaluated at least annually. This evaluation should include, but not be limited to, the following tests (as applicable).

- (1) Review of Clinical Protocols.
- (2) Scout Prescription and Alignment Light Accuracy.
- (3) Image Thickness – Axial Mode.
- (4) Table Travel Accuracy.
- (5) Radiation Beam Width.
- (6) Low-Contrast Performance.
- (7) Spatial Resolution.

- (8) CT Number Accuracy.
- (9) Artifact Evaluation.
- (10) CT Number Uniformity.
- (11) Dosimetry (the scanner displayed $CTDI_{vol}$ values must be within $\pm 20\%$ of the measured $CTDI_{vol}$ values).
- (12) Gray Level Performance of CT Acquisition Display Monitors.

D. Dental

The physics inspection shall conform to the Conference of Radiation Control Program Directors (CRCPD), Quality Control Recommendations for Diagnostic Radiography Volume 1 Dental Facilities July 2001. The performance of dental x-ray inspections shall be annually or every 2 years. This evaluation should include, but not be limited to, the following tests (as applicable).

- (1) Collimation.
- (2) Beam quality (half value layer).
- (3) Timer Accuracy and Reproducibility.
- (4) kVp Accuracy and Reproducibility.
- (5) mA or mAs Linearity.
- (6) Exposure Reproducibility.
- (7) Entrance Skin Exposure Evaluation, with comparison to published diagnostic reference levels and achievable doses (e.g., NCRP Report No. 172).
- (8) Technique Chart Evaluation.
- (9) Image uniformity (artifact evaluation).

Dental CBCT Acceptance and Performance Testing

1. **Acceptance Testing.** Acceptance testing and measurements of air kerma at the isocenter for each kVp station for a range of clinically used mAs settings will be performed initially when the CBCT unit is installed, and following any move of the CBCT to another area inside or outside the initial clinical site. This testing is to ensure that the equipment performance is in agreement with the manufacturer's technical specifications.
2. **Performance Testing.** Each CBCT unit shall undergo periodic quality control tests to ensure that the performance of the machine has not significantly deteriorated and is operating within the manufacturer's technical specifications. This performance testing is performed by a qualified expert annually, at intervals not to exceed 14 months, and after repairs to the CBCT unit that may affect the radiation output or image quality.
3. Some manufacturers provide a phantom and procedures to perform machine specific quality assurance (QA) tests. In cases where the manufacturer provides a phantom and procedures to perform specific tests but the tests are not included in this SOW,

then the manufacturer's machine-specific QA tests shall be performed in addition to the QA tests in this SOW.

Acceptance and Annual physics testing for Dental CBCT

1. Radiation output Repeatability

Make four measurements of the air kerma at the isocenter at a clinically used setting. The measurements should be less than +/-5% of the average of the five measurements and the measurements should be less than +/- 5% of the previous year's measurement.

2. Radiation Output Reproducibility

Measure the air kerma at the isocenter for each kVp station and a range of clinically used mAs setting. Compare the results to the baseline values established at the initial acceptance testing. The values should be +/-5% of the baseline.

3. kVp Accuracy

Measure the kVp at all clinically used settings. The measured kVp should be +/-5% of the selected kVp.

4. kVp Repeatability

Make five kVp measurements each for two clinically used kVp settings. All measured values should be +/-5% of the mean kVp.

5. kVp Reproducibility

Measure the kVp at all available kVp settings. The measured values should be +/-5% of the baseline.

6. Beam quality

Measure the half value layer (HVL) for aluminum. The minimum shall comply with Section F.4.d of the Suggested State Regulations for Control of Radiation, Conference of Radiation Control Program Directors.

7. Radiation field of view (FOV)

Measure the width of the radiation field at the isocenter. The width of the beam should be 3 mm or 30% of the total nominal collimated width.

8. Image Quality

Image the phantom provided by the manufacturer or another suitable phantom. Assess high contrast spatial resolution, uniformity of transaxial images, and image noise. Imaging uniformity shall be assessed over the entire range of axial images.

9. Accuracy of Linear Measurements

Using images of an appropriate phantom, assess the accuracy of distance measurements.

10. Accuracy of Patient Dose Metric Indication

Assess the accuracy of the indicated dose metric (typically DAP).

11. Patient Dose Assessment

From a scan or scans using the facility's standard techniques, record the dose metric (typically DAP) and compare to achievable levels and diagnostic reference levels (if available)

12. Review of the technical QA program

The qualified expert shall review the technical QA program. The review shall include a trend analysis of the QA data. The results of the technical QA program review shall be included in the written report. Any trends that identify problems shall be included in the report along with recommended corrective actions.

13. Display Monitors

Perform a visual analysis of the SMPTE test pattern.

1. Display the test pattern on the imaging console. Set the display window width/level to the manufacturer-specified values for the pattern. Do not set the window/level by eye; doing so invalidates the procedure.
2. Examine the pattern to confirm that the gray level display in the imaging console is subjectively correct.
 - a. Review the line pair patterns in the center and at each of the corners.
 - b. Review the black-white transition.
 - c. Look for any evidence of "scalloping" (loss of bit depth) or geometric distortion.
3. Use a photometer to measure the maximum and minimum monitor brightness (0% and 100% steps)
4. Measure additional steps within the pattern to establish a response curve.
5. Measure the brightness near the center of the monitor and near all 4 corners (or all 4 sides, depending on the test pattern used).

14. Viewing Conditions

Assess the viewing conditions for the area in which the monitor used to evaluate the CBCT studies is located.

E. Mammography

The qualified diagnostic medical physicist inspecting mammography equipment must meet the qualifications outlined in the MQSA and shall provide the facility with up-to-date documentation demonstrating the qualified diagnostic medical physicist is MQSA qualified. Inspections of mammography equipment must comply with the latest

requirements posted on the ACR Web site for the manufacturer of the digital mammography unit being inspected. Inspection items may include:

- (1) Mammographic Unit Assembly Evaluation.
- (2) Collimation assessment.
- (3) Artifact evaluation.
- (4) kVp accuracy and reproducibility.
- (5) Beam quality assessment – HVL measurements.
- (6) Evaluation of system resolution.
- (7) Automatic Exposure Control (AEC) function performance .
- (8) Breast entrance exposure, AEC reproducibility, and average glandular dose.
- (9) Radiation output rate.
- (10) Phantom image quality evaluation.
- (11) Signal-to-noise ratio and contrast-to-noise ratio measurements.
- (12) View box luminance and room illuminance.
- (13) Review Work Station (RWS) tests.

F. MRI

The physics inspection shall conform to the 2004 ACR Magnetic Resonance Imaging Quality Control Manual. The performance of each MRI scanner shall be evaluated at least annually. This evaluation should include, but not be limited to, the following tests (as applicable).

- (1) Magnetic field homogeneity.
- (2) Geometric accuracy.
- (3) Inter-slice RF interference.
- (4) Slice position accuracy.
- (5) High-contrast resolution
- (6) RF coil performance.
 - (a) Volume coils' signal-to-noise ratio
 - (b) Volume coils' image uniformity
 - (c) Volume coils' ghosting ratio
 - (d) Phased array coils' signal-to-noise ratio
 - (e) Surface coils' signal-to-noise ratio
- (7) Slice thickness accuracy
- (8) Low-contrast detectability
- (9) Soft copy displays
- (10) Technologist's QC program
- (11) Site phantom inventory
- (12) Site RF coil inventory

G. PET

The physics inspection shall conform to the ACR PET Phantom Instructions for Evaluation of PET Image, ACR Nuclear Medicine Accreditation Program PET Module.

The performance of each PET scanner shall be evaluated at least quarterly. For PET/CT units the CT must be inspected at least annually per Item C above. This evaluation should include, but not be limited to, the following tests (as applicable).

- (1) Uniformity.
- (2) Spatial resolution.
- (3) SUV analysis.

H. Nuclear Medicine

The physics inspection shall conform to the ACR annual performance tests for nuclear medicine cameras. The qualified diagnostic medical physics shall also perform the quarterly testing as outlined by the ACR. The performance of each nuclear medicine scanner shall be at least annually. This evaluation should include, but not be limited to, the following tests (as applicable).

- (1) Intrinsic Uniformity
- (2) System Uniformity
- (3) Intrinsic or System Spatial Resolution
- (4) Relative Sensitivity
- (5) Energy Resolution
- (6) Count Rate Parameters
- (7) Formatter/Video Display
- (8) Overall System Performance for SPECT
- (9) System Interlocks
- (10) Dose Calibrators (Geometry, if applicable, Accuracy)
- (11) Thyroid Uptake and Counting Systems

I. Ultrasound

The physics inspection shall conform to the ACR performance tests for ultrasound. On an ongoing basis (at least semiannually), the following tests should be done for each ultrasound unit. Testing should be done using two transducers commonly used with any unit employing more than one transducer. Data should be taken from testing of the transducers which are used for the most frequently occurring examination(s) at the site. It is recommended that these be of different scan formats such as one linear (or curvilinear array), and one sector (mechanical, phased, or vector).

- (1) System Sensitivity/Penetration

This test should be done with the following settings:

- maximum transmit power
- proper receiver gain and TGC that allows echo texture to be visible in the deep region
- transmit focus at the deepest depth

The maximum depth of visualization is determined by comparing the gradually weakening echo texture to electronic noises near the bottom of the image.

(2) Image Uniformity

Adjust the TGC controls and other sensitivity controls to obtain an image as uniform as possible.

- vertical or radially oriented streaks?
- dropouts?
- reduction of brightness near edges of the scan?
- brightness transitions between focal zones?

(3) Electrical and Mechanical Safety and Cleanliness

- Are all cords and cables intact (no frays)?
- Are all transducers intact without cracks or delamination?
- Are the transducers cleaned after each use?
- Are the image monitors clean?
- Are the air filters clean?
- Are the wheel locks in working condition?
- Are the wheels fastened securely to the US unit and do the wheels rotate easily?
- Are all accessories (VCR, cameras, etc.) fastened securely to the US unit?

(4) Gray Scale Photography (if applicable) – Do either (a), (b), or (c).

(a) For Scanners with a Discrete Bar Pattern

Count the number of distinct gray bar steps on the viewing monitor. Then count the number of steps visualized in the gray bar on the hard copy image.

(b) For Scanners with a Continuous Gray Bar Pattern

Use calipers to measure the length of the black-to-white transition of the gray wedge on the viewing monitor. If the relative length of the black-to-white transition on the hard copy image is less, document how much is missing.

(c) For Laser Imager (Hard Copy Device)

Prior to filming any images, an SMPTE test pattern created by the Society of Motion Picture and Television Engineers (SMPTE), should be printed using the appropriate window width (WW) and window level (WL). If you are unfamiliar with this procedure, you should review Gray et al., “Test pattern for video display and hard-copy camera,” *Radiology* 145:519-527 (1985), and then contact your local service engineer for assistance. When printed, the 95% density patch within the 100% square and the 5% density patch within the 0% square should be visible, and there should be no notable distortions or artifacts present. If these criteria are not met, contact your service engineer for laser camera calibration before proceeding with *any* filming.

(5) Hard Copy Output Quality Test (Digital) (if applicable)

This test, or a similar test specifically recommended by the hard copy equipment manufacturer.

Required Test Equipment

- Densitometer

- SMPTE Test Pattern or another similar test pattern or phantom image having a wide range of gray scales.

The same test image should be used each time.

J. Display Monitors

The annual performance evaluation conducted by the diagnostic medical physicist includes testing of image acquisition display monitors for maximum and minimum luminance, luminance uniformity, resolution, and spatial accuracy. The image acquisition display monitors for nuclear medicine, PET, CT, and MRI units shall be tested.