X. QUALITY CONTROL & PERFORMANCE TESTING MANUAL OF OPERATIONS FOR CT

The following quality control measures have been developed for the NLST. Only multi-detector CT scanners will be used for the low-dose helical CT scans in the NLST. These quality control and quality assurance procedures apply only to multi-detector platforms.

X.1 DOCUMENTATION OF PERFORMANCE TESTING OF CT SCANNER AT TIME OF INSTALLATION

For purposes of certification for the NLST, it is recommended that a qualified medical physicist supervise the image quality assurance tests on your helical CT scanner. Documentation that performance testing was completed at the time of CT equipment installation will be provided in the form of an attestation signed by the qualified medical physicist who performed the acceptance tests. The performance tests should include assessments of the following:

- Alignment light accuracy
- Slice thickness
- Spatial resolution
- Low contrast resolution
- Image uniformity
- Noise
- Artifact Evaluation
- CT number accuracy
- Display devices

The attestation form should state the kinds of tests that were conducted at the time of equipment installation. The form can be mailed, FAXed, or e-mailed to the ACRIN DMC. A copy should be retained at the site. The tests and measurements that were performed on the scanner(s) are kept at the site, but should be available in the event of a site inspection.

X.2 CT DOSIMETRY INDEX (CTDI)

A qualified medical physicist must perform dose measurements using Computed Tomography Dose Index (CTDI) phantoms on all multi-detector scanners on which screening examinations will be performed during the NLST. With these CTDI measurements, various calculations of dose for adult screening chest CT examinations can be made across the NLST sites. Measurements should be made using the technique factors to be used for screening examinations. The appropriate equations and a calculation spreadsheet will be provided to assist in these calculations. A panel of ACRIN-NLST medical physicists will review the accompanying dosimetry data.

X.3 PERTINENT DEFINITIONS AND TERMS USED IN CALCULATIONS

X.3.1 CTDI Body Phantom: A phantom designed in accordance with the FDA’s performance standard for diagnostic x-ray systems, with regulations specifically applicable to CT systems. Head and body phantoms are manufactured by a number of commercial vendors. The body phantom will be used for ACRIN-NLST phantom testing, and consists of a circular acrylic, polymethyl-methacrylate (PMMA) phantom having (See Figure X.1 below):

- cylindrical holes (four at 1 cm from the edge and one in the center)
- 32 cm diameter and 15-cm length

X.3.2 \( T = Z \text{ axis collimation} \) = width of one data channel (in the z-axis). In multi-detector CT scanners, several detector elements maybe grouped together to form one data channel.

X.3.3 \( N = \# \text{ data channels} \) = the actual number of data channels used during an acquisition.

X.3.4 \( N_{\text{max}} = \text{Maximum } \# \text{ of data channels} \) = the maximum number of data channels along the z-axis.

X.3.5 \( I = \text{Increment} \) = the table increment per rotation of the x-ray tube in a helical scan.
X.4 CALIBRATE SCANNER:
Prior to scanning the phantom, perform tube warm-up and any necessary daily calibration scans (air scans, water scans) as recommended by the manufacturer. It is recommended that the site’s water phantom be scanned and tested for accuracy of the CT number of water, absence of artifacts, and uniformity across the field of view prior to proceeding.

X.5 REQUIRED MATERIALS FOR CTDI
The following materials will be necessary for performance of CTDI measurements:
- Calibrated CTDI (pencil) ionization chamber (typically 10 cm length)
- Calibrated electrometer
- CTDI body phantom
- Dose calculation Excel Spreadsheet (provided in Appendix or supplied electronically by NLST)
  
  If your electrometer measures exposure (R), use the Excel spreadsheet named ‘Dose calculator (exposure).’
  
  If your electrometer measures air kerma (mGy), use the excel spreadsheet named ‘Dose Calculator (air kerma).’

The physicist should record the make, model and serial number of the electrometer and chamber used for dose measurement, as well as the latest calibration date of the chamber and electrometer. Calibration should have occurred within one year of the testing date.

X.6 CTDI RADIATION DOSIMETRY
This section provides explicit instructions for the measure of adult body CTDI values.

X.6.1 Remove the table pad and position the Body (Abdomen) acrylic phantom at scanner isocenter on the table. Ensure that the phantom is correctly aligned in the sagittal, coronal, and axial planes.

X.6.2 Connect the pencil ionization chamber to your electrometer and insert the pencil chamber into the central hole in the phantom. Ensure that all other holes (holes at 3, 6, 9, 12 o’clock positions) are filled with acrylic rods.

X.6.3 Acquire one axial scan at the center of the phantom, with no table increment, using your low dose helical CT technique for this scanner. Although your technique is a helical acquisition, perform an axial scan instead, while keeping the remaining technical parameters unchanged. CTDI dose information must be acquired using axial scan acquisitions.

NOTE: In multi-slice CT, CTDI is a function of detector configuration. Thus, it is imperative that the detector configuration used in the site’s clinical protocol (N T, where N may be less than or equal to Nmax) be used during dose measurements. As some systems do not explicitly note the value of detector configuration, the physicist may need to consult the operator’s manual, literature, or manufacturer to determine the correct value of N T that corresponds to the site’s helical scan protocol. [see McCollough and Zink, “Performance evaluation of a multi-slice CT system” Medical Physics 26:2223-2230 (1999)].

X.6.4 Record the kVp, mA, exposure time (sec), z axis collimation (T, in mm) and number of data channels used (N).
X.6.5 **Record** the exposure in mR (or air kerma in mGy) from the scan. Be sure to know the chamber correction factor for your particular combination of electrometer and ionization chamber.

X.6.6 Repeat the above scan two more times and **record** the measurement from each scan. **Screen save ONE of these images** using WW = 400 and a WL = 100.

X.6.7 Calculate and **record** the average measurement (exposure or air kerma) for the scan. If the data differ by more than 5%, check your equipment and reacquire the data until the three measurements agree to within 5%.

X.6.8 Using the average measured value (exposure or air kerma), calculate CTDI_{100}:

\[
\text{CTDI}_{100} = f \cdot C \cdot E \cdot L / (N \cdot T)
\]

Where
- \( f \) = conversion factor from exposure to dose in air, use 0.87 rad/R
- (for conversion factor from air kerma to dose in air, use 1.0 mGy/mGy)
- \( C \) = calibration factor for electrometer (typically 1.0, but may be 2.0 for some equipment)
- \( E \) = average measured value (exposure or air kerma)
- \( L \) = active length of pencil ion chamber (typically 100 mm, but 160 mm for some chambers)
- \( N \) = *actual* number of data channels used during one axial acquisition
  - (N_{max} is the maximum possible number of data channels used simultaneously in one rotation.
  - For multi-slice CT, N may be less than or equal to N_{max} for a given protocol).
- \( T \) = nominal slice width of one data channel

**Sample Calculations**

**Multi-slice scanner**, 120 kVp, 50 mA, 0.8-second scan and 4 x 2.5 mode
(four 2.5-mm axial scans acquired per 0.8-sec exposure)
Electrometer measures exposure: 40 mR
\[
\text{CTDI}_{100} = (0.87 \text{ rad/R})(1.0)(.040 \text{ R})(100 \text{ mm}) / [(4)(2.5 \text{ mm})] = .35 \text{ rad (3.5 mGy)}
\]

**Siemens VZ multi-slice scanner**, 120 kVp, 60 mA, 0.5 sec scan and 4 x 2.5 mm slice thickness
(four 2.5 mm axial scans acquired per 0.5 sec exposure)
Electrometer measures exposure: 26 mR
\[
\text{CTDI}_{100} = (0.87 \text{ rad/R})(1.0)(.026 \text{ R})(100 \text{ mm}) / [(4)(2.5)] = .23 \text{ rad (2.3 mGy)}
\]

**GE Ultra multi-slice scanner**, 120 kVp, 80 mA, 0.5 sec scan, and 1.25 x 8 mm slice thickness
(eight 1.25 mm axial scans acquired per 0.5 sec exposure, even though data to be reconstructed to 2.5 mm nominal slice thickness)
Electrometer measures exposure: 35 mR
\[
\text{CTDI}_{100} = (0.87 \text{ rad/R})(1.0)(.035 \text{ R})(100 \text{ mm}) / [(8)(1.25)] = .30 \text{ rad (3.0 mGy)}
\]

**Multi-slice scanner** –air kerma chamber, 120 kVp, 50 mA, 0.8-second scan and 4 x 2.5 mode
(four 2.5-mm axial scans acquired per 0.8-sec exposure)
Electrometer measures **air kerma**: 0.32 mGy
\[
\text{CTDI}_{100} = (1.0 \text{ mGy/mGy})(1.0)(.32 \text{ mGy})(100 \text{ mm}) / [(4)(2.5 \text{ mm})] = 3.2 \text{ mGy (3.2 rad)}
\]

For multi-slice scanners, it is helpful to understand that the value of \( N \cdot T \) represents the total z-axis width (in mm) of the active detector (relative to gantry isocenter). Theoretically, this value should equal the nominal width of the radiation beam (in mm) at isocenter. For example, use of a 4 x 2.5-mm detector configuration yields \( N = 4 \) and \( T = 2.5 \), so \( N \cdot T = 10 \). Use the value of \( N \cdot T \) for the CTDI acquisition (which MUST be in the AXIAL mode!), even if the routine protocol is a helical acquisition.

X.6.9 **Record** the resultant value (in mGy) as the CTDI at isocenter in Body phantom.
X.6.10 Move the pencil chamber from the isocenter position to the 12 o’clock peripheral position. Ensure that an acrylic rod is then inserted into the vacated isocenter position.

X.6.11 Repeat sections X.6.3 through X.6.8 and **record** the resultant value (in mGy) as the **CTDI at 12 o’clock in Body phantom**.

X.6.12 Calculate and **Record** (in mGy) **CTDIw**:

\[
\text{CTDIw} = \frac{1}{3} \cdot \text{CTDI}_{100,\text{center}} + \frac{2}{3} \cdot \text{CTDI}_{100,\text{edge}}
\]

Where, **CTDI}_{100,\text{center}} = \text{CTDI at isocenter in Body phantom}

and \text{CTDI}_{100,\text{edge}} = \text{CTDI at 12:00 in Body phantom}

X.6.13 Using the technical parameters of your routine low dose helical chest CT protocol, calculate and **record** (in mGy) the **Volume CTDIw (CTDIvol)**:

For axial imaging: \( \text{CTDIvol (mGy)} = \text{CTDIw} \cdot N \cdot T / I \)

For spiral imaging: \( \text{CTDIvol (mGy)} = \text{CTDIw} \cdot N \cdot T / I = \text{CTDIw} / P \)

Where \( P = \text{Pitch} \).

*It is essential that Pitch be calculated according to the IEC definition, even if the value disagrees with that displayed on the scanner console:*

\[ \text{Pitch (P)} = \text{Tablespeed (I, mm/rotation)} / (N \cdot T) \]

X.6.14 Using an assumed total scan length of **40 cm**, calculate and **record** (in mGy-cm) the **dose-length product (DLP)**:

\[ \text{DLP (mGy-cm)} = \text{CTDIvol (mGy)} \cdot \text{total scan length (cm)} \]

X.6.15 Calculate and **record** (in mSv) the estimated **Effective Dose (E)**:

Where, \( k = 0.017 \) for a low dose helical chest

\[ E \text{ (mSv)} = k \cdot \text{mGy^{-1} \cdot cm^{-1}} \cdot \text{DLP (mGy-cm)} \]

(European Guidelines on Quality Criteria for Computed Tomography, EUR 16262 EN, May 1999)

It is important to note that alternative methods and conversion coefficients exist to calculate Effective Dose. *This is an estimate only, and can differ from other estimates by as much as a factor of 2. This estimate is NOT the dose for any given individual, but rather, for a standardized anthropomorphic phantom, representative of the “whole-body-equivalent” radiation detriment (risk) associated with the “partial-body” CT exam. These values can be used to optimize protocols, and as a broad indication of the relative risk of the CT exam compared to background radiation or exams from other modalities.*
X.7  BI-MONTHLY WATER PHANTOM TESTS PERFORMED BY TECHNOLOGIST

Bi-monthly water phantom tests will be performed on all CT scanners used in the ACRIN-NLST to test for water attenuation, field uniformity, and noise. Field uniformity refers to CT number (HU) variations in a uniform field (usually a water or water-equivalent phantom) and is assessed by comparing the attenuation in a region of interest (ROI) at the center of the uniform field versus along the edges.

Water phantom tests will ensure that the CT equipment is operating optimally at the acquisition parameters described by the protocol, and that degradations in performance can be rapidly determined and processes established for their correction.

The images and measurements obtained from water phantom testing will be reviewed by the ACRIN-NLST Physicist Committee to ensure proper CT equipment performance. Any problems are reported to ACRIN DMC and to the site along with any recommendations for correction. Following correction, phantom retesting is performed to ensure that the equipment is functioning properly. If a scanner is not functioning properly, it will not be used to acquire scans for NLST participants until the technical problems have been corrected and confirmed by retesting.

X.7.1  Description of the Phantom.

A water phantom will be used. These phantoms are usually supplied by the CT manufacturer at the time of scanner installation for purposes of routine quality assurance testing (See Figure X.2 below)

X.7.2  Positioning the Phantom

Place the phantom into the scanner. If a phantom holder is available, then placing the phantom on this holder should provide the correct orientation of the phantom for testing. If a phantom holder is NOT available, then carefully place the phantom on the table top. Avoid placing the phantom directly above any metal in the table or metallic connectors as this will affect results. You can secure the phantom to the table with flexible tape (which will not affect image quality), although avoid any tape of high attenuation, as this too may affect the results.

Align the phantom so that is located in the center of the gantry in the axial, coronal and sagittal planes. Do this by first positioning the phantom so that the CT external alignment laser or lights are accurately positioned over the center portion of the phantom containing water only. If there is no external alignment laser, use the internal laser/lights for positioning. Make sure to avoid adjacent materials (or phantom modules if using multi-purpose modular phantoms) as volume averaging effects may affect test results. Use the laser alignment lights to align the phantom accurately in the coronal, sagittal and axial planes:

- Align the axial light to the center of the phantom containing water only.
- Align the coronal light to up/down center of the phantom (If there are horizontal lines on either side of the phantom; then align to these)
- Align the sagittal light to the left and right center of the phantom (If there is a vertical line on the face of the phantom, then use this).

When the alignment is correct,
(a) If you are using external alignment lasers, then set the external landmark at this point;
(b) If you are using internal alignment lasers, then set the internal landmark at this point.

![Figure X.2](#)  Front and side views of water phantom. Note that axial laser line is located directly over the center of the water phantom.
X.7.3 Scanning the Phantom for Water Calibration and Noise
Prescribe a short helical scan that goes through the center of axial location 0. Use the same technical factors prescribed for screening CT exams for the ACRIN/NLST on this scanner platform (for the reconstruction algorithm, use the non-sharpening algorithm). Use a display field of view (reconstructed image diameter) as close to but not smaller than the diameter of the water-equivalent phantom. The scan series should extend the entire width of the phantom (z-axis).

X.7.4 Measurement of Water calibration, Uniformity and Noise
Of the reconstructed images, select one image representing the center of the phantom for measurements.

a) View this phantom image with a WW = 100 and a WL = 0. Place one ROI of approximately 400 mm$^2$ in the center of the image, one at the 12 o’clock position (2 cm from the edge), and one at the 3 o’clock position (2 cm from the edge) (see Figure X.3 below).

b) Record the mean value and standard deviation for each ROI in the Phantom Data Sheet

c) On the data sheet, calculate and record the Uniformity Value:
   Uniformity Value = Center mean CT # - Edge mean CT # for the two edge ROIs.

d) With these ROIs on the image, perform a SCREEN SAVE function to save the image with the ROIs and their mean and standard deviation values in the image.

e) With all graphics turned off, view the image carefully with the room lighting reduced. Examine the image for artifacts such as rings or streaks and record the presence and appearance of any artifacts on the data sheet. If artifacts are present, a service engineer may need to be contacted to investigate the artifact.

![Figure X.3 – Measurement of Noise and Uniformity.](image)

X.8 Data Transfer of the Water Phantom and CTDI Images
The images (Screen Save Images) acquired in the processing of measuring CTDI and water phantoms should be pushed to the ACRIN Image QC archive at the time of submission of the Equipment Data Forms.

At the time of CT Equipment Certification, push the CTDI phantom Screen Save images, Water Phantom images and the Screen Save images with the ROIs and numerical values to the ACRIN data transfer workstation. At that workstation, change the name of the images to your site ID followed by CTDI and WATER, respectively. Transfer all images to the ACR CT Quality Assurance archive.

For the bi-monthly water phantom tests, push water phantom images and the screen save images with the ROIs and numerical values to the ACRIN data transfer workstation. At that workstation, change the name of the images to your site ID followed by WATER. Transfer the images to the ACR CT Quality Assurance archive.
Y. Quality Control & Performance Testing Manual of Operations for CXR

This manual of operations accompanies ACRIN NLST CXR Machine Certification Form and describes the quality control (QC) and quality assurance (QA) measures to be followed for the NLST chest radiographic equipment. The QC/QA programs of the NLST are designed to ensure a uniform standard of image quality across the NLST in chest radiography as well as to capture important information on the radiation exposures being used for posteroanterior (PA) projection radiography screening. The programs consist of four (4) major components as follows:

1. Certification of individual CXR machines to be used to acquire NLST chest images
2. Description of the CXR machines and their x-ray beam characteristics
3. Consistent sampling of visual image quality by radiologists
4. Consistent sampling of entrance skin exposure (ESE) of screening images

Note: The NLST does not specify the type of image receptor (film-screen or digital) or display medium (film or soft copy) used for purposes of interpretation.

Y.1 Documentation of Performance Testing of CXR Equipment at Time of Installation and Annual Quality Control

As part of the quality control evaluation of chest X-ray (CXR) machines used in the ACRIN/NLST study, the site physicist is expected to perform initial acceptance testing upon installation and thereafter annually test and document the following:

- a. System assembly patency
- b. Collimation
- c. kVp accuracy
- d. mA linearity
- e. Exposure reproducibility
- f. Beam half value layer
- g. Image receptor (including grid) for uniformity and artifacts.

The testing results should be retained at the site, but may be reviewed at the time of site visits. Annual attestations should be completed that document which tests have been performed. Specific Physics tests for the ACRIN NLST CXR Machine Certification may already be performed as part of annual physics evaluation.

Y.2 CXR Machine Certification for NLST

The following are guidelines for completing the ACRIN NLST Chest X-Ray Machine Certification form. A separate certification form is required for each CXR machine used to image NLST patients. The numbered items below map to corresponding fields in the NLST CXR Machine Certification Form

Y.2.1 General Data
1. ACRIN Site: Indicate 4-digit ACRIN site number
2. Site PI
3. Date of Testing: Indicate date that the form and measurements were completed.
4. Indicate Site Physicist.

Y.2.2 CXR Machine
5. Site’s Machine / Room ID Code: Indicate the designation that uniquely identifies this X-ray machine / room. This designation should map to a Unit Number that will be used by the technologist to document on the Screening DR Form (ACRIN 6654 DR) s the specific CXR unit on which an image was acquired. 5b. Assign the machine a unique unit number. This unit number must be consistent throughout the trial. To maintain consistency, the unit number should be posted at the room clearly so that technologists can record this for every examination. Any new CXR unit used to acquire images for NLST should be assigned a new number. If a CXR unit is retired, DO NOT reuse the NLST ID number to which it was assigned.
For example:

<table>
<thead>
<tr>
<th>DR Form</th>
<th>CXR Machine Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Outpatient Fuji CR 5501</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Room 361-B</td>
</tr>
</tbody>
</table>

Signage: NLST Unit NO. 4

6. **Indicate X-Ray Machine Manufacturer**: Please select from code table, if manufacturer cannot be found on list please identify in box provided.

7. **Generator Console Model Name**: Please indicate the manufacturer’s model designation for this machine.

8. **Year manufactured**: Indicate four digit year of manufacture for the generator (not X-ray tube).

9. **Dedicated Chest Unit**: Please indicate whether this machine is designed specifically for chest radiography. A “dedicated chest room” may be used for other work besides chest radiography. However, if the equipment geometry is permanently set for chest work by having a fixed SID and possibly fixed collimation.

10. **X-ray tube nominal focal spot size**: Indicate nominal focal spot size that is clinically used for (PA) chest radiography.

11. **Beam Filtration**: Measure Half Value Layer at 100 kVp
   
   a) **Equipment**: ionization chamber and electrometer calibrated to clinically used CXR X-ray energies and four to six 1-2 mm thick sheets of type 1100 or 1145 aluminum of dimensions sufficient to adequately cover ion chamber.
   
   b) **Place ion chamber**: 100 cm from X-Ray source and collimate such that chamber is just fully contained within X-ray field.
   
   c) **Using the focal spot**: and mA station clinically used for Chest X-Ray select an exposure time sufficient to yield at least 300 mR for non filtered exposure.
   
   d) **Assure measured kVp**: is within 5% of nominal kVp for unfiltered exposure.
   
   e) **Make and record exposure without any filtration.**
   
   f) **Add 2 mm Al between source and ion chamber**: at least four inches from chamber and repeat exposure with same generator technical factors.
   
   g) **Repeat “f”**: with increasing thicknesses of aluminum until measured exposure is reduced to less than half of unfiltered exposure.
   
   h) **Determine and record HVL from graphical plot on semi-log paper or through logarithmic interpolation using the exposure readings that bracket half of the unfiltered exposure value where E0 is unfiltered exposure, Ea is exposure that is just greater than E0/2 at aluminum thickness ta, and Eb is exposure that is just less than E0/2 at Al thickness tb.

12. **Repeat HVL measurement for kVp that is clinically used for PA chest radiography** using steps outlined in “11.”

**Y.2.3 EXPOSURE OUTPUT**

13. **Exposure Output (air kerma)**: For the six nominal kVp settings indicated in the table indicate measured kVp and exposure in air with an ion chamber (see figure below).
   
   a. **Select focal spot and mA station**: clinically used by this machine for PA chest exposures.
   
   b. **Manually select an exposure**: time sufficient to produce reproducible exposures (at least 10 milliseconds – recommend 100 milliseconds)
   
   c. **Place appropriate ion chamber**: 100 cm (40 inches) from tube focal spot (if other distance is used be sure to use “good geometry” low scatter conditions and to correct the recorded exposure to 100 cm).
   
   d. **Collimate to an area**: sufficient to cover the ion chamber.
e. Record exposure for each kVp setting indicated (if 150 kVp is not used at your institution it may be omitted).
f. Using similar set-up measure kVp at each of the indicated settings.

\[ T = \text{thickness of object} \]
\[ D = \text{distance from source to meter} \]

**Y.2.4 TEST EQUIPMENT**
14. **Ionization chamber**: Record the model name, serial number, and calibration date of the ionization chamber used to make measurements.
15. **Electrometer**: Record the model name, serial number, and calibration date of the electrometer used to make measurements.
16. **kV Meter**: Record the model name, serial number, and calibration date of the kV meter used to make measurements.

**Y.2.5 IMAGE RECEPTOR GRID**
17. **Source image receptor distance**: Record the distance from the X-ray tube focal spot to image receptor plane.
18-21. **Indicate the characteristics of the anti-scatter device used for this machine/room**. This information is typically noted on the grid itself. Note that assistance from a service engineer may be needed to access the grid. The information requested includes:
   a. Type of grid
   b. Grid ratio
   c. Grid frequency
   d. Honeycomb design?
   e. Grid focal distance
   f. Grid focal range
Y.2.6 ANALOG IMAGE RECEPTOR:
(Complete this section only if NLST images are acquired with screen: film systems)

22-26. Indicate film, screen, and film processor characteristics for those used for NLST images. If film cassette has two different screens (hybrid) please indicate both. The kinds of information requested include:
   a. Nominal Screen: Film Speed
   b. Film Manufacturer
   c. Screen Manufacturer
   d. Film Processor manufacturer and year of manufacture
   e. Developer Chemistry
   f. Film Transport time and temperature

Y.2.7 DIGITAL IMAGE RECEPTOR / CR OR DR
(Complete this section if NLST images are acquired with digital acquisition devices)

27. CR Reader ID: If CR is used for NLST images, record the CR reader unique designation that will be used by technologist on ACRIN 6654 DR form. Identify the CR reader manufacturer and model number.

28. Digital Radiology (not based on photostimulable phosphor luminescence [PSL] technology) For other digital technologies, record the manufacturer and model number. If not included on list please identify type of receptor, i.e., amorphous silicon thin film transistor, amorphous selenium, CCD, etc.

29. CR Reader/DR calibration: Record the method used for digital exposure calibration. For CR this is typically a manufacturer unique exposure index that correlates to a specific exposure value (i.e., 1 mR) to the imaging plate. For DR units this may correspond to a set exposure value to achieve a certain signal to noise level in a flat field image. The following information is requested:
   a. Frequency of calibration
   b. Availability of records for documentation
   c. Person who verifies calibration
   d. Exposure calibration

30. Target Exposure Index Range: Record the exposure parameter range set by the institution as acceptable for the performance of PA chest radiography. (For example, for a Fuji CR 9501 system, this might be S-value of 175-300).

31. Automatic Exposure Control (Phototiming): Indicate if CR/DR images are obtained with automatic exposure control. Images obtained should have exposure indices that correspond to those designated in “30.”

Y.2.8 FILM PROCESSOR / PRINTER QC

32. Quality Control Program: Record any film processor quality control program in place for either the analog or digital films that are produced for NLST images that measures film base plus fog, exposure index, and some contrast gradient differences. Indicate whether records of that testing are available at the site.

33. Frequency of processor QC: Record the frequency of processor quality control measures.

Y.2.9 DISPLAY AND ARCHIVE FOR DIGITAL MEDIA

34. Display Media: Record the display media used for image review of NLST images for purposes of interpretation by radiologists.

34b. Computer Monitor characteristics: If a computer monitor is used