The primary quality control testing should be done quarterly using the American College of Radiology (ACR) MRI test phantom which is also used for the accreditation process of MRI systems. Each site should purchase the phantom which comes with manuals on how to scan and analyze the subsequent data. For ACR phantom purchase ($730/phantom) contact:

J.M. Specialty Parts
11689-Q Sorrento Valley Rd.
San Diego, CA 92121
858 794-7200

B1. Typical Report:

The ACR phantom was imaged according to the guidelines of the ACR pamphlet "Site scanning instructions for use of the MR phantom" and subsequent measurements were made from sagittal and axial images acquired with T1-weighted and T2-weighted spin echo sequences.

B2. Test Procedure

Seven specific tests are performed from a scanning session that should last less than 20 minutes. A description of each exam and analysis is provided below. Note that all 7 tests provided results which were within the acceptable limits of image quality specified by the ACR which will also be used as the PBTC criteria for acceptable scanning

Test 1: Geometric Accuracy
Linear measurements of the dimensions of the phantom along several directions are made and compared with known dimensions of the phantom. Measured values must be within $\pm$ 2 mm of known dimensions.

Results
a) end-to-end-sagittal view, localizer slice, measured value = 147 mm, actual value = 148 mm.
b) top-to-bottom axial view, slice 1, measured value = 189 mm, actual value = 190 m.
c) left-to-right axial view, slice 1, measured value = 189 mm, actual value = 190 mm
d) top-to-bottom axial view, slice 7, measured value = 190 mm, actual value = 190 mm
e) left-to-right axial view, slice 7, measured value = 190 mm, actual value = 190 mm
f) diagonal 1, axial view, slice 7, measured value = 190 mm, actual value = 190 mm
g) diagonal 2, axial view, slice 7, measured value = 189 mm, actual value = 190mm

Test 2: High Contrast Spatial Resolution

Three pairs of 4 x 4 arrays of 1.1 mm, 1.0 mm and 0.9 mm holes are imaged and counted with imaging sequences having a 1 mm spatial resolution specification. The number of distinguishable holes in each array are identified.

Array 1(1.1 mm holes) – all holes identified
Array 2(1.0 mm holes) – all holes identified
Array 3 (0.9 mm holes) – only ¼ holes identified

Test 3: Slice Thickness Accuracy

The slice thickness insert of the phantom consists of two crossed ramps which yield estimates of the actual vs proscribed slice thickness of 5 mm. Length measurements of the top and bottom ramp signal intensities were 63 mm and 41 mm respectively from which the actual slice thickness is calculated using the formula

Slice thickness = 0.2 x (63 x 41/(63 + 41)) = 4.97 mm

which is well within the specified range of 5.0 $\pm$ 0.7 mm required for acceptance.

Test 4: Slice Position Accuracy

Slices 1 and 11 are aligned with the vertices of crossed 45o wedges so that when perfectly aligned, two black bars will appear next to each other in each of the images of slice 1 and 11. For perfect slice position, the bars will have equal length. If the difference between the bar lengths is less than 5 mm, then the center of the slices are within 2.5 mm of the prescribed locations and within tolerance. The bar length differences in slices 1 and 11 were approximately 3 mm, well within tolerance (less than 5 mm) for this measurement.

Test 5: Image Intensity Uniformity

A uniform region of the phantom (axial slice 7, 19,849 mm^2 area) was selected and two regions-of-interest (ROI's), 100 mm^2 each, with the highest and lowest signal intensities were identified. Signal intensities from these two ROI's were used to calculate the percent integral uniformity (PUI) through the equation

$$PUI = 100 \times (1 - (ROI_{high} - ROI_{low})/(ROI_{high} + ROI_{low}))$$

The ROI_{high} and ROI_{low} were measured as 1374 and 1227, respectively, yielding a PUI value of 94 %. This is above the minimum PUI value of 87.5 % required for acceptance.

Test 6: Percent Signal Ghosting

The large ROI identified for image intensity uniformity (Test 5) is used to estimate signal intensity within the ACR phantom (ROI_{large}). Four additional measurements are made in the air outside of the phantom to estimate noise values along both the frequency and phase encode dimensions. Ghost signal occurs only along the phase encoding direction so that the ghost signal is calculated as

Ghosting ratio = (left + right – top – bottom)/(2 x ROI_{large})

Measurements were 1321, 11.1, 10.9, 17.8 and 16.8 for the large, top, bottom, left and right ROI's respectively where the left and right were the phase encode noise measurements containing the ghost signals. The ghosting ratio was thus calculated as 0.005 which is well below the 0.025 limit specified for acceptance.

Test 7: Low Contrast Object Detectability

Slices 8 – 11 of the ACR phantom contain 10 spokes each containing 3 low contrast objects per spoke with contrast decreasing from 5.1 %, 3.6 %, 2.5 % and 1.4 % for slices 11 – 8, respectively. One counts the number of spokes for which all three objects can be seen in each slice and sums the number of spokes so-counted through all four slices (a spoke is not counted if any one of the three objects are not visualized). From the T1 spin echo scans, 36 spokes were counted and for the T2-weighted spin-echo sequence 37 spokes were counted. This far exceeds the 9 spokes required per scan for acceptance.