

## Standard Operating Procedure

### Weekly CT QC Phantom Test: GE Revolution, RevES, RevApex

ABCD-21-16-90209

#### SITE APPLICABILITY:

All Medical Imaging (MI) sites in Fraser Health (FH), Providence Healthcare (PHC), Provincial Health Services Authority (PHSA), and Vancouver Coastal Health (VCH).

#### PURPOSE:

To ensure consistent image quality over the CT scanner system's lifetime and to establish and maintain a regular Quality Assurance (QA) program.

To comply with the Diagnostic Accreditation Program (DAP) standard for CT QC testing.

#### SCOPE:

Applicable to sites with a GE Revolution, Rev ES and Rev Apex CT scanner.

#### RESPONSIBILITIES:

The CT department (CT technologist) at the site will perform the Weekly QC and ensure that a water phantom and QA phantom are both scanned under a prescribed set of conditions:

- Ensure that the mean CT number falls within the range of the manufacturer's specifications.
- Ensure that the standard deviation representing image noise and the calculations for image uniformity are within acceptable parameters.
- Ensure the contrast to noise ratio is within acceptable parameters
- Repeat this test on a weekly basis to detect changes in image quality values before the problem becomes visible. This is performed in addition to the Daily Phantom test.
- Perform a "Checkup" scan or "FastCal" if it was last performed more than 12 hours ago.
- Ten Baseline QC scans must be performed by the site's CT technologists when specifically requested to do so by the physicist or a quality coordinator. This would occur when QC data does not fall within acceptable parameters in the 2 weeks following the replacement of CT imaging components. (tube, detector, collimator, etc.)

The CT Technologist will record baseline data (when required) and subsequent QC data in the **Daily** QC logbook and record on the Medical Imaging (MI) Quality [HealthBC] SharePoint site specific CT folder.

The CT technologist will compare the subsequent QA results from Daily QC against the baseline results.

- If degradation in image quality/obvious artifacts, failing noise and uniformity calculations, or CT number outside of the manufactures specifications is observed, contact radiology service.
- Early intervention could prevent a major breakdown and/or negative impacts to patient care.

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### REQUIREMENTS:

<b>Personnel required: 1</b>		<b>Phantom Weight: 4 kg (8.8 lbs)</b>
<b><u>Task</u></b>	<b><u>Estimated time (minutes)</u></b>	
Phantom setup time	2	
Acquisition time	2	
Analysis/ Recording time	If Passes, ~ 4 minute / If Fails, ~ 6-9 minutes	
Dismantle phantom setup	2	
<b>Total Time</b>	<b>10 - 15 minutes</b>	

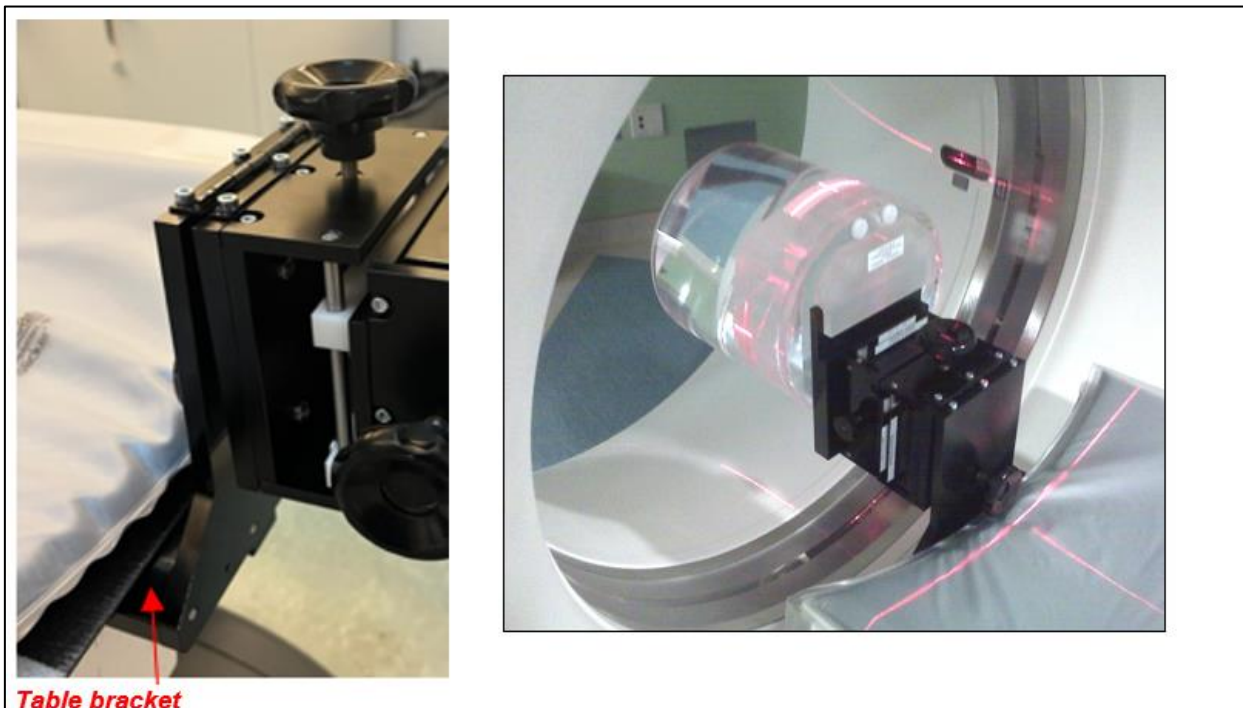
### PROCEDURE:

#### Tools and Test Equipment

20cm Water Phantom

QA Phantom (image quality)

Figure 1: *Attachment of the Water Phantom to the Table Gantry*



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Adhere to the following guidelines when handling or positioning the phantom.

- Visually inspect the water and QA phantom and phantom holder for damage before each use. If damaged, do not use the broken piece. Have it replaced immediately.
- The phantom bracket on the phantom, used to support it on the phantom holder, is not a handle. It should not be used to hold or carry the phantom. While transporting the phantom, carry it securely with both hands to avoid dropping it. A damaged phantom can potentially cause injury.
- The phantom bracket is meant to have a snug fit on the phantom holder. This minimizes motion during scanning, which could lead to false failures in the QA images. The snug fit requires the user to take care when positioning or removing the phantom from the phantom holder.

### Procedure

*Daily Quality Control scans should be done after the daily start up (reboot), tube warmup and system calibrations (fast cal).*

#### 1. Position the Water Phantom


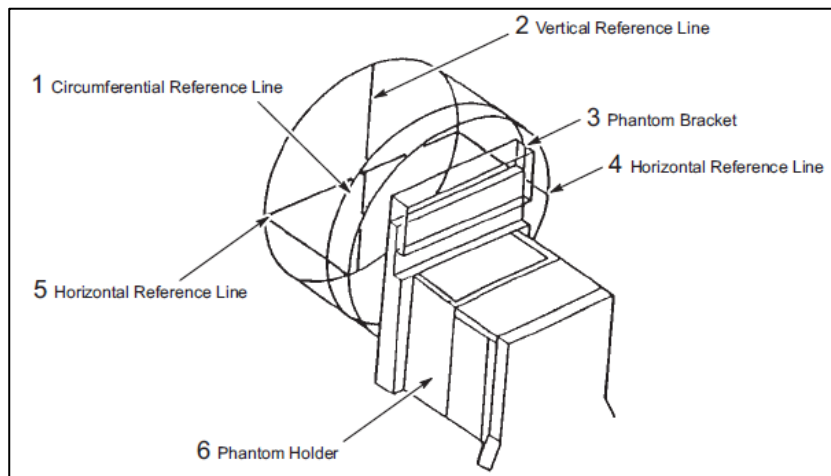
- 1.1 Place the water phantom on the phantom holder and level it.
- 1.2 Turn the knob facing the cradle clock-wise to tilt the top of the phantom AWAY from the gantry.
- 1.3 Use the laser alignment lights to position the phantom (see **Figure 2**):
  - a. Align the axial light to the circumferential line marking.
  - b. Align the coronal light to the horizontal lines on either side of the phantom.
  - c. Align the sagittal light (where it strikes the top of the phantom) to the vertical line on the top of the phantom.
  - d. Position the phantom and select laser alignment button 

Figure 2: **Phantom reference lines.**



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### 2. Prescribe the QA Series for the Noise and Uniformity Tests

- 2.1 Select the scheduled **QC patient** from the worklist
- 2.2 Select 2 protocols from the **default** protocol list:  
 [Adult < Miscellaneous < LMMI Weekly CT QC < Water Phantom]  
 [Adult < Miscellaneous < LMMI Weekly CT QC < QC Phantom]
- 2.3 Click on **Accept**
- 2.4 Ensure any **Auto-push** function is set to **off**
- 2.5 Verify the protocol uses the acquisition parameters in Table 1 and Table 2
- 2.6 Click on **Confirm Settings**
- 2.7 Press **Start Scan** on keyboard (120 kV)
- 2.8 Click on **Continue**
- 2.9 Click on **Confirm Settings**
- 2.10 Press **Start Scan** on keyboard (80 kV)
- 2.11 Click on **Continue**
- 2.12 Click on **Done Scanning**
- 2.13 Click on **Done Scanning**
- 2.14 Repeat steps 1.1 through 2.13 for the QA phantom and then **Close Exam**

### 3. If the facility hasn't created a Weekly QA protocol, use the following parameters to finish the QA series prescription:

On the **Helical View Edit** screen select the following parameters:

**Table 1: Parameters for QA** Protocol Name: **LMMI Weekly CT QC**  
**120 kV and 80 kV (Patient Supine) Water Phantom**

	Interface	Input for 120 kV	Input for 80 kV
<b>Anatomy Selection</b>			
	Full FOV Start	<b>S7.5</b>	<b>S7.5</b>
	Full FOV End	<b>I7.5</b>	<b>I7.5</b>
	Scan FOV	<b>Small Body</b>	<b>Small Body</b>
	DFOV	<b>22.7 mm</b>	<b>22.7 mm</b>
	A/P Centre	<b>A0.0mm</b>	<b>A0.0mm</b>
	R/L Centre	<b>R0.0 mm</b>	<b>R0.0 mm</b>
<b>kV and mA Control</b>			
	kV Mode	<b>Manual</b>	<b>Manual</b>
	kV	<b>120kV</b>	<b>80 kV</b>
	mA Mode	<b>Manual</b>	<b>Manual</b>
	mA	<b>315 mA</b>	<b>315 mA</b>

**Note:** This is a **controlled** document for LMMI internal use. Any documents appearing in paper form should always be checked against the electronic version prior to use. The electronic version is always the current version.

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	Interface	Input for 120 kV	Input for 80 kV
<b>Scan Type</b>			
	Scan Type	Axial	Axial
	Hi Res Mode	Off	Off
	Rotation Time	1s	1s
<b>Coverage and Speed</b>			
	Table Positions	One	One
	Detector Coverage	80 mm	80 mm
	Number of Passes	1	1
	Rotation Time	1 s	1 s
	Total Exposure Time	1 s	1 s
<b>Primary Recon Settings CT Number Accuracy &amp; Uniformity, Noise</b>			
	Thickness	5 mm	5 mm
	Recon Type	Std	Std
	ASiR-V	0%	0%
	Window Width	400	400
	Window Level	40	40
	Flip/Rotate	None	None
<b>Secondary Recon Settings Artifact</b>			
	Thickness	0.625 mm	0.625 mm
	Recon Type	Std	Std
	ASiR-V	0%	0%
	Window Width	400	400
	Window Level	40	40
	Window Level	None	None

**Table 2: Parameters for QA** Protocol Name: LMMI Weekly CT QC  
 120 kV and 80 kV (Patient Supine) QA Phantom (Contains IQ Objects)

	Interface	Input for 120 kV	Input for 80 kV
<b>Anatomy Selection</b>			
	Full FOV Start	S7.5	S7.5
	Full FOV End	I7.5	I7.5
	Scan FOV	Small Body	Small Body
	DFOV	22.7 mm	22.7 mm
	A/P Centre	A0.0mm	A0.0mm
	R/L Centre	R0.0 mm	R0.0 mm

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	Interface	Input for 120 kV	Input for 80 kV
<b>kV and mA Control</b>			
	kV Mode	Manual	Manual
	kV	120kV	80 kV
	mA Mode	Manual	Manual
	mA	315 mA	315 mA
<b>Scan Type</b>			
	Scan Type	Axial	Axial
	Hi Res Mode	Off	Off
	Rotation Time	1s	1s
<b>Coverage and Speed</b>			
	Table Positions	One	One
	Detector Coverage	80 mm	80 mm
	Number of Passes	1	1
	Rotation Time	1 s	1 s
	Total Exposure Time	1 s	1 s
<b>Primary Recon Settings CT Number Accuracy &amp; Uniformity, Noise</b>			
	Thickness	5 mm	5 mm
	Recon Type	Std	Std
	ASiR-V	0%	0%
	Window Width	400	400
	Window Level	40	40
	Flip/Rotate	None	None

#### 4. Analyze the Water Phantom Images

Display the primary and secondary reconstructed water phantom images (**120 kV**) of the helical scan and perform analysis as described in the following sections.

##### 4.1 Perform the following:

- CT Number, Noise and Uniformity tests** at scan location **S2.5** of the helical scan of the primary (5mm) images.
- Artifact test:** Inspect all secondary (0.625mm) reconstructed images for any obvious artifacts.

##### 4.2 Record the data from the tests in the corresponding columns of the weekly QC log sheet. (Orange cell colour = Failure)

##### 4.3 If a significant change in values is noticed, first check the Small FOV calibration status.

- Calibrate the small FOV if the most recent calibration data falls outside the guidelines established by the facility.



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- 4.4 Repeat the entire procedure if either the CT number, noise and uniformity, CNR or artifact tests fail, ensuring the correct phantom positioning and protocol have been used.  
Record the failed and repeated data on the log sheet.
- 4.5 If a test fails a second time, report the failure to the supervisor and site coordinator.
- 4.6 Follow facility procedures to notify radiology service.
- 4.7 Repeat the above procedure (4.2–4.6) for all reconstructed **80 kV** (5mm) water phantom images

#### 5. CT Number, Noise, and Uniformity of Water

Water phantom test for CT number, noise and uniformity (see **Figure 3**).

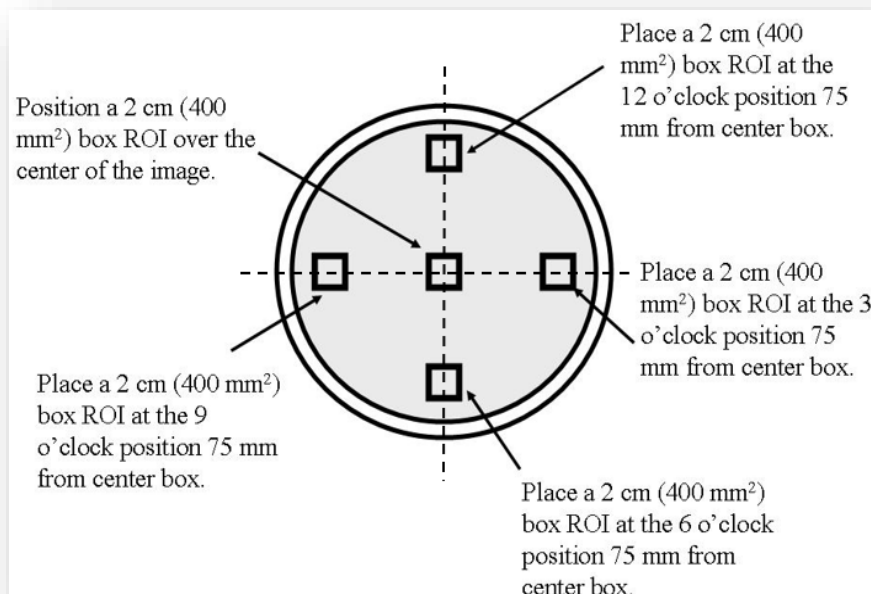
Use scan location **S2.5** (Recon1) 5mm primary reconstructed images

Use the **Standard** algorithm to reconstruct the image.

- 5.1 Select **Grid** overlay. Precisely center the grid vertically and horizontally.
- 5.2 Select **Box ROI** to position a  $400 \text{ mm}^2 \pm 20 \text{ mm}$  box ROI over the center of the image.
- 5.3 Record the center ROI mean CT number and standard deviation (Noise) in the QC log sheet.
- 5.4 Select **Box ROI** and move the cursor to the 12 o'clock position (75 mm from Center ROI's center to the 12 o'clock ROI's center).
- 5.5 Record that mean CT number on the weekly QC log sheet on MI Quality site.
- 5.6 Repeat step 5, 6 and 7 for each of the 3, 6 and 9 o'clock positions.

*\*Note: Uniformity = the absolute difference between the CT numbers from the Centre ROI and the each of the 12, 3, 6 and 9 o'clock ROIs*

Figure 3. **CT Number, Noise, Uniformity section**



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### 6. Artifact Test

- 6.1 Assess the 120 kV and 80 kV secondary reconstructed (0.625mm) water phantom images for obvious artifacts.
- 6.2 Record in Daily and Weekly log sheet and QC room checklist on the MI Quality site.

### 7. Contrast to Noise Ratio (CNR) Image Quality (QA) Phantom

Open the **120 kV: CNR** images

Select **S2.5** (or as close as possible)

- 7.1 From Measure/Annotate
  - a. Select Grid Overlay
  - b. Select the Circle ROI tool and place approx. **200 mm<sup>2</sup>** (+/- 10 mm<sup>2</sup>) in the small circle (without wire)
- 7.2 Record the average HU (av) in the weekly Excel log sheet
- 7.3 Move the circle ROI to the center of the image (centered on the crosshairs)  
Ensure the ROI does not include water
- 7.4 Record the mean (av) and standard deviation (sd) in the weekly Excel log sheet in Image Quality Water (HU) column
- 7.5 Repeat for steps 7.1-7.4 for **80 kV: CNR** images. (See Figure 4)

Figure 4: **Contrast to Noise Ratio**

**Measured at S2.5 for 120 kV and 80 kV images with 5mm slices**

Measurement of **water** value



Measurement of **plastic**



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### 8. Finalization

- 8.1 Close any image files still open on the screen.
- 8.2 Save to PACS, only those images that have obvious artifacts. (Ensure that auto-push is not on)
- 8.3 Remove the phantom from the system bore and return to storage location.
- 8.4 Record all data on both the MI Quality Site log sheet and QC Room Checklist.
- 7.5 Take exam to **Completed** status in PACS (if required) and then RIS.

### 9. Typical Results and Allowable Variations

GE expects the standards of allowable variation in image quality parameters to vary with the installation and image evaluator(s).

Ensure the prescribed technique was used, then follow the facility guidelines to inform service when the variations reach the specified maximum deviation as indicated by the log sheet or observations.

#### 9.1 CT Number, Noise and Uniformity of water and IQ/CNR

When imaging and analyzing the water section of the phantom is performed correctly, the following should be seen:

- a. CT number of the center ROI within the range of  **$0 \pm 4$  HU**, exceeding GE's specifications.
- b. Standard deviation (Noise) of the center ROI should not vary from the baseline by more than **0.2 HU**.
- c. Uniformity within the allowable range of **2 HU** from the established acceptance baseline values.

When analyzing the Image Quality (QA) Phantom:

- a. CRN and IQ values should not vary from the baseline by more than **10%**

#### 9.2 Phantom Image Artifacts

Because the human eye determines clinical image quality, it remains subjective and difficult to define.

No obvious artifacts should be visible when viewing the reconstructed image with standard window width and window level).

Examples of artifacts that are serious enough to be reported to radiology service are shown in *Figures 4 and 5* below.

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Figure 3: *Cupping Artifact*

Figure 4: *Ring Artifact*

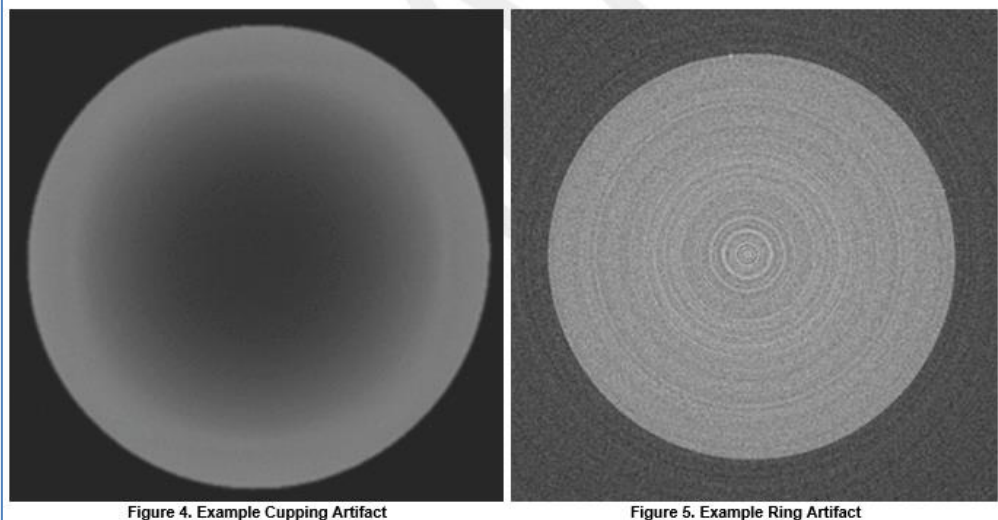


Figure 4. Example Cupping Artifact

Figure 5. Example Ring Artifact

#### REFERENCES/ASSOCIATED DOCUMENTS:

Diagnostic Accreditation Program Accreditation Standards – Diagnostic Imaging  
<https://www.cpsbc.ca/accredited-facilities/dap/accreditation-standards-DI>

5443887-1EN, Rev# 2 (March, 2015 Revolution CT Technical Reference Manual

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<b>First Effective Date:</b>	28-JUN-2023			
<b>Posted Date:</b>	05-MAR-2024			
<b>Last Revised:</b>	23-FEB-2024			
<b>Last Reviewed:</b>	23-FEB-2024			
<b>Approved By:</b>	Medical Physicist Lead, MI			
<b>Owners:</b>	Quality Coordinator, MI			
<b>Revision History:</b>	<b>Version</b>	<b>Date</b>	<b>Description/ Key Changes</b>	<b>Revised By</b> (Name and Position)
	1.0	28-JUN-2023	Initial release	Cheryl Mason, Quality Coordinator
	2.0	xx-MAR-2024	Revise responsibility section, Clarify frequency of daily and weekly test, Change QA to Water phantom, Change 10% to 0.2HU, Change WW and WL from default to standard	Cheryl Mason, Quality Coordinator