

Regional Radiation Protection Service

Oncology and Research Suite Royal Surrey County Hospital Guildford Surrey GU2 7XX
Tel: 01483 408395 Email: rsc-tr.RadProt@nhs.net

ON-SITE INSPECTIONS

Commissioning and Acceptance Radiation Protection Report

Facility and associated information

Employer:	AMDS	Date of assessment:	31 st January 2024
Facility:	Mobile CT unit "CT23"		
Location:	Tested at Lamboo Medical, Haydock, St Helen's		
Equipment Make	GE		
Equipment Model	Revolution EVO		
and System No.:	SN: CBDGG2300081HM		
Tube Details:	GE MX200CT III Tube (SN: 119483BA6)		
Local contact(s):	Jill Mckenna, Head of Imaging & Operations		





Summary

A GE Revolution Evo CT scanner has been installed into a new mobile CT facility constructed by Lamboo Medical. Commissioning of the system was undertaken on the 31st January 2024. A detailed environmental radiation protection assessment was also undertaken to assess the lead shielding in the walls, floor and the roof of the new mobile unit.

The unit was checked in accordance with the requirements of the Ionising Radiations Regulations 2017 (IRR17) and the Ionising Radiation (Medical Exposure) Regulations 2017 (IR(ME)R17). The performance of the CT scanner was assessed and compared with the manufacturer's specifications where applicable, expected performance and IPEM Reports 32 and 91. Results from these tests will provide baselines for future measurements. Engineering controls, safety features and warning signals provided by the employer were also checked as part of the survey.

It is understood that the installer, GE Medical, have completed the Critical Examination.

Points of non-compliance and recommendations

Flag	No.	Note	Actioned (date/initials)
	1	The risk assessments for the mobile units should be updated to include this unit. Area Local Rules should be written for this unit and put on display. A fault book should also be available with the unit.	
	2	Emergency procedures must be reviewed to ensure that the appropriate power-off options are clearly identified for this specific unit.	
	3	A local QC programme should be established which includes both the recommended manufacturer's QC and the tests required to meet the requirements of IPEM 91.	
	4	A full survey of patient dose should be undertaken once the scanning protocols have been established.	

Key:



Immediate action required



To be resolved as soon as practicable



To be addressed



Point to note



Satisfactory

Radiation Protection Overview

The CT system and physical controls comply with statutory requirements.

A two-stage warning light was in place in the control room and in the equipment room to the rear of the scanner. These were tested and indicated that the wiring installation was correct, and the position is satisfactory.

An environmental survey was carried out by measuring instantaneous dose-rates (IDRs) in the areas around the CT scan room including the roof of the mobile unit. Measurements were made using a helical body protocol. Measurements were made whilst scanning a 32cm Perspex phantom to simulate scatter. A helical body scan was selected and exposure factors used were 140 kVp, 250 mA, Large Body FOV, 1.0 s rotation time, 40 mm collimation and 'detail' pitch (0.516:1). The scan time was approximately 9.1 s. The indicated CTDIvol was 61.4 mGy, which is worst case and not likely to be clinically representative. Results are summarised below and detailed results are given in Appendix A.

All IDRs quoted in this report may be divided by a factor of 3 to give the dose-rates averaged over one minute as it can be assumed that the x-ray beam will only be on for a 20 second period in every minute. This is a conservative overestimation and in clinical use dose-rates (averaged over a minute) are likely to be lower.

Location	Measured Instantaneous Dose Rate (IDR)
Operator position	The maximum IDR at an expected operator position was measured to be 0.1 $\mu\text{Sv/h}$, which was measured at chest height. The IDR under the desk at the seated operator position was 0.1 $\mu\text{Sv/h}$.
Control room wall (see Fig A1)	A maximum IDR of 4.3 $\mu\text{Sv/h}$ was measured through the control room wall.
Main door from control room to scan room (see Fig A1)	A maximum IDR of 15.8 $\mu\text{Sv/h}$ was measured along the side of the door. Around the window of the main door a maximum IDR of 2.31 $\mu\text{Sv/h}$ was measured.
Control room windows(see Fig A1)	A maximum IDR of 0.1 $\mu\text{Sv/h}$ was measured along the side of the control room window.
Door in slide out to patient lift (see Fig A2)	A maximum IDR of 12.9 $\mu\text{Sv/h}$ was measured along the side of the window in the door. Around the sides of the door a maximum IDR of 6.6 $\mu\text{Sv/h}$ was measured.
Door to rear equipment room (see Fig A3)	A maximum IDR of 9.9 $\mu\text{Sv/h}$ was measured along the side of door. Through the walls a maximum IDR of 3.1 $\mu\text{Sv/h}$ was measured.
External walls (bottom of walls) (see Fig A4)	A maximum IDR of 3.1 $\mu\text{Sv/h}$ was measured along the bottom of the side walls of the unit.
Under slide-outs (see Fig A4)	At floor level under the slide outs of the unit the maximum IDR was measured to be 5.6 $\mu\text{Sv/h}$.
External walls (middle of walls) (see Fig A5)	Excluding the door to the patient lift, a maximum IDR of 5.5 $\mu\text{Sv/h}$ was measured along the side walls of the unit.
Roof of unit (see Fig A6)	A maximum IDR of 9.3 $\mu\text{Sv/h}$ was measured through the roof. This will not impact on the site positioning of the unit.

The following points were noted during testing:

- The window specification was etched into the glass indicating a lead equivalence of 4.0 mm Pb at 150 kVp.
- Lamboo specification indicates that 4.0 mm Pb has been installed in the walls and 2.65 mm Pb has been installed in the doors, floor and roof.
- Exposure lights on the console and gantry were all functioning as expected.
- It is expected that Local Rules, Systems of Work, and Emergency Procedures will be subsequently developed, as on other units of this type.
- A local QC programme will need to be established.
- A fault book should be made available once in use.
- The emergency off buttons were tested and were all found to be working as expected. There is also a main power button in the Operator Room that can remove all power to the gantry.

Equipment Performance Testing

The scanner performance was found to be within expected tolerances and confirmed to meet the manufacturer's specification, where available. Results were also found to be comparable to those obtained on other scanners of a similar type.

Imaging resolution and slice reconstruction were measured to be satisfactory and meet the manufacturer's specification where available. CT noise values and CT number calibration were found to be satisfactory and comparable with other systems. Where appropriate, the values recorded will provide baseline values for annual routine performance testing of the scanner.

A comprehensive review of the performance results is appended to this report.

Prepared by: Matt Rowlandson, Principal Physicist

Authorised by: Tom Jupp, certified Radiation Protection Adviser (RPA)

2nd February 2024

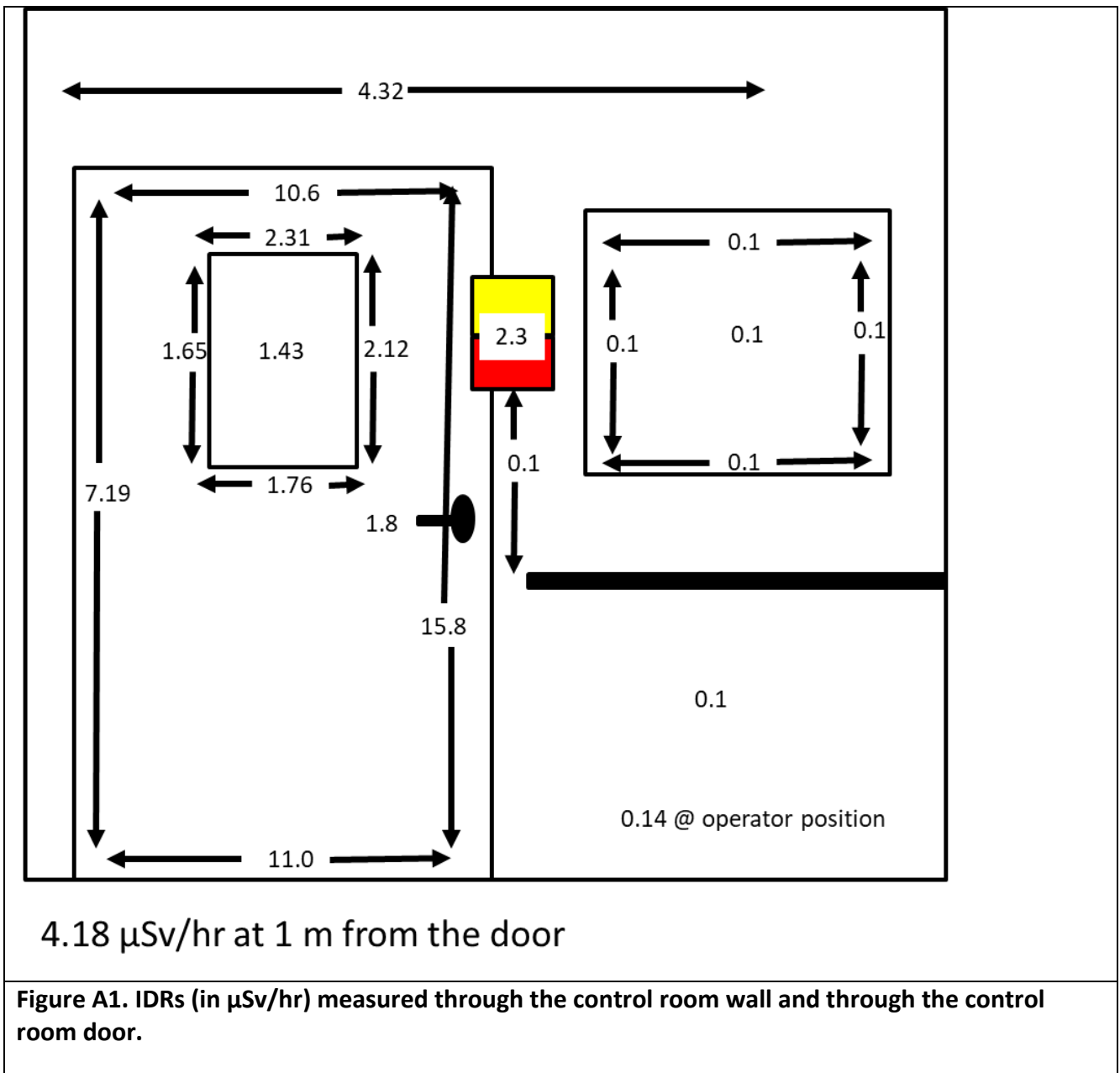
Distribution: Jill Mckenna, Head of Imaging & Operations

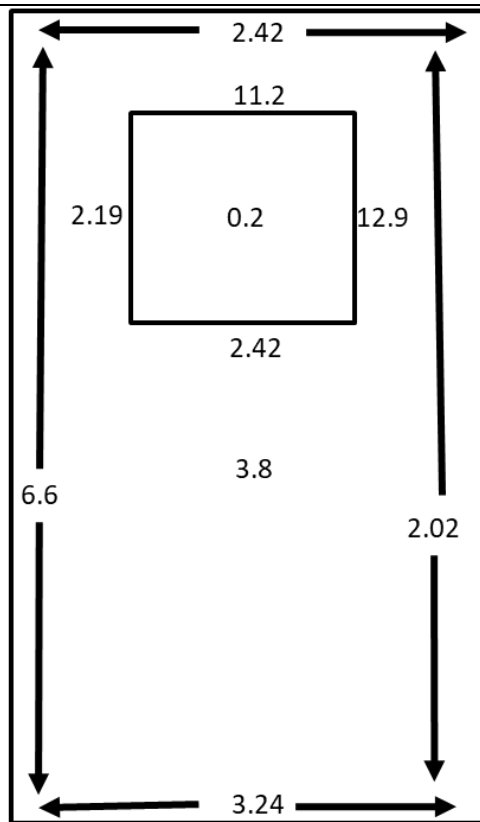
Appendix A:

Environmental Protection Measurements

All measurements were made using a helical body protocol. Measurements were made whilst scanning a 32cm Perspex phantom to simulate scatter. A helical body scan was selected and exposure factors used were 140 kVp, 250 mA, Large Body FOV, 1.0 s rotation time, 40 mm collimation and 'detail' pitch (0.516:1). The scan time was approximately 9.1 s. The indicated CTDIvol was 61.4 mGy, which is worst case and not likely to be clinically representative.

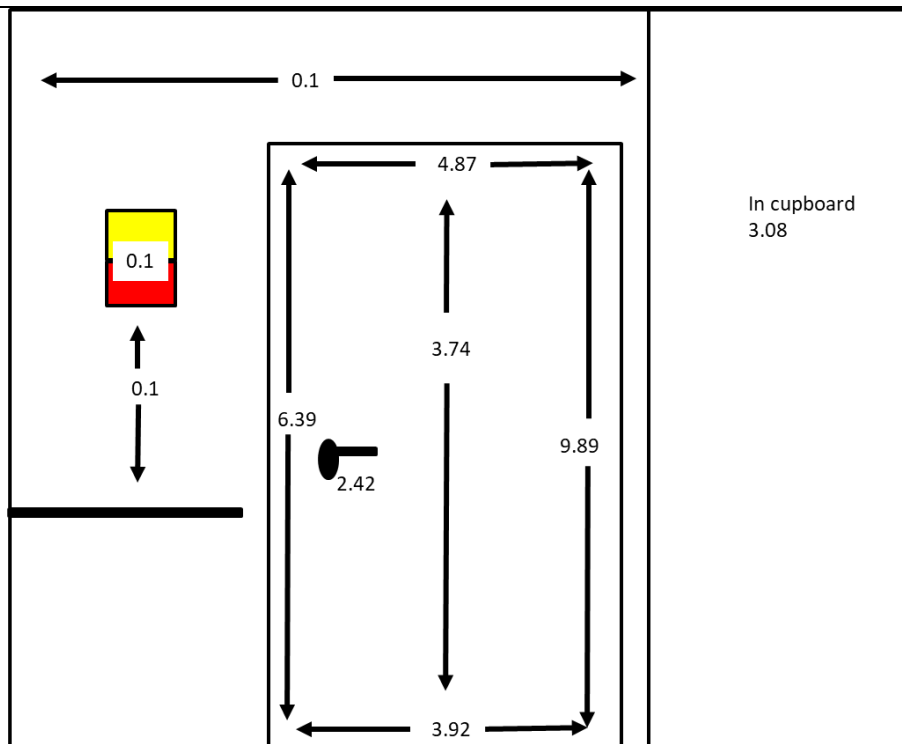
A 32cm PMMA phantom was placed in the beam for scattering purposes. The dose rate meter used was an Raysafe 452. Results as reported are maximum instantaneous dose-rates (IDR) in $\mu\text{Sv/hr}$. All IDR results presented may be divided by a conservative factor of 3 to give the instantaneous dose rate averaged over one minute; it can realistically be assumed that the x-ray beam will only be on for a maximum 20-second period in every minute. Thus the IDR reported is a conservative overestimation.





3.86 $\mu\text{Sv/hr}$ at 1 m from the door

Figure A2. IDRs (in $\mu\text{Sv/hr}$) measured through the door to the patient lift in the slide-out.



3.31 $\mu\text{Sv/hr}$ at 1 m from the door

Figure A3. IDRs (in $\mu\text{Sv/hr}$) measured through the door to the rear equipment room.

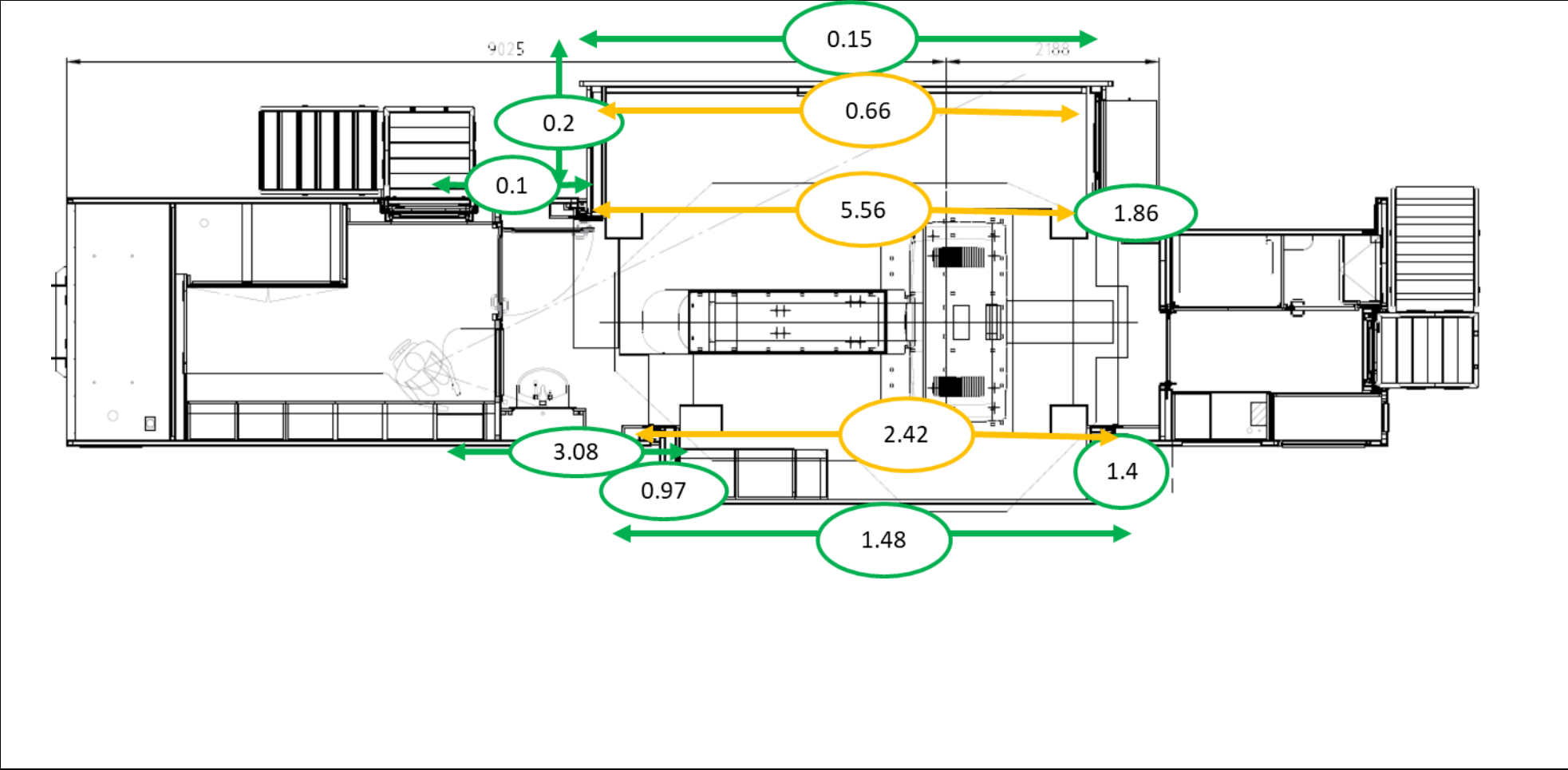


Figure A4. IDRs (in $\mu\text{Sv/hr}$) measured at the bottom external walls (green) and under the slide outs (yellow).

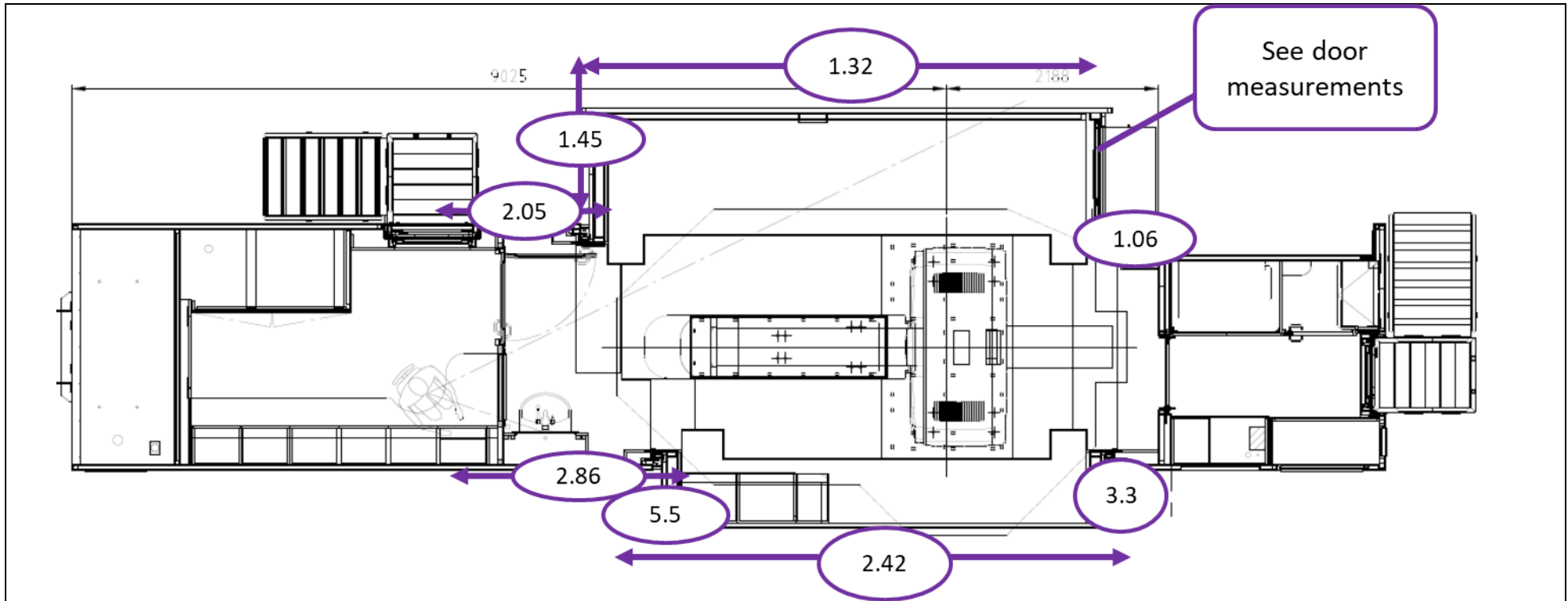


Figure A5. IDRs (in $\mu\text{Sv/hr}$) measured through the middle of the external walls.

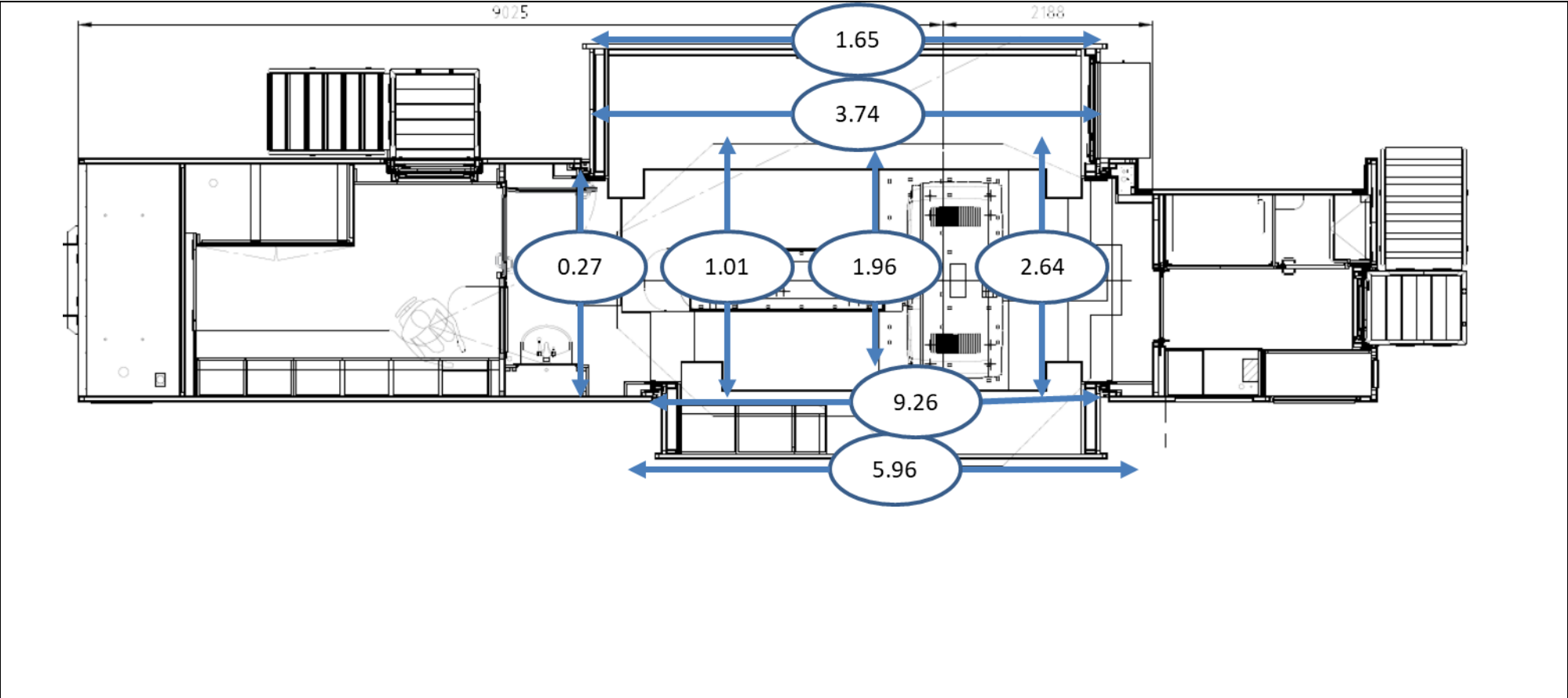


Figure A6. IDRs (in $\mu\text{Sv/hr}$) measured through the roof of the unit

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RADIATION PROTECTION AND PERFORMANCE REPORT

Facility and Equipment

Employer:	AM Diagnostic Services	Survey Type:	Commissioning
Equipment type:	CT Scanner	Survey Date:	31 st January 2024
Manufacturer:	GE	Surveyed by:	Matthew Rowlandson Benjamin King
Model:	Revolution EVO	Reported by:	Matthew Rowlandson
System S/N:	CBDGG2300081HM	Report date:	2 nd February 2024
Local name:	CT23	Authorized by:	Tom Jupp

Radiation Protection - Environment

Assessment	Criteria	Satisfactory	Comment
Area Local Rules	On Display	✗	1
	RPS name correct	-	
	Up to date	-	
Local QC	Local QC being performed	✗	3
	Failings acted upon	-	
Warning lights and signs	Warning lights operational / signs in place	✓	

Dosimetry

Measurement	Criteria	Result	Satisfactory	Comment	
CTDI ₁₀₀ in air at isocentre	Within ±15% of reference value (29.1 mGy/100mAs)	29.0 mGy/100mAs	✓		
CTDI ₁₀₀ repeatability	Within ±10% of mean	0.0%	✓		
CTDI ₁₀₀ in air variation with		mA	1.4%	✓	
		mA (Large focus)	1.4%	✓	
		Time	-0.3%	✓	
kV	Within ±15% of reference value	1.0%	✓		
Collimation	Within 20% of reference value	3.8%	✓		
FOV (bow-tie filter)	Within ±15% of reference value	0.7%	✓		
Off-axis (10 cm)	Within ±15% of reference value	0.5%	✓		
Filter centring	Within 5%	-1.3%	✓		

CTDI in Perspex

Measurement	Criteria	Settings		Stated CTDI (mGy/100mAs)	Measured CTDI (mGy/100mAs)	Satisfactory	Comment
		Phantom	kV				
CTDI in Perspex	Within 15% of stated value	Body	80	3.35	3.48	✓	
			100	6.58	6.75	✓	
			120	10.6	10.8	✓	
			140	16.1	16.6	✓	
		Head	80	7.20	7.61	✓	
			100	13.2	13.7	✓	
			120	20.4	21.0	✓	
			140	30.0	31.4	✓	

Image Quality

Noise and Uniformity - local water phantom

Measurement	Criteria	Settings			Reference	Result	Satisfactory	Comment
		Image Filter	Iterative Reconstruction	Collimation (slice recon) (N x T mm)				
CT Number of Water	Within ±5 HU of Reference	STANDARD	-	64 x 0.625 (8 x 5.0)	0.00	0.99	✓	
	Uniformity within ±10 HU of centre				-	0.76	✓	
Pixel Noise Value	Within ±10% of Reference				4.73	4.84	✓	
Interslice measurements	Within expected range?	STANDARD	None	32 x 0.625 (32 x 0.625)	-	-	✓	
			-	16 x 2.5 (16 x 2.5)			✓	
			-	64 x 0.625 (64 x 0.625)			✓	

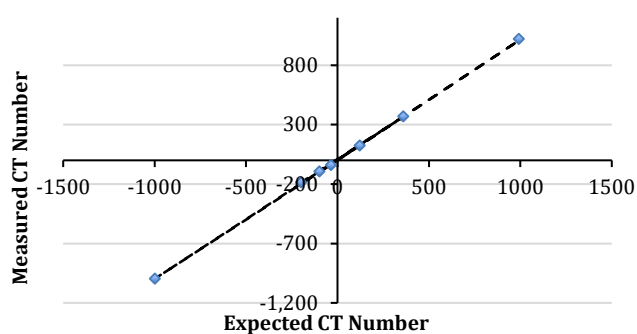
Artefact Evaluation

Measurement	Criteria	Settings			Satisfactory	Comment
		Image Filter	Iterative Reconstruction	Collimation (slice recon) (N x T mm)		
Artefacts	No significant artefacts	STANDARD	-	64 x 0.625 (8 x 5.0)	✓	

CT Number Linearity

Measurement	Criteria	Settings			Satisfactory	Comment
		Scan Mode	Iterative Reconstruction	kV		
CT Number Linearity	Within $\pm 2\%$ or 10 HU of reference values	Axial Head	None	120	✓	
				80	✓	
		Helical Head	None	50%	✓	
				120	✓	
		Axial Body	10%	♦		
		Helical Head	100%	♦		

Axial Head, 120 kV, IR: None, mA: 200,
Collimation: 16 x 0.625 mm, Imaged slice
thickness: 1 x 10.0 mm



Material	CT Number	
	Reference	Result
Air	-997.7	-996.0
PMP	-186.7	-183.7
LDPE	-94.9	-91.4
Polystyrene	-38.2	-37.4
Acrylic	121.9	124.7
Delrin	366.1	371.8
Teflon	1006	1024

Imaged Slice Thickness

Measurement	Criteria	Stated Thickness (mm)	Measured Thickness (mm)	Satisfactory	Comment
Imaged Slice Thickness	Within $\pm 20\%$ or 1 mm of stated values	0.62	0.64	✓	
		1.25	1.21	✓	
		2.50	2.48	✓	
		5.00	4.93	✓	
		10.0	9.49	✓	

Other

Measurement	Criteria	Filter	Reference	Result	Satisfactory	Comment
Geometric Linearity	Within 0.5 mm of expected value	STANDARD	50.0	49.7	✓	
	Ratio between 0.98 - 1.02		1.00	0.99	✓	
High Contrast Spatial Resolution	Within 2 lp/cm of reference	Edge	11.0	11.0	✓	
		Standard	7.00	7.00	✓	
Modulation Transfer Function	<p style="text-align: center;">Modulation Transfer Function</p> <p style="text-align: center;">MTF</p> <p style="text-align: center;">Spatial Frequency (lp/mm)</p> <p style="text-align: right;">Reference Survey</p>				✓	

Collimation

Irradiated Slice Thickness

Measurement	Criteria	Collimation (N x T mm)	Reference Thickness (mm)	Measured Thickness (mm)	Satisfactory	Comment
Irradiated Slice Thickness	Within ±20% or 1 mm of reference	1 x 1.25	3.32	3.74	✓	
		1 x 2.5	4.60	4.96	✓	
		1 x 5.0	7.83	9.23	✓	
		1 x 10.0	13.0	13.9	✓	
		2 x 10.0	22.7	23.4	✓	
		4 x 10.0	42.9	44.2	✓	

Z-Axis Efficiency

Measurement	Criteria	Expected Efficiency (%)	Measured Efficiency (%)	Satisfactory	Comment
Z-axis efficiency	Within ±10% of expected	43.3	33.4	✓	
		59.6	50.4	✓	
		60.8	54.2	✓	
		75.2	71.9	✓	
		89.3	85.4	✓	
		94.9	90.6	✓	





Couch, Scan Plane & Laser Alignment

Measurement		Criteria	Satisfactory	Comment
Laser Alignment	Axial (Internal)	Within 2 mm?	✓	
	Sagittal (External)		✓	
	Coronal (External)		✓	
	Internal to External		✓	
Couch	Height scale calibration		✓	
	Travel scale calibration		✓	
Scout to scan plane localisation			✓	

Miscellaneous

Measurement	Criteria	Settings	Stated	Measured	Satisfactory	Comment
X-Ray Tube Leakage	Less than 1mGy/hour at 1 m	kV: 120	-	0.0046 mGy/hr	✓	
Half Value Layer (mmAl)	Within 1 mm of stated value	Filter: Small kV: 120.0	7.60	7.26	✓	
		Filter: Large kV: 120.0	8.10	8.35	✓	
Gantry Angulation	Within 1° of expected value	29.0°	-	28.5°	✓	
		30.0°	-	29.2°	✓	
Tube to detector Alignment	Penumbra is the same on both sides	1 x 2.5 mm	-	-	✓	
mA modulation	Modulating as expected	Off-set CTDI phantom – z modulation	-	-	✓	
		Chest/Abdo Phantom – x/y modulation	-	-	✓	

Comments

Flag	Comments	Local action taken (where required)	Sign & Date
	1. The risk assessments for the mobile units should be updated to include this unit. Area Local Rules should be written for this unit and put on display. A fault book should also be available with the unit		
	2. Emergency procedures must be reviewed to ensure that the appropriate power-off options are clearly identified for this specific unit.		
	3. A local QC programme should be established which includes both the recommended manufacturer's QC and the tests required to meet the requirements of IPEM 91.		
	4. A full survey of patient dose should be undertaken once the scanning protocols have been established		



Immediate action required



Resolve as soon as practicable



To be addressed



Point to note



Satisfactory

♦ indicates baselines have been set based on the result, for use in future routine surveys

Reference values are taken from system specification or other systems of the same type