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RADIATION PROTECTION SERVICE

DEPARTMENT OF WELLBEING, SAFETY AND HEALTH

UNIVERSITY OF LEEDS

RADIATION RISK ASSESSMENT 22:
GE LUNAR IDXA BONE DENSITOMETER

1. SCOPE AND PURPOSE

This radiation risk assessment is for the use of a GE Lunar iDXA x-ray scanner.

The purpose of this risk assessment is to assess the risks from exposure to ionising radiation in order to identify the measures needed to restrict the radiation exposure of employees or other persons and it has been prepared in accordance with the guidance given in ACoP 8 to the Ionising Radiations Regulations 2017 (IRR17).

This assessment does not assess the risks from planned medical exposures to patients or volunteers undergoing scans which is subject to a separate dose and risk assessment (see IRMER procedures).

2. DOCUMENT CONTROL

Version	Author	Date of issue/review	Comments
1.0	ARC	1 May 2015	
2.0	ARC	18 June 2018	Review and update for IRR17
2.1	ARC	21 September 2018	Minor revisions

3. NATURE OF SOURCES OF IONISING RADIATION

The GE Lunar iDXA Bone Densitometer is an x-ray scanner used to measure bone density and body composition.
The scanner consists of an x-ray head mounted underneath a scanner table with the x-ray beam directed upwards to a detector arm above the patient.
The x-ray tube operates at 100kV with a maximum 2.5mA current and a filter splits the x-ray output into high and low energy components at 70keV and 38keV. The resulting x-rays are output as a fan beam (4.5º) that is 18.4 mm x 3.3 mm at the table top whilst the x-ray head/beam and detector arm are moved along the table axis to traverse the scan area required

4. DOSE ASSESSMENTS

Manufacturer's (GE) data give estimated patient skin entrance doses ranging from <10µGy for hand, forearm or total body scans to 329µGy for spine or femur scans [a]. Calculations of the effective dose to the patient based on phantom measurements [b] are 1-10µSv per scan.
Isodose plots of the scatter dose have been measured by the manufacturer using a 25x25x15 cm water phantom and 100kV, 2.5mA [a], reported scatter dose rates are:

- 2µGy/h at 2m from the centre of the scanner table - confirmed by measurement [c].
- 50µGy/h at the edge of the scanner table close to the scanner head.

Estimated radiation dose rates close to the unshielded tube will be of the order of up to 30 Gy/h [d], and scatter dose rates up to a few mGy/h [e].
Estimated doses should be compared with:

- University of Leeds dose constraint for radiation workers = 1mSv/year [f]
- Dose constraint for exposures to the public from any new source of radiation = 0.3mSv/year [g]
- Average radiation dose to the public in the UK = 2.7mSv/year [h]

EXTERNAL DOSES

Estimated radiation dose rates to which anyone can be exposed:

The projected maximum usage of the scanner is estimated at a maximum of 20 scans a week using either standard or thick total body scans and for the purposes of this assessment a maximum of 20 thick body scans per week has been used to give a 'worst case' dose estimate.

Scan conditions for thick total body scans are 0.188mA for 796 seconds, i.e. 59.9 secs (2.5mA equivalent)

Therefore 20 scans = 1198 seconds (2.5mA equivalent) = 0.33 hours / week = 17.3 hours / year.

Doses to operator

Maximum radiation dose per year to an operator at an operator position 2m from the scanner would be: 2µSv/h x 17.3hours = 35µSv / year.

The estimated maximum dose to an operator during normal operation is therefore 3.5% of the university's dose constraint and 1.3% of the average UK public exposure to radiation.

Maximum radiation dose per year within the controlled area close to the scanner head would be: 50µSv/h x 17.3hours = 865µSv / year.

The estimated maximum dose to a person remaining in the controlled area during operation is therefore up to 90% of the university's dose constraint and 30% of the average UK public exposure to radiation.

Doses external to the room

XRID41: The adjacent office (6.88) wall has 50mm plaster board plus one layer of Knauf Safeboard (attenuation at 100kV = 1E-2).
Measured doses in this office are less than 0.02µSv/h [c] = 0.35µSv/year.
Other adjacent external areas are corridors only and an occupancy factor of 0.2 can therefore be applied [e].

XRID53: Adjacent external areas are corridors, pathways and storerooms and an occupancy factor of 0.2 can therefore be applied [e].

Any position outside the scanner room would be at least 2m from the table and at most points is much more than this. The shielding effect of building materials has not been taken account which would also reduce the dose further.

Doses to staff and visitors outside the scanner room would therefore be much less than 0.2 x 35 = 7µSv/year.

The estimated dose to staff, visitors, and the public is therefore less than 2.3% of the public dose constraint and less than 0.3% of the average UK public exposure to radiation (equivalent to less than 1 day of background radiation exposure).

INTERNAL DOSES

Likelihood of contamination arising and being spread
Not applicable – x-ray source.

Estimated levels of airborne and surface contamination
Not applicable – x-ray source.

5. DOSIMETRY

TLD dose meters will be issued to operators and a TLD dose meter used to monitor the operator environment.

6. SAFE USE AND MAINTENANCE

The equipment is subject to a maintenance / service contract.
Manufacturer's safety specifications are that "To avoid scatter radiation, the operator should remain … at least 6 feet (1.83 m) away from the center of the scanner on iDXA" [a].

7. ENGINEERING CONTROL MEASURES AND DESIGN FEATURES

The x-ray head has a shutter that only opens during a scan and the x-ray beam is filtered and collimated to produce a nominal radiation field at the iDXA scanner table top of 18.4 mm x 3.3 mm.
Lead oxide shielding surrounds the x-ray tube insert inside the tube housing assembly and reduces radiation levels around the scanner table.

Warning lamps on the scanner arm and operating console indicate x-ray emission.

An emergency stop button is located on the front panel.

During a diagnostic failure, the Failsafe Circuit stops power to the scanner motors and closes the x-ray shutter.

8. PLANNED SYSTEMS OF WORK

Local rules are in place and specify:

- Requirements for management of work, training and authorisation.
- Requirements for critical examinations.
- Requirements for monitoring of dose rates.
- Work instructions including instructions for controlling exposures.
- Contingency plans.

Operating instructions for the equipment are available.

9. PERSONAL PROTECTIVE EQUIPMENT

No additional PPE is required for this work.

10. ACCESS TO AREAS WHERE THERE ARE SIGNIFICANT DOSE RATES OR CONTAMINATION LEVELS

The scanning room is secured with a programmable key-fob system and only authorised personnel have access.

The restricted area that the operator should not enter whilst x-rays are being emitted has been set at 2m from the scanner table and is designated as a Radiation Controlled Area during scanner operation.

11. RISK EVALUATION AND CONTROLS

	Risk evaluation	Control measures	Residual risk after controls		
			Likelihood	Severity	Risk
Radiation exposure during normal use	**Exposure to operator:** Scatter dose rate <2µSv h^{-1} at 2m. Estimated annual dose (see calculations above) <0.035mSv/y. Risk during normal use is negligible (very much less than the university's dose constraint of 1mSv/y).	Operator training. Demarcation of a controlled area within 2m of scanner. Access restrictions for scanner room. Local rules include instructions for operator to keep out of controlled area whilst scan in progress. Daily QA procedures. Critical Examination before the x-ray tube is first used; if repaired, altered or moved; and annually. Dose levels confirmed by personnel dose meters (TLDs).	**Low**	**Low**	**Low**
	Exposure to scatter radiation outside the scanner room: Scatter dose rate <2µSv h^{-1} at 2m. Estimated annual dose (see above) <<0.007mSv/y.	Access restrictions for the scanner room. Critical Examination before the x-ray tube is first used; if repaired, altered or moved; and annually. Dose levels confirmed by environmental dose monitoring.	**Low**	**Low**	**Low**

Possible accident situations or failure of control measures and steps to prevent or limit their consequences	**Exposure to scatter radiation inside controlled area during normal operation**: Scatter dose rate up to 50µSv/h at edge of scanner table. Estimated annual dose < 0.9mSv/y	Operator training. Demarcation of a controlled area within 2m of scanner. Local rules include instructions for an operator to keep out of the controlled area whilst a scan is in progress.	**Low**	**Medium**	**Low**
	Removal of panels / shielding giving access to unguarded x-ray beam Removal of panels or shielding could give access to areas where there is a high dose rate. Radiation exposure could exceed the University annual dose constraint of 1mSv. Dose rate could exceed dose constraint and legal dose limits.	Operator training. All repairs and modifications to the equipment must only be carried out by a qualified service engineer. The service engineer must have sole use of the room if servicing requires the removal of shielding or over-riding of safety features.	**Low**	**Medium**	**Low**
	Damage to the equipment by misuse, impact or fire X-rays; potential dose rate – Svh^{-1}. Scatter dose rate - $mSvh^{-1}$. If the equipment were subject to damage the x-ray shielding may be compromised and radiation exposure could exceed dose constraints and legal dose limits.	If the equipment, enclosure or interlocks have been damaged in any way or a malfunction is suspected the user should: - switch the power off and remove the keys - inform the RPS who will arrange for the equipment to be checked by an engineer.	**Low**	**Medium**	**Low**

12. REFERENCES

[a] Lunar enCORE-based X-ray Bone Densitometer, Safety and Technical Specification Manual, GE Healthcare, rev 5, Sept 2010.

[b] Fundamentals of Bone Densitometry, National Osteoporosis Society, https://www.nos.org.uk/document.doc?id=657.

[c] UoL Critical Exam reports: CRIT1501 XRID41 FBS, CRIT1732 XRID53 PSYCH.

[d] Handbook of Radiological Protection, Part 1: Data, HMSO 1971.

[e] Radiation Shielding for Diagnostic X-rays, Report of a joint BIR/IPEM working party, May 1998 – Feb 2000, BIR 2000.

[f] Management of Sources of Ionising Radiation - Guidance, Health and Safety Services, November 2016.

[g] Work with ionising radiation, Ionising Radiation Regulations 2017, Approved Code of Practice and Guidance, HSE, 2018.

[h] Ionising Radiation Exposure of the UK Population: 2010 Review, PHE-CRCE-026, Public Health England, April 2016.