1.1 Introduction

The aim of this portfolio is to demonstrate my competency in working as a Clinical Technologist employed within the NHS in a Radiation Physics discipline. I aim to highlight the skills and knowledge I have gained whilst working in this role and to demonstrate through this portfolio that I have met the criteria specified on the Register of Clinical Technologists (RCT) equivalence route for Radiation Physics. Following assessment of this portfolio I seek to gain professional registration onto the RCT.

1.2 My role in the department

I work as a Specialist Technical Officer (Clinical Technologist) in the Radiological Physics department at XXXX Trust and I have been in this role since May 2011. Prior to my current role I worked as a Senior Assistant Technical Office (SATO) within the same department from November 2005 - May 2008.

The main responsibilities of my current role include the routine Quality Assurance (QA) tests on range of complex x- ray systems and associated imaging equipment. In addition I also carry out testing on non-ionising UV therapy equipment. The majority of my work I undertake is routine QA testing **[A8, B4, D1]**. The tests I carry out include safety features of the systems as well as performance measurements of the x-ray tube and associated imaging equipment. The series of tests I carry out come from several documents including IPEM Report 91: Recommended Standard for the Routine Performance Testing of Diagnostic X-ray Imaging Systems; IPEM Report 32 Part VII: Measurement of the Performance Characteristics of Diagnostic X-ray systems: Digital Imaging Systems; and IPEM Medical & Dental Guidance Notes. Tests are made on the systems detailed for each modality in these documents and results are compared with baseline values (where applicable) and with tolerances outlined in these documents.

I assist with the provision of personnel dosimetry devices and I am involved with patient dose surveys and dose optimisation work for a number of different x-ray modalities **[D6, D7].**

In addition I am involved in acceptance and commissioning tests on newly installed equipment including dental, fluoroscopy and general digital systems **[D2]**. I also respond to non-routine work requests, for example where a user has reported a fault with a system **[B5]**. My job also involves trailing and assessing new equipment, which includes a range of different x-ray systems from dentals, DR mobiles and mobile image intensifier systems, as well as assessing new testing equipment which the department may look at purchasing **[B1]**. This includes reviewing the state of our existing tests equipment to determine if it is still functioning correctly and reliable as well as being fit for purpose. I have developed templates and protocols for our team to use to perform in house function testing of our test equipment. This has proven valuable in picking up faults/reliability issues with our test equipment and allows us to plan ahead for replacement kits **[B8]**.

In total about 30-40% of the work I do is non-routine work, with the remaining 60-70% being routine. I work both as a part of a team and independently in my job. I work both with

Sample portfolio

scientifically & technically minded people as well as those who have a more clinical background and are less technically minded, so I have developed my communications skills throughout my time in the post so I can work effectively with everyone **[A6]**. I am heavily involved with training of staff including STP trainees, trainees we currently have from Malta and also Radiology and IT staff from within my own hospital Trust.

In all areas of my work, I perform a range of tests on systems using specialist measuring equipment which I have been trained to operate. I analyse the results I get from the testing and produce a formal report for the end user of the system detailing the findings and where appropriate any recommendations **[B4]**. I have become knowledgeable in many x-ray modalities, but I also know the limits of my technical expertise and I can quickly recognise when I need to seek help and advice from more senior colleagues. I know the skills and responsibilities of each member in our department, so I can ensure I seek advice or pass information onto the correct member of our team **[E1]**.

Although I am not directly involved with patient care as part of my job, I work in areas where patients are often close by so it is essential that I act in a professional and courteous manner at all times. Furthermore in my job role I deal with people from all professions including clinical staff and service engineers. A few years ago I took a lead role in a project at XXXX when they switched from wet film processing to digital CR processing. The systems had some issues when they were installed and this led to significant delays in the project. It was my responsibility to liaise and co-ordinate with the clinical staff as well as project managers, engineers and sales reps from the different companies to get the issues sorted. This proved particularly challenging as the project was under a very tight schedule and it was difficult to get everyone on site at the same time. I had to explain the issues to the engineers who were scientifically/technically minded and as well as clinical staff who were not as technically minded, so finding the right balance was essential to working as part of a team like this to ensure the problems were rectified properly. In the end all the issues were sorted and the project went live on the expected date. I received very positive feedback from the Project Manager for the hard work I did with this assignment **[A6, E1]**.

I am committed to fulfilling the requirements of the Good Scientific Practice requirements and I use this document to ensure I conduct myself in a professional way at all times and in all aspects of my work. I often get positive feedback on site from users for the work I carry out and I have included a couple of examples of customer feedback which can be found in *Appendix 14* **[A7, E1]**.

1.3 Health & Safety / Risk assessments

XXXX Trust has mandatory training which all staff must complete. This ranges from hand hygiene to moving & handling and a lot of the mandatory training affects how I carry out my day to day job role. Infection control training is essential for anyone working in a hospital environment. My job role does not include direct patient contact although I do work in clinical areas; therefore I need to ensure I adhere to the infection control policy. I always ensure I am appropriately dressed (no ties, shirt sleeves rolled up to elbow) and where appropriate I will get changed into scrubs before entering departments. I regularly wash my

Sample portfolio

hands and always use the alcohol gel when entering and leaving a department. I also use hair nets where required.

I regularly transport heavy and bulky equipment as part of my job and often this can be to different sites. As such I have had undertaken moving and handling training provided by the Trust and I always ensure I follow this training in practice by lifting items in the correct way and transporting them safely, thus minimising the risk to myself and ensuring I work in a safe way.

I often have to deal with requests from Radiographers when they have noted an artefact on an x-ray image. In order to investigate the fault further, I will export the patient images for further analysis back in the office. It is extremely important that I don't compromise patient confidentiality in doing this, so I always use encrypted memory sticks to store the images on and where possible annonymise the images before exporting. When discussing the issue with users and/or other members of my team, I always refer to the image with 'Patient Id 12345…' rather than the patient's name directly to protect the identity of the patient. Once the images have been finished with, I always ensure they are deleted and they are only stored for as long as they are needed. I do archive certain images for example if there has been a particularly interesting fault on a system that could be useful at a later date. I ensure every patient identifiable piece of information is removed from the image before it is archived.

I keep up to date with all the mandatory training and this is reviewed on an annual basis as part of my appraisal process. At this time, I have no outstanding mandatory training that needs to be completed and all my mandatory training is 100% up to date. A copy of my mandatory training records can be found in *Appendix 1* **[A1]**.

Before working on any piece of x-ray equipment, I always consider the risks that may be involved. All the machines I routinely test produce x-rays, which is a form of ionising radiation that can be dangerous if exposed to, so it is important to carry out a risk assessment where appropriate before working on any machine. Mobile x-ray equipment is common across all the hospitals we routinely visit and testing these systems presents a different set of risks. It can be common for us to be asked to test these units in rooms which are not normally used for x-ray work. On these occasions I carry out a full risk assessment to determine a) if the room is adequately shielded and large enough to keep a safe distance b) if there are any issues in using the room for the duration of the tests e.g. do staff use it for other things such as tea room, thoroughfare etc. c) if I need to wear any additional protection for example a lead apron or use any protective shielding such as a mobile screen.

I always notify staff in the department that I will be working on an x-ray machine in the room and not to enter without asking first. I place temporary warning notices on the doors leading to the room to ensure all staff and public are aware it is dangerous to enter.

For mobile fluoro systems, I usually have to wear protective clothing for the duration of the tests as the rooms we are asked to test these units in typically are not designed for that purpose. I try to keep the screening time down to a minimum and thus reduce the overall time the x-rays are being produced. By carefully planning the position of the equipment in

Sample portfolio

the room, I can maximise the distance between myself and the x-ray source. Using these three radiation protection principles (time, shielding and distance) I can ensure I minimise the risk involved in testing mobile x-ray units **[A2, A4]**.

As well as the risks from ionising radiation, there are also electrical and biological risks involved when testing units. We do not carry out electrical safety testing on equipment, however we do ask for proof that new/loan units have been certified electrically safe by a qualified person before we will start work on it. For existing equipment, I ensure the equipment has undergone its last routine electrical safety test on schedule and that it passed before we work on it.

With regards to biological hazards associated with equipment - it can be common for x-ray systems used in a theatre environment to be contaminated during clinical use. This could be anything from patient fluids (urine, blood etc.) to splashes of contrast agent. It is the responsibility of the Radiology department to ensure equipment is clean and has been properly decontaminated before we work on it. I ensure that this is done by use of an Equipment Handover Form, which must be completed by both the Radiology staff and me before I begin any tests. The form is used by all departments we visit and serves a number of purposes. The form states that equipment should be decontaminated before handover, so by signing the form, the Radiographer is declaring that the equipment has been properly cleaned and decontaminated before I use it. I therefore do not have to clean/decontaminate the machine myself, but I will always perform a visual check on all parts of the system to ensure it has been thoroughly cleaned before I use it **[A4, B3].**

Furthermore, the form will hand over control and responsibility of the equipment to me whilst I am testing it. This allows me to work under our own Local Rules whilst testing the system. Once I have finished my checks, I sign the form and note any work I have carried out that has changed the performance of the system in anyway (e.g. patient doses changed). The equipment is cleaned once again by the Radiographer before being returned to clinical use. The handover therefore allows Radiology to have an auditable trail detailing what tests were carried out on the system and when, as well as protecting me from contamination of unclean equipment **[B3]**.

On a handful of occasions I have refused to test a piece of x-ray equipment due to inadequate facilities being provided (room being too small to expose safely). More recently at one of our customer's sites, I refused to test a mobile image intensifier system as the c-arm was covered in dried blood and had not been decontaminated.

I often work alone and occasionally this can be on a site, such as a mobile van, where I will be the only person there. For surveys such as this we operate a lone working policy whereby I periodically check in with someone in the main office so they know I am safe. This policy allows colleagues in the office to know when I should call and that if I don't to raise the alarm that there may be something wrong.

Sample portfolio

1.4 Legislation & incident reporting

There are two key pieces of legislation that are applicable in my job role, these are the Ionising Radiation Regulations 1999 (IRR 99) and the Ionising Radiation (Medical Exposure) Regulations 2000 (IR(ME)R 2000). IRR99 governs the use of equipment which produces ionising radiation and makes it a legal requirement for employers to have the performance of their x-ray systems tested. IRR99 is also based on the principle that exposure to ionising radiation, no matter how small can be potentially harmful and therefore exposure should be kept As Low As Reasonably Practicable (ALARP). It is also a requirement of IRR99 (Part IV, Regulation 17), that Local Rules exist concerning radiation safety. These are a set of key working instructions and local policies which when followed will restrict exposure in radiation areas. Each department in Radiology will have a set of Local Rules for that area. We have our own Local Rules as we have access to an x-ray training room in our department. As we operate the x-ray systems differently to how clinical staff would, it is important that I have read and understood our own Local Rules before working on any x-ray systems. Finally, IRR99 specifies that all employees who work with ionising radiation should be monitored and their doses recorded. I regularly wear a TLD badge which will record any dose I receive.

IR(ME)R 2000 regulations focus more on how the equipment is used in terms of medical exposures rather than on the equipment itself. Under IR(ME)R 2000, I am defined as an Operator when in control of the x-ray equipment and carrying out any type of testing that requires an exposure to be made. Operators are typically defined as anyone who has any practical involvement that can influence radiation dose to the patient; however the guidance also specifies that physicists and technologists are included in this definition when operating the x-ray equipment for the purposes of carrying out testing. IR(ME)R 2000 also requires that employers undertaking medical exposures to establish Diagnostic Reference Levels (DRLs) and that these should be frequently reviewed.

Both pieces of legislation are therefore relevant for my job as I perform routine QA tests on x-ray equipment and I am involved with patient dose audits to ensure that doses are optimised and kept ALARP and are reviewed against both national and local DRLs **[A3]**.

Although I am not directly involved in reporting of radiation incidents, it is something I have to be familiar in my job role. Often I am required to assist in doing incident reporting and this can include speaking with Radiology staff to establish the circumstances of any incidents that have occurred. It is important to obtain accurate details regarding the cause of the overexposure and where possible records of exposure factors such as kV, mA(s), screening time (if applicable) and DAP, as well as details on the original intended examination. Radiation incidents can occur for a number of different reasons, but can typically be categorised into 2 groups; overexposures due to equipment failure/malfunction or overexposures due to operator error. Equipment related overexposures would breach the IRR99 regulations; any overexposure due to some form of operator error breach the IR(ME)R2000 regulations. This could be anything from the wrong exposures being set or even the wrong patient being examined.

Sample portfolio

Some incidents will need to be reported to the relevant authorities. Breaches of IRR99 must be reported to the Health & Safety Executive (HSE). Incidents which breach IR(ME)R regulation must be reported to the Care Quality Commission (CQC) **[A5]**.

2.1 Quality Management System (QMS)

Our department is currently accredited to BS EN ISO 9001:2008 and as such we work within a Quality Management System (QMS). A QMS is a set of business policies, procedures and processes which ensure consistent working practices are carried out by all members of the team at all times. It ensures that we are all working to the same set of procedures and that we are all undertaking the work we carry out in the same way. The QMS also provides a way for us to develop and improve our processes & procedures in a structured, controlled and auditable way.

Our QMS consists of, amongst other things, Work Instructions, Technical Instructions, QA templates and an equipment management database. The database is used to maintain a comprehensive record of all x-ray systems we test and for each separate asset is a full history of jobs performed with the associated reports attached **[B7]**.

Our equipment management database is called E-quip and I had extensive involvement in creating all the assets on this database and setting up testing schedules for each asset. This allows us to routinely query the database to see which systems are due for their routine QA testing. It can also be used to check against performance targets to ensure we are providing a consistently high level of service for our customers. I regularly carry out audits on the database to ensure the records are accurate and up to date.

Screenshots of a sample of our equipment inventory database along with the QMS record for a random asset is shown in *Appendix 2* **[B2]**.

One of the main benefits of having a QMS is that it can be used as a very powerful tool in helping improve and refine the service we provide. The QMS allows us to have a formal process in developing the procedures we follow and allows us to develop new processes to accommodate changes in the systems we test and the technologies we use to carry out our work. We have System Improvement Notes (SIN) which all staff members use to formally submit changes we think will improve part of our service. These are submitted into the QMS and are carefully reviewed on a monthly basis by senior managers. If accepted, there will be a formal process to put the suggestion into place and in turn this will become integrated into the QMS. I have submitted numerous SINs since we started using a QMS and many of these have helped improve the efficiency of our service. I have shown 2 examples of these in Appendix. One of these SINs was rejected and one accepted.

Auditing is an essential part of any well run QMS and our own system has both regular internal and external audits. We carry out a full internal audit of our section prior to an external auditor visiting. This is usually performed by a member of staff from a different section within Medical Physics who has little/no knowledge about our own processes. This allows us to prepare better for the external visit and also allows us to demonstrate, through our own internal audit process, that we have identified areas in our system that are weaker

Sample portfolio

than others and need improving. The QMS is therefore always evolving, adapting and improving.

Several years ago we began to audit our own working practices against the work/technical instructions that were in place. I was audited on an Intra Oral (IO) dental survey. I successfully passed the audit however a discrepancy was noted in how I performed the HVL measurement on dental units compared to what was written in the technical instruction. This lead to a change in the technical instruction as it was agreed amongst our team the method I was using was more appropriate. A copy of the completed audit is show in *Appendix 14.* For the external audits, an auditor from BSI will visit our department and usually spend the day asking different staff to demonstrate how certain procedures are done in our department. I have previously been asked to demonstrate how the equipment database work and how to query it to pull relevant data from. I was also asked to demonstrate how it was used to records jobs done on specific pieces of equipment **[B2]**.

I have also created several Microsoft Excel templates for a number of modalities we carry out QA testing for and these also form part of our QMS. These template files include intra oral & panoramic dentals, general digital systems and also display monitors. Each of these templates is used routinely for work by all members of the team. I have had significant input in developing other templates for modalities including Computed Radiography (CR) and fluoroscopy.

As well as the equipment database I have been heavily involved in creating work and technical instructions for the QMS. This ensures that all staff work to a set of protocols when carrying out QA testing and ensures testing is carried out in a consistent and safe manner. I have developed many of the technical instructions over a period of time after I have reviewed the initial work I have done. For example changing the order in which we do the tests or the way in which we set up a certain test can improve the efficiency of our testing and the accuracy of our measurements. One example of this improvement is developing macros to draw ROIs on digital images for quantitate analysis, rather than drawing the ROIs manually. This improved the accuracy of our analysis and ensured all staff were carrying out the measurements in the same way.

Sample portfolio

This reflective practice is essential to refining our protocols and procedures in the department and is a key learning process. One example of this included in *Appendix 10* which shows a technical instruction for carrying out routine QA testing of Philips MultiDiangnost/EasyDiagnost Eleva fluoroscopy systems. This was written after several surveys were performed and the process was changed to improve efficiency **[A10]**.

3.1 Radioactive source management, transport & disposal

Our department has recently carried out some work in XXXX and we were appointed to provide shielding specifications for a new-build hospital. As part of that process we were asked to check the shielding in the walls of the building were adequate before equipment was installed at the site. In order to facilitate these checks, we transported a radioactive source (^{57}Co) to XXXX to verify the shielding met the initial specification. ^{57}Co has a decay scheme which produces γ photons with energies of 122keV (85.6%) and 14keV (9.16%), or

through the emission of 136keV photons (10.6%). It also has a half-life of 271.8 days. The majority of the specifications were for x-ray rooms and were therefore specified in terms of Pb equivalence for a 100kV beam. It was possible to transport a mobile x-ray unit to XXXX and expose the walls for the purposes of assessing the shielding, however it was more practical and efficient to take a sealed source instead and use this to check the shielding. The photon energies produced in the decay process are ideal as the majority are similar to the energy of the maximum diagnostic energy that the x-ray systems will be used at. The ideal photon energies and the relatively long half-life of ^{57}Co make it an ideal source to use for assessing shielding in the walls, where testing would typically take a week to do.

Although I was not directly involved in this particular project, the processes and procedures involved with handling and transporting radioactive sources are something I must be familiar with in my job role. As such I have described below the procedures I would carry out if I were asked to do ensure that the radioactive material is safe to be transported.

There are 2 key pieces of legislation which govern the transportation of radioactive sources and waste in the UK. These are the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (2009) (CDG2009) and the International Carriage of Dangerous Goods by Road (ADR, 2015). The regulations do not differentiate between radioactive waste and radioactive sources with respect to activity limits and maximum surface dose rates.

Providing that the radioactive material does not have a surface dose rate exceeding $5\mu Svh^{-1}$, the material can be transported as an Excepted Package. An Excepted Package is considered to have radioactive content at low enough levels such that the potential hazards associated with transporting it are insignificant and no additional testing is required regarding containment of shielding integrity. As such we do not require an additional permit to transport it.

The additional legislation and guidance specified in ADR, 2015 details maximum activity levels for a number of radionuclides if they to be transport as an excepted package. This is in addition to the requirement that an excepted package must not have a dose rate at the surface exceeding $5\mu Svh^{-1}$. The maximum activity specified in ADR, 2015 for ^{57}Co is 1TBq. This is the maximum upper limit for transport, but lower limits exist if the material is to be classed an excepted package. These requirements are shown below:

Table 2.2.7.2.4.1.2: Activity limits for excepted packages

Physical state of contents	Instruments or articles		Materials
	Item limits [a]	Package limits [a]	Package limits [a]
(1)	(2)	(3)	(4)
Solids			
special form	10^{-2} A_1	A_1	10^{-3} A_1
other form	10^{-2} A_2	A_2	10^{-3} A_2
Liquids	10^{-3} A_2	10^{-1} A_2	10^{-4} A_2
Gases			
tritium	2×10^{-2} A_2	2×10^{-1} A_2	2×10^{-2} A_2
special form	10^{-3} A_1	10^{-2} A_1	10^{-3} A_1
other forms	10^{-3} A_2	10^{-2} A_2	10^{-3} A_2

[a] *For mixtures of radionuclides, see 2.2.7.2.2.4 to 2.2.7.2.2.6.*

Figure 3.1a - extract from ADR, 2015

Sample portfolio

The tables A1 and A2 are referenced elsewhere in the ADR document. The columns in the ADR table above state that the maximum activity (1TBq) should be multiplied by 10^{-2} to get the maximum activity limit to be classed as an excepted package - 10GBq. The source we purchased had an activity of 555MBq and is therefore well below the maximum activity limit so meets this requirement to be transported as an excepted package **[B6]**.

We purchased a shielded rolling case for the ^{57}Co source to ensure it could be shielded whilst being transported. It is a flood source and so has a large surface area (620 x 420mm) so it is important to ensure that all parts of the source are adequately shielded before transporting. We carried out an assessment of the package to determine the dose rate at the surface. This was done initially by using a contamination monitor to look for 'hot spots' where a high dose rate may be measured **[C3]**. We did this by holding the contamination monitor at arms-length to maximise the distance from the source and systematically sweeping around the package checking all surfaces. This method is typically used to find regions of interest that warrant further investigation using a dose rate meter. Most of the package appeared to be adequately shielded; however there was a hot spot towards the top corner of the package:

Figure 3.1b - contamination and dose rate monitoring of ^{57}Co source package

Further investigation was then performed on the hot spot to determine the actual dose rate at the surface. This was done using a hand held dose rate meter and as can be seen in Figure 3.1b, the dose rate measured at the surface was ~8µSvh^{-1}. This was in excess of the maximum limit for an excepted package. We could have still transported the source as it was as a Category 1 or 2pckage, but this would have required additional signage and driver training. The other alternative was to add some additional shielding to the container to bring the dose rate down sufficiently. We used some Pb rubber to do this and carefully lined the whole of the inner compartment of the container. The source was removed from the container whilst this work was carried out and placed into a safe storage area so we were not at any risk when carrying out this work. The flood source has built-in handles to allow us to move it around easily and these areas are free from Cobalt, nevertheless it is important to minimise the time holding the source and to hold it away from our bodies to ensure the risk from exposure is kept as low as possible.

Once completed, the source was put back into the container and the measurements were repeated. All surfaces of the package were re-tested using the hand held dose rate meter. The additional shielding proved to be sufficient to bring the dose rate down below the 5µSvh^{-1} limit (Figure 3.1c) **[C1]**.

Sample portfolio

Figure 3.1c - follow up dose rate checks on ^{57}Co package

Now the source was safe to be transported as an excepted package, the appropriate paperwork was completed. All transported radioactive material must have a consigners certificate declaring what material is being transported. Additional information including the form (solid/liquid), the serial number and the activity must also be declared on the consigner's certificate **[C1]**. A copy of the consignment note which XXXX (RPA) completed when transporting the source to a recent trip to XXXX Hospital is enclosed in Appendix 5.

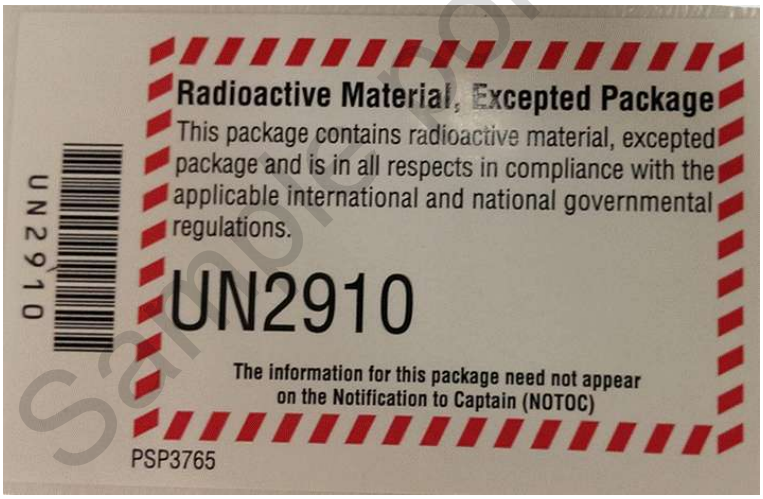

Figure 3.1d - excepted package label

In addition, a label must be placed on the inside of the package with the correct UN number to comply with the regulation of the United Nations Committee of Experts on the Transport of Dangerous Goods. In the case of our ^{57}Co package, the appropriate number is 2910, which refers to 'radioactive material, excepted package-limited quantity of material'. A photo of the label on our package is shown in Figure 3.1d. There is no requirement for a label to be placed on the outer surface of an excepted package due to the limited quantities of radioactive material inside. The regulations do not differentiate between radioactive waste and radioactive sources with respect to Excepted Package quantities and activities.

Sample - Ontario

Sealed sources

Within our department we have a number of radioactive sealed sources which are used for a variety of reasons including wipe/leak testing and also for training & lectures. The Ionising Radiation Regulation 1999 (IRR99) require that a detailed inventory of the sources should be kept and this should be regularly reviewed and updated.

The inventory should include all details on the source including radionuclide, serial number, reference activity and reference date & time. The sources need to be stored in both a secure and shielded environment and it is important to ensure that the source inventory is regularly checked and is up to date - this was one of my responsibilities in my previous role **[B6]**. A screenshot of our current source inventory which was last checked in 2015 is shown in *Appendix 3.*

Previously we have had a much larger number of sources on site, but several years ago we went through the process of disposing of a number of sources that were no longer used. At the time I assisted the RPA in this process, both in updating the inventory and performing measurements of the sources to ensure the dose rates were low enough to be considered safe for transport/disposal at the surface of the bin. I also assisted in calculating what the activity of each source would be on the day they were due for collection using the reference date and reference activity, as this was a requirement for the disposal paperwork. In total we disposed of 34 sealed sources from our inventory. I have included the consignment records of this disposal process in *Appendix 4*.

As well as sealed source disposal, one of my previous responsibilities was to organise the consignment and disposal of radioactive waste within the Trust. We did not dispose of this waste on site and instead it was collected by a third party (XXXX) for incineration at their site. The same processes applied to the waste as the sealed sources, although with the waste sometimes this was in liquid form, so additional care was needed when handling this waste to ensure it did not leak and contaminate other surfaces.

Sample portfolio

3.2 Wipe/leak testing of radioactive sealed sources

Leak/wipe testing is a requirement under IRR 99, Reg 27(3) for all radioactive sealed sources and the purpose of the checks is to demonstrate the continued integrity of the primary source containment. Wipe testing of sealed sources is carried out routinely to ensure that the source remains sealed and is not contaminating surrounding areas. The minimum interval between tests specified in IRR99 is 2 years, however in XXXX we typically do this on an annual basis and/or when the sources have been changed. Tests are also performed immediately if any damage is suspected as recommended in the Medical & Dental Guidance Notes (8.36).

The method for performing a leak test is to wipe the surface of the sealed source with a wipe that is made to at least the standard specified by ISO 9978. Any contamination leaking from the source will be impregnated onto the wipe and this can then be detected. The risk involved in carrying out leak testing like this is relatively low, however there is potential for exposure of whole or part of the body to ionising radiation (usually beta or gamma radiation)

and/or skin contamination with radioactive material, which can lead to irradiation of the body or even possible uptake into the body.

At the time of taking the wipe, the sample is considered as possibly leaking radioactive material and therefore precautionary measures are always taken to minimise the risk in carrying out this work. I always wear protective gloves throughout the process of wipe testing. I use tongs to minimise my direct contact with the source and also to maximise the distance between the source and my hands at all times. The sealed sources are handled for only as long as is necessary to perform the test and are never handled directly. Once the wipe test has been made, the source is carefully put back into storage. From this point on, the wipe is assumed to have been contaminated until a measurement has been made to prove otherwise. As such the wipe is stored in a plastic bag to prevent contact with other surfaces and limit the risk of cross contamination.

We would typically test multiple sources at the same time and once all have been checked, the wipes are then stored in adequately shielded containers at all times until they are ready to be measured **[C2]**.

The detector used to determine any leakage on the wipes is a Multi-Channel Analyser (MCA), which is a scintillation counter. It has a range from ~15keV up to ~1MeV and can therefore detect a wide range of energies. This is housed inside a specially designed jig which consists of large amounts Pb and Cu shielding. The Pb is primarily there to ensure users are safe from any radioactivity that could be on the wipes. It also acts as a shield from other sources which could contribute false readings to the measurements. The Cu sheet is on the inner most part of the shielding and the purpose of this is to ensure any x-ray photons created from the interactions of the sources with the Pb shielding are absorbed and do not contribute to the readings.

Prior to any measurements, the counter is checked to ensure it is operating correctly. This is done by placing a known radioactive source in the detector and performing a measurement of the photon energies emitted. Typically we would use a source which has a photon energy close to what we would expect to see on the wipe to verify the detector is performing as expected at this energy range. One of the common sources we use is ^{137}Cs, which has a decay process that produces a peak photon energy at ~661keV. As the half-life of ^{137}Cs is very long (~30 years) it is an ideal source to use from one year to the next to verify that the calibration accuracy of the MCA is correct.

Once the software is enabled and the count rate starts, it is clear to see if the detector is working properly and if it is correctly calibrated. We can check the accuracy of the detector by comparing the displayed peak photon energy with the know peak photon energy. If there is a small difference, we can simply apply an offset to all subsequent measurements we make. Ideally, the detector should be calibrated properly to display the peak photon energy properly, however this is not always possible/practicable.

Once the MCA is confirmed as working satisfactorily, the wipes are positioned in the detector assembly and these are left for ~1hour in total. The detector will be active for the duration of this and will be counting the number and energy of the photons it detects. An

Sample portfolio

hour is typically required as we are expecting to see little/no readings from the wipes if the source is not leaking. By running for an hour we allow small traces of contamination to be detected and these are visible above the normal background reading.
The results are then analysed and the graph is checked to see the count rate across the energy range. Ideally we would expect to see a flat line across the chart as show in Figure 3.2a, as this would indicate nothing but background radiation has been detected.

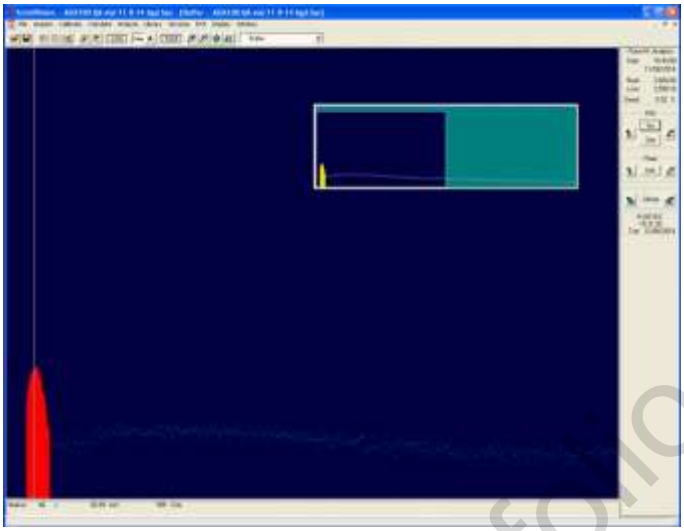

Figure 3.2a - sample results of wipe tests showing nothing above background

If the activity of the wipe is measured to be <200Bq, as specified in Medical & Dental Guidance Note (8.37), then the source is considered to be leak free. Anything above 200Bq, or any peaks on the graph above background would immediately point to there being a contaminated sample on one of the wipes and therefore would have failed the test.

All the wipe tests I have carried out have shown similar results to those shown in Figure 3.2a and have indicated that there was no contamination present. If however I did detect any contamination on the wipe, I would immediately remove the source in question from service. I would show the results to a more senior member of the department, for example a Clinical Scientist and assist in investigating the problem further. The source would be placed in a safe environment whilst I investigate the surrounding areas and check for contamination. One possible reason for the source to fail this test is that the container has become damaged. This could be physical damage which may have occurred from mishandling the source, or the container may have broken down over time due to damage caused by the source itself. Any physical damage of the container can be visually checked and suspect areas can be checked further for contamination. I would assist in the process of decontamination of surrounding areas. If the source cannot be adequately decontaminated or moved to a suitable container, it must be disposed of.

All contamination monitors and dose rate meters used for work described in this chapter must be well maintained and have a valid calibration certificate. All our meters undergo routine visual inspection and function tests to check their batteries are sufficiently full and that they are operating properly. Comprehensive records are kept for each meter and these are stored on the equipment database **[C3]**. If any instrument does not meet these requirements, it is removed from service and placed into quarantine and cannot be used until the issue has been rectified.

Sample portfolio

3.3 Dosimetry

As part of my previous job role as Senior Assistant Technical Officer (SATO), I was responsible for the routine calibration, issuing and reading of the personal dosimeter TLDs for a number of departments within the Trust. The whole body dosimeters have always been provided by a third party (XXXX) but I was responsible for providing TLDs which were used for staff extremity monitoring. This was typically finger dose monitoring in Nuclear Medicine, Radiopharmacy and Nuclear Cardiology departments within LTH. Occasionally eye doses were also monitored. I was solely responsible for managing this in house service and had to manage my time well to ensure that the TLDs were all properly calibrated, annealed and batched up in sachets in good time for staff to use at the beginning of each month **[C4, D6]**.

The results were analysed on a monthly basis with each staff member having a full history of doses for that calendar year. I was responsible for the record keeping of these dose results and carefully analysing the data to look for results that exceeded a dose threshold. It was my responsibility to notify more senior staff, both a Medical Physics Experts (MPE) and a Radiation Protection Advisor (RPA) of the results and discuss my findings with them. I subsequently assisted in providing radiation protection advice to staff who regularly received high doses on their TLDs **[A9]**.

We have since moved away from providing the service in house and instead we now purchase the TLDs from XXXX. I helped manage the switchover to the external provider to ensure there was minimal impact for end users. We now receive both the full body TLD and extremity TLD dosimeters from XXXX along with the results which are provided in electronic and paper format. These records usually arrive once a week and for a period I was responsible for analysing these reports and maintaining our own records to keep track of each staff member. Our department is responsible for ensuring all staff that work with ionising radiation are provided with an appropriate personnel dosimetry device and I assist in delivering this part of our service **[A8, C4, C5, D6]**.

I have trained new staff members who have joined the department since on how to manage this part of our service and how to record, maintain and analyse the results we receive.

3.4 Environmental TLD monitoring

In my job role I participate in organising environmental surveys using the TLDs. This is both for routine testing and monitoring of new installations **[D1, D3]**.

TLDs are ideal to carry out this assessment as they are very small meaning they can be positioned almost anywhere without being obtrusive or distracting. The energy deposited onto the TLD from x-rays is trapped in the TLD structure and this energy does not dissipate for a long time. As such it is possible to leave the TLDs up for long periods at a time. This is advantageous as it will give a more realistic indication of the typical doses in these areas. A week is typically not long enough because if the department have a particularly quiet week, the doses would not be an accurate representation of normal workload. By leaving the TLDs up for approximately 3 months we get a clearer picture of what is happening. Furthermore by leaving for a 3-month period, we are likely to get a measurable dose from the TLD above

Sample portfolio

normal background radiation levels. Some of these TLDs will be placed in areas where I would expect to see little or no dose at all, so by allowing a 3-month investigation period I can allow a sufficient dose level to build up. I always keep a small number (10% of batch)

I arrange for a calibrated batch of TLDs, typically 30-40, to be sent from RRPPS and I ensure they are ordered in good time so they will arrive before the start date on the environmental survey.

Radiation protection equipment such as the protective screens (both fixed and mobile where applicable) are tested as part of the routine environmental TLD survey to ensure they are still offering sufficient protection for the workload and procedures in the room **[D3]**.

The calibrated TLDs are positioned at key points inside and outside the room. Typically 2 TLDs are used in each position but this was not always possible due to the limited number available. I use my own judgement based on the training and experiences I have had to decide where best to place them. Most rooms will see a TLD placed either side of the protective lead screen to ensure it is providing adequate protection. Other rooms may have high occupancy areas outside (e.g. patient waiting area), so the walls separating them would be tested. Any other areas of concern would also be assessed. After 3 months the TLDs are removed and the results are assessed to see if there are any areas of concern.

I have included a sample of some results I obtained from a survey of XXXX Hospital in 2006 which included vascular and CT rooms as well as the general rooms. This can be found in *Appendix 6* **[A9]**.

Protective clothing such as lead (Pb) aprons does not get tested in this way, however they are routinely tested to ensure they are still offering. Protective aprons and skirts are prone to damage if they are not stored properly. The Pb inside them is relatively thin and if they are folded or stored incorrectly, this protective layer can split. The protective clothing is visually inspected for any signs of damage and/or incorrect storage of them when they are not is use. This monthly check is typically carried out by Radiographers, however I will always carry out a visual check on the protective clothing available when I am on site. If there is a suspicion of damage, then myself or other team member would investigate this further. I do this by checking the apron on a fluoroscopy system. This check can actually be done on any type of x-ray imaging system, but is far quicker and easier on a fluoroscopy system. I would systematically screen all parts of the apron to check for any signs of damage to the protective inner layer. If there are cracks or damage to the protective layer, these are easily shown up as bright spots on a fluoroscopy image. If the apron is found to be satisfactory, then it is returned to clinical use; if not the apron is removed from service with immediate effect. At this point I would discuss my findings with the Team Leader Radiographer for that area at demonstrate the problem to them. If necessary I would seek further advice from an RPA if users were reluctant to remove it from use (if for example they had a limited number of aprons available).

Sample portfolio

Appendix 1 - LTHT Mandatory training records [A1]:

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Appendix 2 - Equipment inventory system [B2]:

Sample of equipment inventory database

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Sample asset record on E-quip

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Appendix 3 - Current sealed source inventory [B6]:

Below is a screenshot showing a sample of the inventory of sealed sources we currently have at XXXX:

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Appendix 4 - Sealed source disposal record [B6, C1]:

NB - some pages of the document detailing the sources that were disposed have been removed as the text was ineligible after scanning. In total, 34 sealed sources were disposed of in this process:

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Appendix 5 - Source transport consignment certificate [C1]:

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Appendix 6 - Environmental TLD survey report [A9, D1, D3]:

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Sample portfolio

Appendix 7 - Investigation of Orthopaedics image quality issue [A6, B5]:

The following piece of work was carried out in 2010.

Introduction

Recently there was a new digital x-ray system installed in the Orthopaedics department at XXXX. The majority of work undertaken using this set is to look at scoliosis (bending of the spine) in paediatric patients. There is a similar system currently in use in main X-ray which uses CR cassettes rather than digital detectors – 3 separate images are taken covering the length of the spine. The 3 images are overlapped slightly so that the software has a reference point in each region of interest (ROI) to help match them up using software algorithms. This new system works in a similar way, but instead uses a single plate digital detector to capture 3 images at different points and then the processing software combines all the images in the same way.

Summary of problem

Shortly after the system was first installed, users have reported a major problem with the images. The software was performing poorly at stitching the images and the issue was so serious that several centimetres of the image were either being duplicated or completely missed off depending on how the software interpreted the data. It required manual manipulation of the 3 unstitched images to correctly line them up before a diagnosis could be made. This took extra time per patient and ultimately compromised the level of service the patients were getting. This problem was seen by our team and subsequently reported to Siemens who were aware there was an issue and were planning on releasing a software upgrade to correct the fault. We were asked to retest the system before it was used clinically after the software upgrade took place.

Action plan

As this was a problem we had not seen before, I had to come up with a suitable plan of action. The first thing I decided was to create a new test phantom which will be used to test the system.

Developing the test object

Test objects such as chest phantoms are used to carry out an assessment of x-ray systems with the test conditions as close as possible to a proper clinical exam. To carry out a proper investigation into this problem, I had to develop a new test object from scratch to ensure the testing was as close to a real clinical exam as possible.

I had to consider all aspects of the problem:

- The system is used primarily on paediatric patients, so the body size should be carefully considered – young children & adolescents up to 18yrs old.

- The problem is with the whole spine image (spanning 3 detectors shots), so our existing chest phantom would not be large enough to see the problem as it would only cover 1 image at most.

Sample portfolio

- Users reported the stitching problem is more noticeable for a severe scoliosis, so the spine needs to be as flexible as possible to simulate severe scoliosis.

To simulate the body in the image, I used several containers filled with water to create the approximate size of an orthopaedic patient. The containers come in a variety of different shapes and sizes so it was possible to combine some that could simulate the size of a small adult. These were all then filled with water ensuring there were no air pockets left in. As the human body is ~70% water, this was a good approximation and will offer an equivalent attenuation of the beam as a patient would.

Figure 7.1 - containers used for body phantom

When the problem with this system was originally reported to us, I made a test spine phantom using cuttlefish bones bought from the local pet store. These were found to offer an approximate attenuation to bone and could be cut & filed down to whatever shape we needed so they proved to be ideal for this purpose. The images with the cuttlefish spine came out quite well, but there was a lack of real clinical detail that would be seen from a real spine. It was therefore difficult to see if any part of the image had been missed off or reproduced by the stitching software. We had a real spine in the department that was currently used for training purposes, however it was fixed on a metal pole and was not fit for purpose in its current form. After consulting with other staff in the department, I decided to dismantle this spine use it to create a new test object that could be used to simulate scoliosis.

Each of the spinal vertebrae was attached to a flexible plastic rod. I needed to put a spacer in between each vertebra to simulate the intervertebral discs so they were not touching each other when the rod was bent. I decided to use a thin piece of kitchen sponge between each of the vertebrae to simulate this. At all times whilst developing and using the test object, I wore protective clothing whilst handling the body parts. This included gloves and also a facemask to protect myself when creating the test object in our workshop. The test object was stored away at all times when it was not in use to prevent any cross contamination. Furthermore I gave consideration to members of the public, particularly young children who may be sensitive/upset to seeing human body parts like this so it was always covered when transporting it around the hospital. The finished test object is shown in Figure 7.2.

Sample portfolio

Figure 7.2 - creating the spine phantom

I worked closely with the help of the lead radiographer in orthopaedics who initially reported the problem. Together we positioned the body phantom and spine test tool in a typical clinical orientation and I assisted the Radiographer in making the exposures. The severity of the scoliosis was altered throughout the testing so we had a good range of images to test the system with. Several exposures were made at each setting so we had a good selection of images to analyse. The exposures were made using the standard protocols they would normally use and they also did the image analysis as per their protocol.

After we obtained all the test images, I assisted in cleaning/decontaminating the equipment to ensure the system could be returned to clinical use.

Some sample images along with photos of the experimental setup are shown on the following page in Figure 7.3.

Sample portfolio

Appendix - Images from orthopaedics

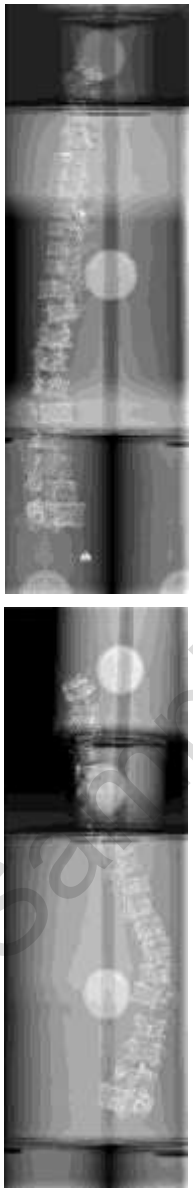

Figure 7.3 - photos of the experimental setup and resulting images from clinical exposures. Each exposure simulated a higher degree of scoliosis to fully test the capabilities of the system

Sample portfolio

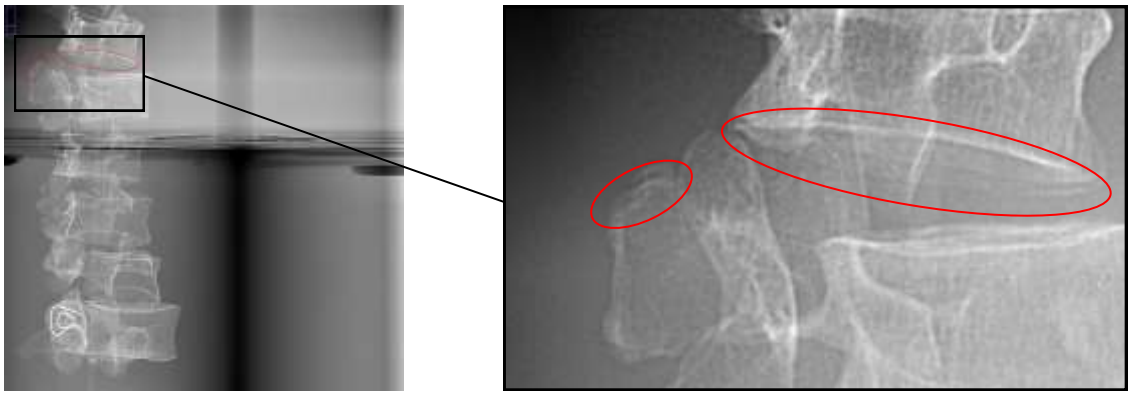

Figure 7.4: The stitched images showing the artefact

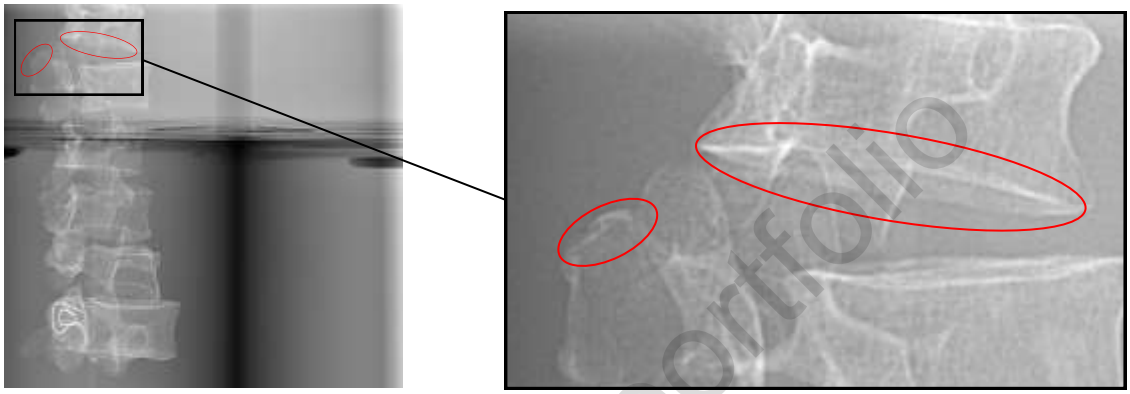

Figure 7.5 - the same images in unstitched format do not show the artefact

Sample portfolio

The images above show the artefacts associated with stitching the images together. These are taken from the first set of images with the spine approximately straight.

At first glance, there appears to be very little, if any difference between the two images. There is however a very subtle stitching line where part of the anatomy is duplicated in Figure 7.5. On the area of the image between the 12th thoracic vertebra and the 1st lumbar vertebra, there are a couple of edges which have been duplicated – I have circled these for clarity. Although it was very subtle, the images still require manual manipulation to ensure they are lined up correctly. If we magnify the same part of the anatomy for the unstitched image, the artefacts are not there confirming that the problem arises from a stitching artefact due to the software.

Despite the artefact still being present, this is a much greater improvement from the initial images where several centimetres of the spine was being duplicated and/or missed off completely. The images still however require manual manipulation in order to be aligned correctly. The problem was seen on all images with varying degrees of simulated scoliosis.

Further tests were carried out on the system using a reference ball. This is an aluminium ball approximately 2.5cm in diameter and is highly attenuating. The ball was positioned over the area where the images would overlap. The idea was to force the software to use this as the reference point and apply the stitching algorithms at this point to combine the images more accurately. It was difficult however to position the ball accurately on the crossover line so it took a few exposures to get it right. The final images of the ball appeared to be perfectly spherical at first, but closer analysis

showed there was some distortion indicating the software was not working correctly and the stitching lines could still be seen.

Another method we tried was to use a long thin sheet of copper behind the phantom. The idea was that by having a very high attenuating piece of material in each image, rather than just on the overlap edge, the software would find it easier to reference the points of interest in the images and stitch them together properly. The spine was fixed in a vertical position and the copper was placed at an angle of ~30°. By doing this we hoped the software would be able to distinguish it from all other anatomy in the beam and apply the algorithms only to this point – every other point would then be correctly lined up. Various attempts using this method were tried, but none were successful.

Finally we tried using a ruler with lead (Pb) markings on. This is often used clinically with patients as a reference for the patient's size. The resulting images from these tests showed clearly where the stitching lines were as the numbers on the ruler did not increment properly and were sometimes duplicated.

All three of these methods proved to be ineffective and there were still subtle stitching lines visible where the images crossed over.

Conclusions

From a technical point of view, it appears that the upgrade to the software has greatly improved the stitching accuracy significantly; the system is now out by a few mm rather than cm. However, from a user point of view, it could be argued that this has in fact made the problem worse. As the stitching problem is less noticeable now, it becomes increasingly more difficult to detect it and users now have to spend longer analysing each image than previously. This requires the skill of a radiographer who cannot only recognise these stitching lines, but correct the images too. All of this means additional time spent per patient and ultimately patient waiting times increase.

So unfortunately users are still left with the same issue as before when they have to manually adjust each series of images taken to eliminate the stitching lines. As the problem with the equipment was not fully rectified, users of the system were advised to keep a log of the images they were taking and recording how much manual adjustment was needed (if any) so we have some evidence to take back to the manufacturers. Initial results are looking as follows:

6 of the 14 images taken so far (43%) required no stitching at all and were lined up perfectly. 4 needed slight adjustment and 4 needed major adjustment. Users will continue to log the process and we will audit this in the future to see if there has been any noticeable improvement. With the images I took and the data currently being collected in the logbook, we hope to go back to the manufacturer and show this as evidence that the system is still not performing as specified.

Sample portfolio

Appendix 8 - Calibration of Dose Area Product (DAP) meter [B5, D5]:

On 17th September 2012, XXXX Main X-ray Room 5 had a new Dose Area Product (DAP) meter installed as the previous one developed a fault that could not be fixed. The replacement DAP was fitted by the X-ray engineering team within XXXX.

The DAP meter is used routinely after each examination with the Radiographer recording the displayed DAP onto the patient's permanent record. As such in order to ensure that any patient dose assessment carried out in this room is done properly, it is essential that the DAP meter is correctly calibrated, or that an appropriate calibration factor is obtained if the meter cannot be adjusted.

Initial testing on the DAP meter showed it was under reading by up to -21% (average -14%). Although this falls within the desired ±25% tolerance, my initial thoughts were that this could be improved given it was a new meter. The results of my tests are shown below:

DAP calibration:

DAP manufacturer:	PTW Freiburg	Test reading before adjustment:	129
DAP model:	Diamentor	Couch between DAP & chamber?	No
DAP serial number:	57523-02820	X-ray field size in cm²:	173.843
Position of DAP:	Under LBD	DAP meter units:	cGy.cm²
Channel used:	A		

Set kVp	Set mAs	DAP meter reading	DAP meter reading (cGy.cm²)	Dose meter reading (mGy)	Actual DAP (cGy.cm²)	Percentage difference	Calibration factor	Before or after adjustment?	Test reading set
81	10	6	6	0.4377	7.61	-21	1.27	Before	129
81	20	14	14	0.8843	15.37	-9	1.10	Before	129
60	40	15	15	0.9642	16.76	-11	1.12	Before	129
102	20	22	22	1.418	24.65	-11	1.12	Before	129
81	10	7	7	0.437	7.60	-8	1.09	Before	129
81	10	7	7	0.4332	7.53	-7	1.08	After	144
81	20	16	16	0.8942	15.55	3	0.97	After	144
60	40	16	16	0.9714	16.89	-5	1.06	After	144
102	20	25	25	1.409	24.49	2	0.98	After	144
81	10	7	7	0.4368	7.59	-8	1.08	After	144

Final test reading:	144
Calibration factor if applicable:	1.09

Sample portfolio

Figure 8.1 - results of DAP calibration checks

I made several adjustments to the sensitivity of the meter and after the final recalibration, the DAP meter accuracy improved and now had a maximum deviation of -8% (average -3%). I felt this was sufficient and was an improvement over the initial result. The room was returned to clinical use following this job and the DAP meter has been used in this room ever since. The copy of the final report is shown below:

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Appendix 9 - Calibration of Radiology dose meter [B5, D5]:

Radiographers at XXXX Hospital contacted us to say their own QA tests on the X-ray rooms and mobile systems were showing a number of units were approaching or exceeding the remedial limit for change in tube output. Upon reviewing the Radiographer QA results for the systems in XXXX Hospital, I noticed that the recorded dose had decreased on all of the machines they routinely perform QA testing on. It was just by chance that the one they called up about had passed the remedial level and as such had flagged up on their spreadsheet to call us.

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Figure 9.1 - Radiographer QA results flagging up fault with system

I was therefore fairly confident that it was either a problem with their dose meter or a problem with how they were setting up the tests. It was extremely unlikely that all the systems had dropped in output at the same time. I was on site carrying out the routine QA tests on one of their rooms and offered to check their meter whilst I was there. I did this by performing a cross comparison with our own Unfors Xi meter using their x-ray room as the source.

It became clear straight away that there was a problem with their meter. For long exposure times (>100ms), both our meters agreed quite well with each other in terms of kV measurements and dose. For short exposures however, there was a discrepancy in the dose measurement, although the kV accuracy was fine. This pointed to a difference in how the meter was measuring the dose.

I traced the source of the fault with the meter to an option in the settings menu called 'Trig delay'. Some systems (for example AC powered intra oral dental units) can have large spikes in the first part of the waveform and these can skew the measurements from the Unfors meter. The Trig Delay option allows us to discard this part of the waveform by triggering the measurement part way into the exposure. In this case the Trig Delay was set to 10ms; our own meter was 0ms. I therefore changed the setting and repeated the measurements, which corrected the problem with the meter and showed it was working properly.

As adjustments were made to the way the meter worked, I performed a full cross calibration with our meter on site. Before I left site, I spoke with the Radiographer who reported the initial problem and reassured her it was nothing that she was doing wrong, but was an issue with the meter. She was initially quite worried that she was at fault for the results. We repeated the tests and entered the results onto the spreadsheet (Figure 9.1) which showed the system now passed, so it was a good result to leave the site with a working dose meter and positive feedback from the Radiographer.

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Sample portfolio

Appendix 10 - Routine QA survey of a Digital Radiography (DR) x-ray system [A6, A8, B4, D1, D4]:

Survey of XXXX Main Room 3 - Siemens Axiom Artis DR system

In January 2016 I performed the routine Quality Assurance (QA) testing on a digital x-ray system at XXXX Hospital. My role in doing this job was lead surveyor and I worked alone when carrying out this work.

Upon my arrival, I completed a handover form which had then allowed me to start work on the system. After a quick visual inspection of the system, I began to set up my test equipment.

I performed a range of technical tests on all parts of this system to determine how the performance compared with baseline reference data and also with the current legal requirements. Tests were carried out on the x-ray tube/generator, Automatic Exposure Control (AEC) systems and also on both digital detectors. The tests and associated tolerances performed come from three main reports; IPEM Report 91; IPEM Report 32 (Part VII) and The Medical & Dental Guidance Notes.

All safety features of the system were tested on site. A series of exposures were made to test the performance of the x-ray tube/generator and all results were recorded on site using a Microsoft Excel template file created by our team specifically for this x-ray modality. AEC termination doses were measured directly and all measurements were made using specialist survey equipment which I transported to the site. Images were captured on both digital detectors and all these were exported from the system onto a CD. Feedback was given verbally to end users regarding the overall performance of the system and whether it could continue to be used in normal clinical practice. This was also indicated on the final part of the handover form which I completed just prior to leaving site.

The following day, some of the exported images were analysed back in the office using Image J software and a series of macros that have been written to aid in the analysis of digital images. Other specialist software (IPEM Report 78 Spectrum Processor) was used to calculate the total filtration of the x-ray tube.

Results from all the tests performed were carefully analysed and checked to see if any exceeded remedial or suspension levels. Following on from the analysis of the measurements I produced a formal report detailing the results of the survey. The frontpage of the Excel template was converted to a PDF report and this was e-mailed to the team leaders and a number of senior radiographers. The report was also linked to job/equipment asset on our equipment management database and at this point the job was closed off. At this point, the job is complete and the next routine testing for this system will be due in January 2018.

A copy of the report which was e-mailed to the Radiographers is shown below:

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Sample portfolio

Appendix 11 - Analysis of patient dose data [A6, A8, D7]:

XXXX Dental Institute (LDI) - Audit of intra oral patient doses (November 2015):

Below is a copy of the report which was sent to end users following a patient dose audit at XXX. I obtained most of the measurements and performed all the analysis on the data. I produced all parts of this report including the revised exposure chart and this was then checked by a qualified Medical Physics Expert (MPE) before being sent to end users.

Our recent round of routine QA surveys in XXXX have identified that a large number of the systems in use exceed the current National DRL for the reference Mandibular Molar examination. Furthermore our audit of the surgeries indicates there appears to be some inconsistency in which exposure chart is in routine use amongst the different departments.

The table below shows the average dose across all surgeries we measured. There is also information related to the maximum dose measured for each surgery of the reference examinations. The results have been taken using the exposure factors indicated on the exposure chart in the surgery and have been compared against the current National Diagnostic Reference Level (DRL).

Examination	National DRL (mGy)	Average LDI dose (mGy)	Maximum LDI dose (mGy)
Adult Mandibular Molar	1.7	1.174	1.689
Child Mandibular Molar	0.7	0.929	1.35

The table above shows that Adult patient doses are all below the current National DRL and no further action is required regarding these exposure settings.

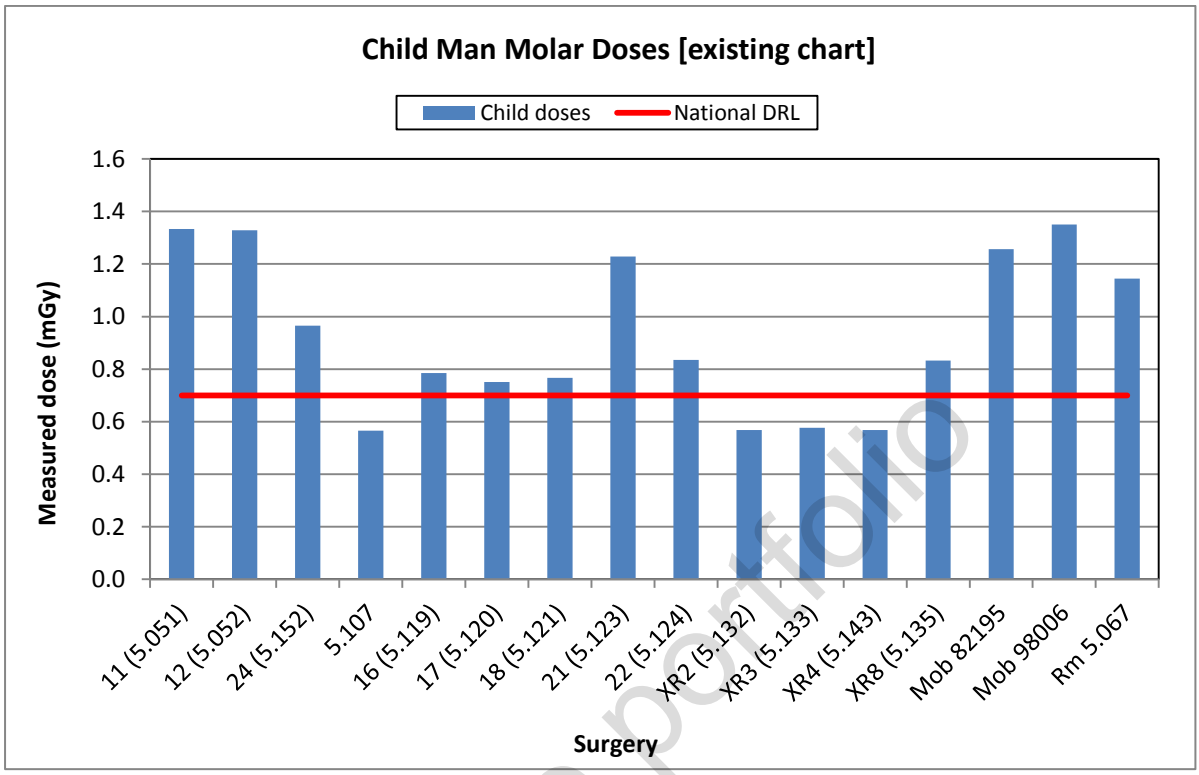
With regards to the Child patient doses, a large number of the surgeries exceed the current National DRL and in some surgeries the measured doses are almost 2x the National DRL. The large variation is partly because some departments appear to be using different exposure charts which are now out of date.

Our survey results showed that 75% of all the systems we tested gave dose levels which currently exceeded the Child National DRL using the provided exposure charts. All the systems which exceeded the DRL are Planmeca Prostyle Intra systems. These are currently operating at the default tube current of 8mA. Our tests show that simply by reducing the tube current to 7mA (which is the same as the Instrumentarium systems), and coupled with the correct exposure chart which is provided below, doses would be reduced sufficiently to ensure most would fall below the National DRL.

This change would ensure that exposure times can remain the same between the Planmeca and Instrumentarium systems. The overall reduction in dose on the Planmeca systems would be ~12.5% for all examination and patient types.

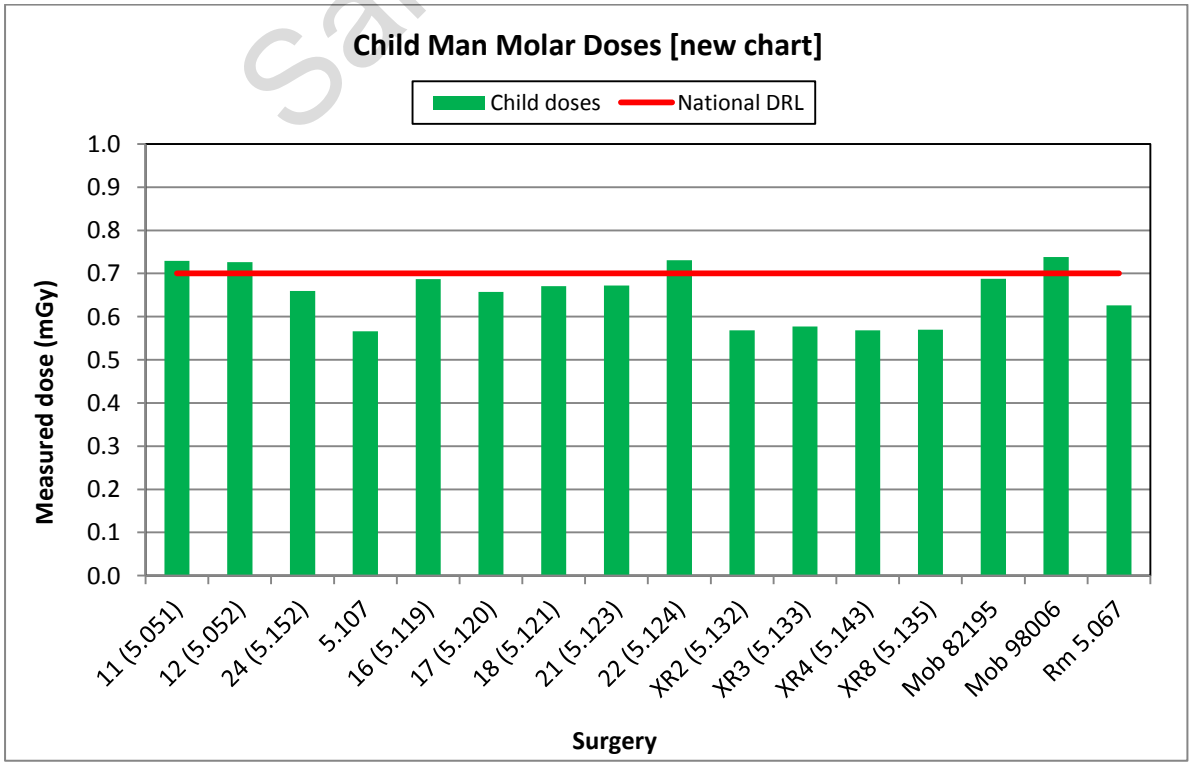
Sample portfolio

In the technical manual for the VistaScan systems is a recommended exposure chart for use with their dental CR systems. This information has been carefully considered when carrying out this work to ensure that patient doses can be As Low As Reasonably Practicable (ALRAP) whilst ensuring dose levels remain sufficient for the CR system to produce radiographs of diagnostic quality. The chart below shows the locations of the surgeries which are exceeding the Child National DRL in their current operation:



Sample portfolio

The proposed changes to the exposure chart will reduce the doses to a level where most fall under the National DRL. Furthermore doses will be more consistent across all the surgeries as a standard set of exposure factors will be used by all departments.



Recommendations:

We recommend that the enclosed exposure chart is put into routine clinical use at the earliest opportunity for all the surgeries which have Planmeca Prostlye Intra x-ray systems. Note that the change in tube current (mA) is a parameter which must be changed manually on the Planmeca systems and all users should be made aware that this setting should now be used routinely. The Instrumentarium/GE Focus systems default to 7mA for all exposures so no changes need to be made to how you operate these systems.

The exposure chart should be cascaded around all the surgeries in LDI and team leaders in those areas should be advised to use this chart at the earliest opportunity. Any existing charts in the surgeries and/or on any mobile equipment should be removed and replaced with this one.

As dose levels on the Planmeca systems are being reduced, it is important to ensure that clinical image quality remains adequate at these dose settings. As such I recommend that users carefully review image quality for the first few weeks after the charts have been issued. If there are any concerns relating to the quality of radiographs following these changes, please contact us as soon as possible for further advice.

Report written by: XXXX
Position: Specialist Technical Officer

Report checked by: XXXX
Position: Medical Physics Expert

Date: 26/11/2015

Sample portfolio

Appendix 12 - Commissioning tests at NYOS XXXX [A2, A4, A6, A8, A9, B3, D2, D4]:

Introduction

In December 2015, I was involved in acceptance testing and critical examination tests on a new Philips Digital Diagnost DR system with 3 detectors. This was installed at XXXX in XXXX, which is a clinic run by the XXXX. The work was carried out with XXXX who is our departments Radiation Protection Advisor (RPA). My role on this job was to take the lead in performing the acceptance tests of the system and to assist XXXX with the Critical Examination checks. In addition to these checks, we were also asked to carry out tests on the walls of the room to ensure they were adequately shielded. The acceptance tests and shielding tests were performed on behalf of NYOS. The Critical Examination is a legally required test under IRR99 and is the responsibility of the installers to ensure this is performed. The tests differ from the acceptance tests in that they include more extended tests on the safety features and warning devices of the system. The Critical Examination was performed on behalf of Philips Healthcare.

Health & Safety / Risk assessment

Upon our arrival to the site it became clear that there was still construction work going on in the building, although the x-ray room itself had been mostly finished. As such it was important to make everyone on site we would be working there and to sign in upon arrival at the site. Although the warning lights to the x-ray room appeared to be operational, there was no handle and/or lock on the door leading into the room. Furthermore builders were walking in and out of the room in order to finish off jobs in there. We took the necessary precautions by ensuring we alerted the builders on site that we will be using the x-ray machine in there. We placed additional warning notices on the door and blocked the door from the inside to ensure no-one would enter the room whilst we were exposing. Some of the x-ray equipment/detectors were covered in dust where drilling work had been taking place close by, so we cleaned & decontaminated all the equipment before staring any of our measurements.

Summary of tests

The engineer from Philips Healthcare was on site and remained there whilst we carried out the tests. It was important to communicate effectively with him as his assistance was required in order to carry out some of the safety checks on the system (in particular the emergency stops and the AEC backup timers) which formed part of the Critical Examination checks.

I performed the full acceptance tests on the x-ray tube/generator and the 3 detectors. I used the Unfors R/F detector for the majority of the measurements (e.g. kV accuracy, timer accuracy and tube output, tube filtration). The Unfors survey meter, which is a highly sensitive dose rate meter, was used to assess the shielding of the x-ray tube by measuring the tube leakage. Further tests were carried out on the digital detectors using the dose meters as well as test objects to assess image quality.

I assisted XXXX in carrying out the shielding checks of the wall and door of the room. This was done at multiple points on the wall and door. We affixed the dose meter to the points. I was in control of the x-ray systems whilst XXXX recorded the measurements. From the results, XXXX calculated the transmission through the walls/door and from this determined the Pb (lead) equivalence. These

Sample portfolio

values were then checked against the initial building spec for the site to see how they compared. Copies of the acceptance, critical examination and shielding assessment reports are shown below:

Appendix 12(i) - Acceptance testing report:

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Appendix 12(ii) - Critical Examination report:

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Appendix 12(iii) - Shielding assessment report:

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Appendix 13 - Technical Instruction (TI) written for the QMS [A10]:

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Appendix 14 - Customer feedback [A7, E1]:

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Sample portfolio

Appendix 15 - Incident reporting [A5, B5, E1]

One of the radiation incidents I was recently involved with occurred at XXXX Hospital which is one of the hospitals within our own Trust. The x-ray department at XXXX has a number of Siemens Axiom Aristos digital systems and the fault seemed to be attributed to this particular model of system. I took the initial call where users reported an x-ray being taken but an undiagnostic image being produced. I consulted with a Medical Physics Expert (MPE) before providing feedback to the users to perform some of their own QA tests to investigate the issue further. Further faults with the system(s) then occurred which lead to an overexposure of a patient. We removed the room from use and starting an investigation process to determine the cause of the fault.

I determined the cause of the problem by carrying out a number of investigative surveys on the system, some of which were with Siemens engineers. A detailed summary of the incident which was sent to users is included below and following this is a copy of the QA report I sent following the final set of tests I carried out on the system after Siemens fixed the issue.

On 27th August 2014, a knee examination was performed in room 2 at XXXX hospital which resulted in a patient underexposure without a diagnostic image. Radiography staff rung medical physics for advice and were advised to perform their radiography QA tests (including the system detector QA). As the results of this testing was satisfactory, it was decided to put the system back into clinical use.

On 28th August 2014, the same issue occurred however on this occasion the exposure factors were correct but the resulting image was noisy and appeared unexposed. Radiography staff suspended the room from clinical use and sought advice from medical physics who advised that the room should remain suspended from clinical use and that Siemens by asked to investigate.

Siemens attended on the 28th & 29th August 2014 (notification number 3480608123). Service reports indicated that the system had selected the wrong detector to read from. A new PC was ordered and fitted to the system (notification number 3480608123). Medical Physics QA checks were then performed on the system (2nd Sept 2014), the fault did not reoccur and the performance of the system was satisfactory. The system was returned to clinical use with the advice that staff should monitor the performance of the system closely.

On Tuesday 4th November 2014, the fault occurred again in Rm 2 (knee exposure with correct exposure factors but resulting image was noisy background image). The room was immediately suspended from clinical use and Siemens and Medical Physics informed.

Siemens attended on the 5th & 6th November 2014 (notification number 3480624926). Service reports suggest that the fault was caused by the same error as on the previous occasion. The system PC was changed and the organ programs from XXXX room 3 were transferred onto room 2.

On Tuesday 11th November 2014, an incident occurred in XXXX room 3. On this occasion the radiographer was performing a repeat lateral knee examination. When the exposure was made the image was not a clinical image but a noisy background image and the actual exposure factors (90kVp, 41.66mAs DAP 125.2µGym^2) used were not the correct ones (63kVp, 3.84mAs, DAP 5.5µGym^2). The room was immediately suspended from use and Siemens and Medical Physics contacted.

Sample portfolio

Medical Physics calculations indicated that the patient had received an overexposure by a factor of approximately 32 and consequently this exposure needs to be reported to the HSE as an exposure much greater than intended. Medical Physics have escalated the matter with the manager with responsibility for radiation safety with Siemens and informed him that they intended to report the fault to the HSE and have given Siemens the opportunity to report the matter to the MRHA.

Fault description:

The Siemens Axiom Aristos MX / VX systems use a predefined examination menu to improve workflow. This process will automatically select the exposure factors and detector (wall or table) to correspond with the next anatomical examination in the menu.

If the radiographer decides to repeat the previous examination in the menu then the system will allow the radiographer the opportunity to re-select this examination. However if this is done while the system is in the process of selecting the next step in the examination menu then it is possible that to corrupt the examination data (including the exposure factors and detector selection) causing the fault.

Extensive testing by Siemens and Medical Physics on 14th November 2014 has demonstrated that the fault does seem to occur if the radiographer does not change the examination until the system has completed its processes. In addition although Medical Physics could cause the system to corrupt the exposure data with an error rate of approximately 1 in 10, they could not replicate the fault as a secondary safety feature prevented the system from exposing.

Consequently following satisfactory Medical Physics and radiographer QA testing and further radiographer training the system was returned to clinical use.

Dose estimates:

All risk estimates are based on a risk factor of 0.05/Sv (NRPB, Vol 4, No 4).

Room 2

AP knee exam 27th August exposure factors 50kVp, 2.68 mAs.
Effective dose 0.08µSv corresponding risk 1 in 250 million - trivial

AP knee exam 28th August exposure factors 63kVp,3.84 mAs
Effective dose 0.2µSv corresponding risk 1 in 100 million - trivial

AP knee exam 4th November exposure factors 63kVp,3.84 mAs
Effective dose 0.2µSv corresponding risk 1 in 100 million - trivial

Room 3

Unintended Lateral knee exam 11th November exposure factors 90kVp, 41.66mAs
Effective dose 3.5µSv corresponding risk 1 in 6 million - trivial

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Appendix 16 - System Improvement Notes (SIN) [B7]:

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Appendix 17 - Internal QMS audit [B7]:

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