EngTech Competencies Document

Section A – Use engineering knowledge and understanding to apply technical and practical skills.

A1 – Review and select appropriate techniques, procedures and methods to undertake tasks.

A2 – Use appropriate scientific, technical or engineering principles.

Section B – Contribute to the design, development, manufacture, construction, commissioning, operation or maintenance of products, equipment, processes, systems or services.

B1 – Identify problems and apply appropriate methods to identify causes and achieve satisfactory solutions.

B2 – Identify, organise and use resources effectively to complete tasks, with consideration for cost, quality, safety, security and environmental impact.

Section C – Accept and exercise personal responsibility.

C1 – Work reliably and effectively without close supervision, to the appropriate codes of practice.

C2 – Accept responsibility for work of self or others.

C3 – Accept, allocate and supervise technical and other tasks.

Section D – Use effective communication and interpersonal skills.

D1 – Use oral, written and electronic methods for the communication in English of technical and other information.

D2 – Work effectively with colleagues, clients, suppliers or the public, and be aware of the needs and concerns of others, especially where related to diversity and equality.

Section E – Make a personal commitment to an appropriate code of professional conduct, recognising obligations to society, the profession and the environment.

E1 – Comply with the Code of Conduct of your institution.

E2 – Manage and apply safe systems of work.

E3 – Undertake engineering work in a way that contributes to sustainable development.

E4 – Carry out and record CPD necessary to maintain and enhance competence in own area of practice.

E5 – Exercise responsibilities in an ethical manner.

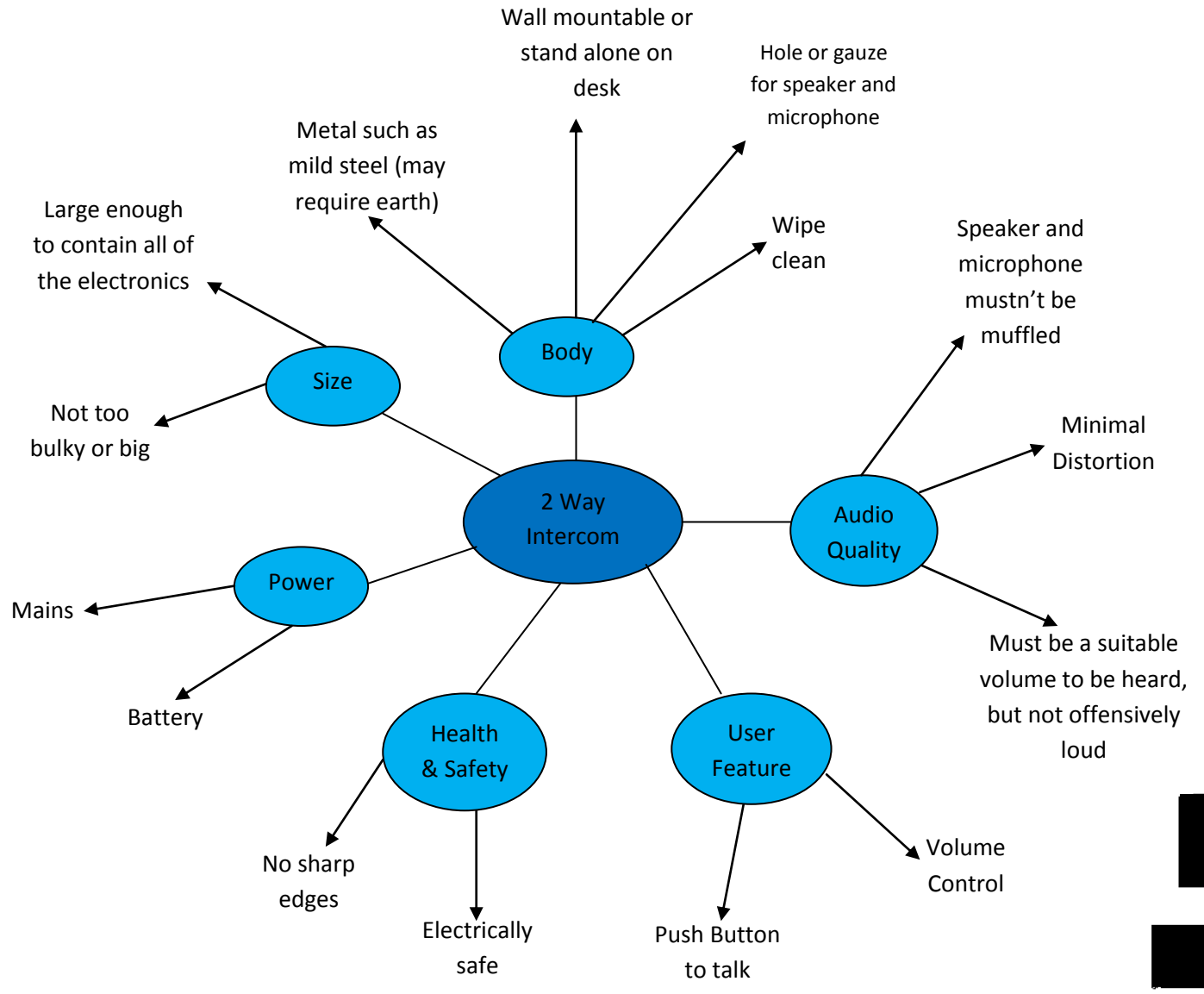
Section A - Use engineering knowledge and understanding to apply technical and practical skills.

A1 – Review and select appropriate techniques, procedures and methods to undertake tasks.

Intercom Project (Prototype)

The intercom system I have designed will be used in the Brachytherapy department of the hospital. Brachytherapy is a treatment in which a small radioactive pellet known as a seed is placed inside the body of the patient. The idea of this is that the radiation is located directly next to, or inside a (usually cancerous) tumour that is being treated. The radiation damages the cancerous cells so that they cannot regenerate or repair themselves; therefore the cancer reduces in size, potentially curing the patient. The 2 way intercom system that I am building will be very important for the protection of staff members treating and looking after the patients. Due to the radiation, the patient and the staff member wouldn't be able to communicate as the patient is in a secure bunker with thick walls and doors. The 2 way intercom system will allow both the patient and the staff member to communicate both ways during the course of the treatment. This is potentially a safety device as if the patient is feeling unwell or in discomfort then they can make the medical staff aware of this. Also if a patient has contact with the staff members during their treatment they are more likely to feel relaxed and at ease having a better overall experience.

Below is a mind map showing the specifications that my Intercom may have met:



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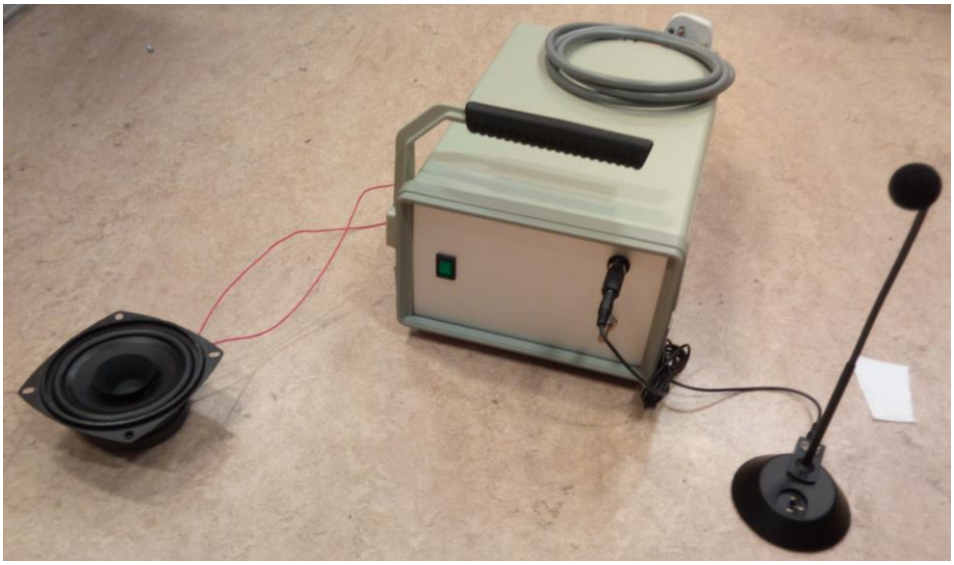

Description	Visaton Round Speaker Driver, 30W nom, 50W max, 8Ω	Visaton Round Speaker Driver, 30W nom, 50W max, 8Ω
	 512-815 Quick View	 431-8892 Quick View
Brand	Visaton	Visaton
Mfr. Part No.	FR 108 OHM	2004
Datasheet		
Driver Shape	Round	Round
Maximum Rated Power	50W	50W
Impedance	8Ω	8Ω
Nominal Rated Power	30W	30W
Depth	47mm	40mm
Frequency Type	Full Range	Full Range
Maximum Frequency Response	20 kHz	20 kHz
Cone/Dome Size	100mm	71mm
Weight	0.38kg	0.28kg
Cone/Dome Width	100mm	71mm
Length	105mm	78mm
Width	105mm	78mm
Frequency Response	80 Hz → 20 kHz	100 Hz → 20 kHz
Speaker Driver Size	8.1 to 13 cm (5 in)	8 cm (3 in) and Under
Minimum Frequency Response	80 Hz	100 Hz
Category	Speaker Drivers	Speaker Drivers
RS Stock No	512-815	431-8892
Availability	✓ In stock for FREE next working day delivery	✓ In stock for FREE next working day delivery
Price	Each Qty Unit price 1 £11.82	Each Qty Unit price 1 £14.92

When ordering the speaker the first stage was to choose an appropriate website in which to research and order the speakers. I chose to use the RS website as they had a good range available and we already order parts from them meaning that the order would come through quickly.

Next, I entered the specifications I required into the search bar of the website. I compared the two most suitable speakers to make sure that I was getting the better one for the circumstances. I chose the speaker on the left hand. The reason for this is that it had a larger range of frequency response, and also was the cheaper option. The speaker I ordered isn't as compact as the other option however the difference in size didn't really matter as I am building the case myself so can take the size difference into account. If the product needed to be portable the heavier weight may have been an issue but because the speaker will be mounted into the ceiling, this won't be an issue. It was important that I took both economy and function into account when I was choosing the speaker, as I didn't want to waste money on a more expensive speaker that wouldn't have had been much, if at all better than the cheaper option for the circumstances I need it for, however it was equally as important to ensure that the speaker would be of a suitable specification to ensure the system worked to its best capabilities.

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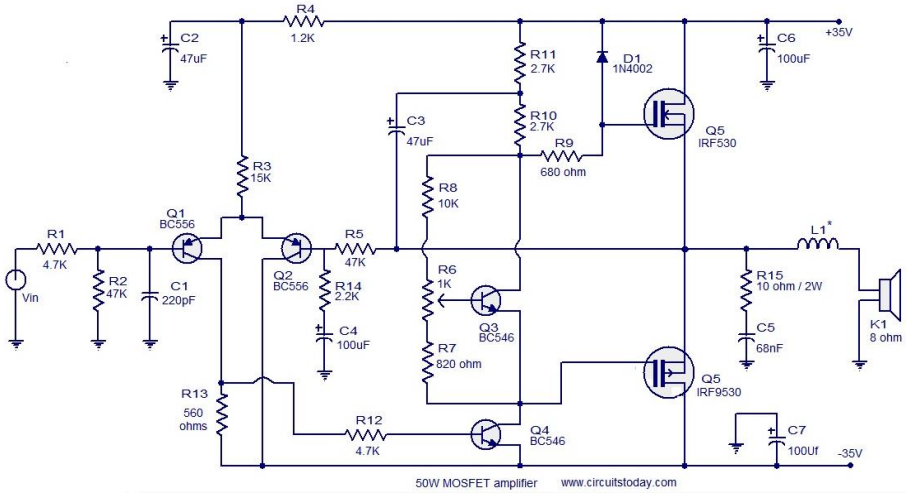
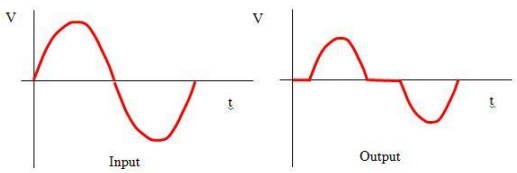
Circuit Theory

50W MOSFET Amplifier



The main circuit that I have used is a 50W MOSFET amplifier. The circuit is part of my work-based electronics taskbook, and as can be seen on the image above, the circuit was originally from a website on the internet. The main reason I chose to use this circuit is that I was already building it as part of my work based learning, and so I had already ordered the components, which would allow me to spend less and therefore keep my overall budget much lower. Another reason I chose the circuit is because I wasn't originally sure what gain or amount of amplification I would need and so I decided that 50W would definitely be more than enough. The circuit uses a 35V split supply, meaning that there are both a +35V supply and a -35V supply along with an earth rail. The input of the circuit is marked on the left hand side as Vin, and in my project this is where the incoming signal from the pre amp comes into the amplifier circuit. The signal first passes through a buffer stage setup by two BJT transistors Q1 and Q2. Q3 and Q4 make up the driver stage of the amplifier. It is important that these transistors were matching otherwise the amplifier would not work as intended, leading to the waveform being amplified non-symmetrically.

The final amplification stage of the circuit is a push-pull amplifier built using MOSFET transistors. This would be a class B amplifier. Each of the MOSFET transistors amplifies half of the wave, one positive and one negative. The MOSFET transistors must both be of a similar type, called a complimentary pair. This means that the amplifier is quite efficient as the transistors are only on for half of the time, and using this much more power can be achieved using a given supply voltage when compared to a class A amplifier such as a common emitter. A disadvantage with the push-pull amplifier is that if the two transistors don't match, then crossover distortion can be created. This is when the transistors turn on and turn off time isn't quite right creating gaps between the positive and negative half cycles of the wave. To prevent this there is a potentiometer to control the quiescent current, which stops the cross over distortion as shown in the graph below.



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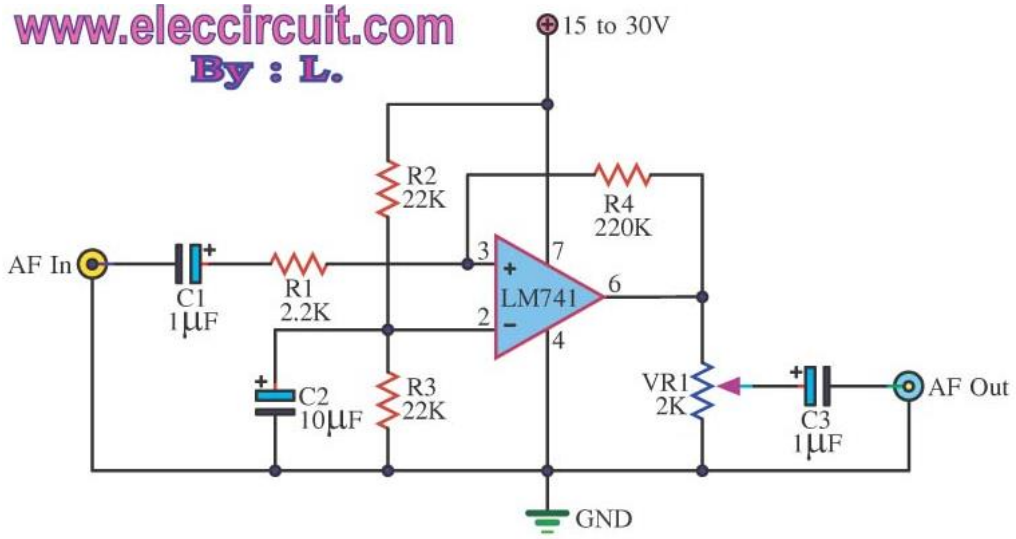
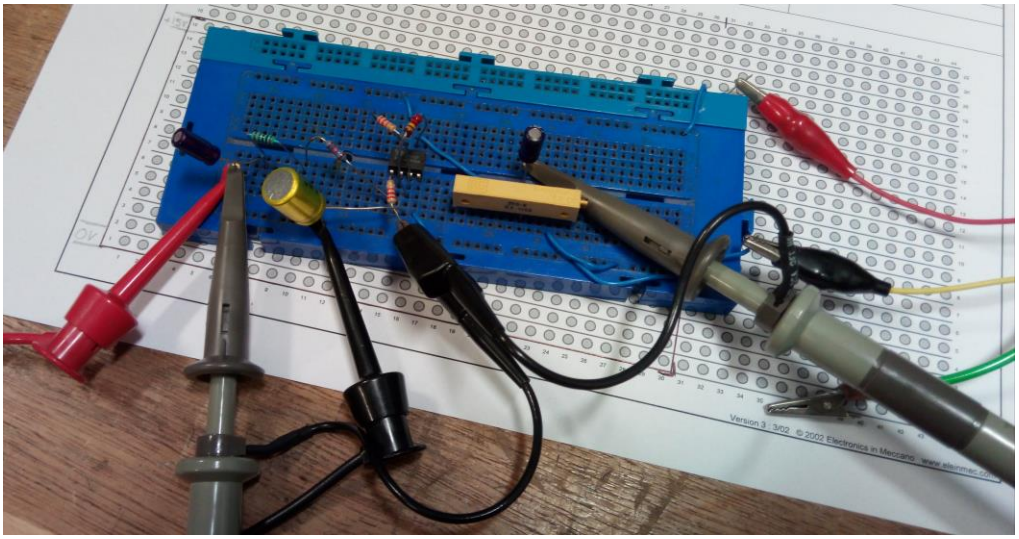
741 Op Amp pre Amp



The circuit that I have shown above is a pre amp circuit that uses a single op amp chip called a 741. I used this pre amp to amplify the input signal from the microphone so that the main amplifier can increase the amplitude of the signal, allowing it to be heard throughout the entire room. I chose this circuit after carrying out research because I felt that this was a relatively simple circuit using components that I already had available to me. For example I already had a 741 chip that I could use from another circuit I had made, and at work we have a number of components such as resistors always available. The circuit above shows a 15-30V supply and a ground rail at the base. I used this and found that the circuit worked really well however in my project I needed to use batteries to achieve this as I didn't have time to tap this supply voltage from the mains input to the project. In the future I could improve the project by using a single mains supply, without batteries being required. I could also then use a redesigned circuit to use a +10 and -10V rail or something of a similar value. As mentioned below, I have also prototyped this circuit to ensure that it worked as intended.



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The image I have included above is the testing stage of the pre amp circuit. I found this circuit on the internet by researching pre amp circuits. After choosing the circuit it was very important to test it. I have done this using breadboard which I have found to be very useful. This is because it allowed me to test the circuit before soldering. Using breadboard is a much quicker method of testing a circuit as it is a push fit connection. Any mistakes in the circuit can be rectified very quickly and simply. I used the breadboard to ensure the circuit was fully working. I did this by using an oscilloscope to compare

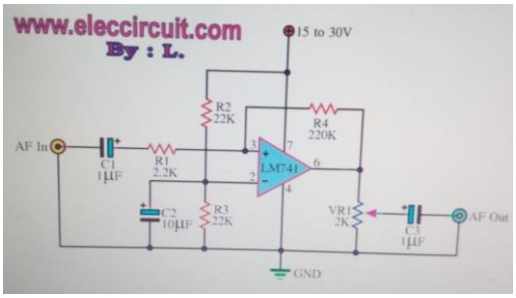
both the input and the output of the circuit. As mentioned earlier in this document, while testing this circuit I found an issue with the circuit, however I was easily able to amend it using the breadboard. If I had soldered the connection it would have been more difficult and more inconvenient to fix. Once I was confident the circuit was fully working as I wanted it to, I was more confident and so could solder the components onto veroboard. I did this as veroboard gives a permanent connection meaning that it is more durable, and especially in amplifiers and sound uses, a better connection would improve the circuit's performance by giving better sound quality. Once the circuit has been made the breadboard can be reused over and over again.

Problems Encountered (and resolutions)

One of the issues that I had is when the transistors holding the amplifier to the heat sink snapped. The reason for this was that the transistor legs were the only thing providing support to the vero board amplifier circuit. To fix this issue I had to replace the MOSFET transistors which involved de-soldering them from the veroboard, and unscrewing them from the heat sink. New transistors then needed to be soldered onto the board. I then tested the circuit again to ensure it was still working as intended. To do this I used a signal generator and an oscilloscope, and compared the input wave to the output wave, making sure that it had been amplified. To prevent this problem from occurring again I have made a bracket to hold the veroboard steady, preventing the transistor legs from being work hardened and snapping again. To ensure that this didn't cause issues with the circuit, the bracket has been mounted using nylon screws and nuts to ensure it is insulated from the circuit.

Another problem that I encountered was when building my preamp circuit. I had researched a simple pre amp circuit shown in the image below using just a single 741 op amp chip. This was easy to build on breadboard to check it worked. The circuit didn't work once I had built it and so I tried to find where I had gone wrong. After trying to fault find for a while, I realised that the comments section on the website I found the circuit on, mentioned that the circuit diagram wasn't correct and that the connections to the inverting and non-inverting op amp inputs were in fact the wrong way round. Therefore I swapped them around on the breadboard, which was very quick and easy to do as it was just push fit, and found that the circuit was then working correctly. I tested with a signal generator and an oscilloscope and found that the circuit amplified the 20mV input from the microphone up to around 1V peak to peak which was exactly what I needed. I then built the pre amp on veroboard as soldered joints provide a much better connection than breadboard and are permanent giving a much better sound quality. This issue has taught me to not always trust circuits from the internet, and to always build a prototype to ensure that it works before using it or making it permanently.

[redacted] [redacted]



mistake on pin 2 and pin3 they should be reversed

The overall idea of the project was to help improve the ease at which the patients and staff can communicate. This is an important technique used to help patients to have a better quality of treatment as they will feel like more care and attention has been given to them. I imagine that the bunker in which they are treated could be an isolated and lonely place to be, especially for the length that some treatments can take, often overnight. Therefore I personally think that if the patient is able to communicate any feelings or issues with the staff members then this will definitely improve their experience of treatment here at [redacted]

[redacted]

***A2** – Use appropriate scientific, technical or engineering principles.*

Agility Multi-Leaf Collimator

What is an MLC?
An MLC (Multi Leaf Collimator) is a device used in the head (also called BLD – Beam Limiting Device) of an Elekta Medical Linear Accelerator. This is used to shape the radiation output beam to prevent healthy tissue from receiving too much radiation, preventing as serious treatment side effects and decreasing patient recovery time. The Agility MLC is made up from 160 individual leaves made from 95% Tungsten, 3.75% Nickel and 1.25% Iron. Each MLC leaf is driven by an individual motor and gearbox. The first MLC was designed and improved on at the Christie Hospital where the physics team, engineers and the manufacturer who were then able to design the original MLC.

The MLC position is determined by an optics system. On the Agility MLC there is a new system that uses UV LEDs to flood the MLC with UV light. Each of the leaves has a ruby located on the end. This Ruby is made from a material that fluoresces when UV light is present. The term fluoresce means that the ruby once exposed to UV light will give off Infra-red light.

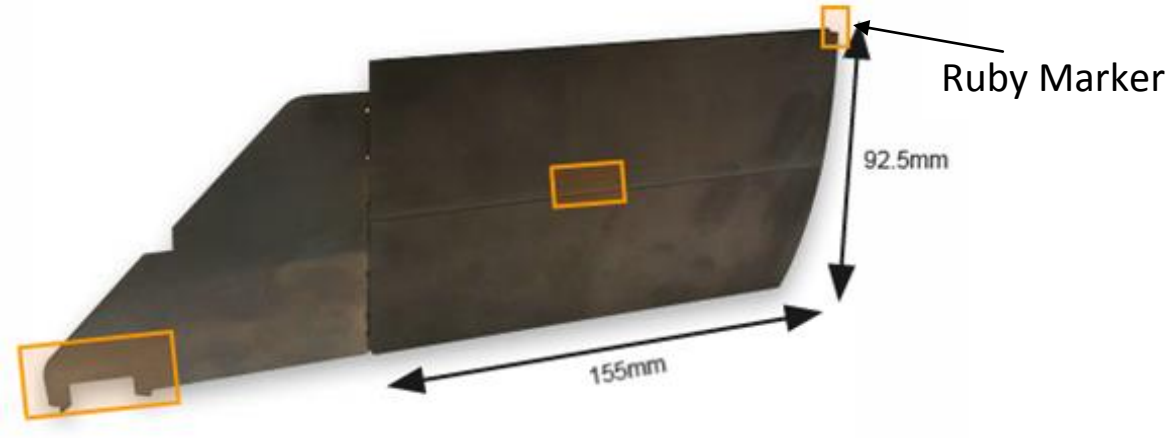


Figure 3.4 shown below includes the LED projector assembly as shown by label number 4. This PCB also contains a heat sink and cooling fan to prevent overheating. The board contains 3 UV LEDs and one green visible light LED. The green LED is to provide the user with a visible field of where the MLCs current position is so that the operator can see where the radiation will be delivered. This is especially useful to ensure the machine is calibrated properly and also to line up QC test tools and the patient being treated. The green colour is so that this wavelength doesn't interfere with the IR wavelength read by the optics system. Once the UV LEDs are on the UV passes through a beam splitting mirror which will also be mentioned later in this write up. Due to the special coating of film on the front face of the beam splitter, UV can pass through, but IR will be reflected. This is also decided by the orientation of the mirror. After the UV light has passed through the beam splitter, the light is then reflected by the mylar mirror causing a flood field effect, meaning that the UV light floods the MLC causing the rubies to flouresce. The Mylar mirror is made from aluminized polyester film. This allows X-rays and electrons to pass through it but importantly, reflects light.

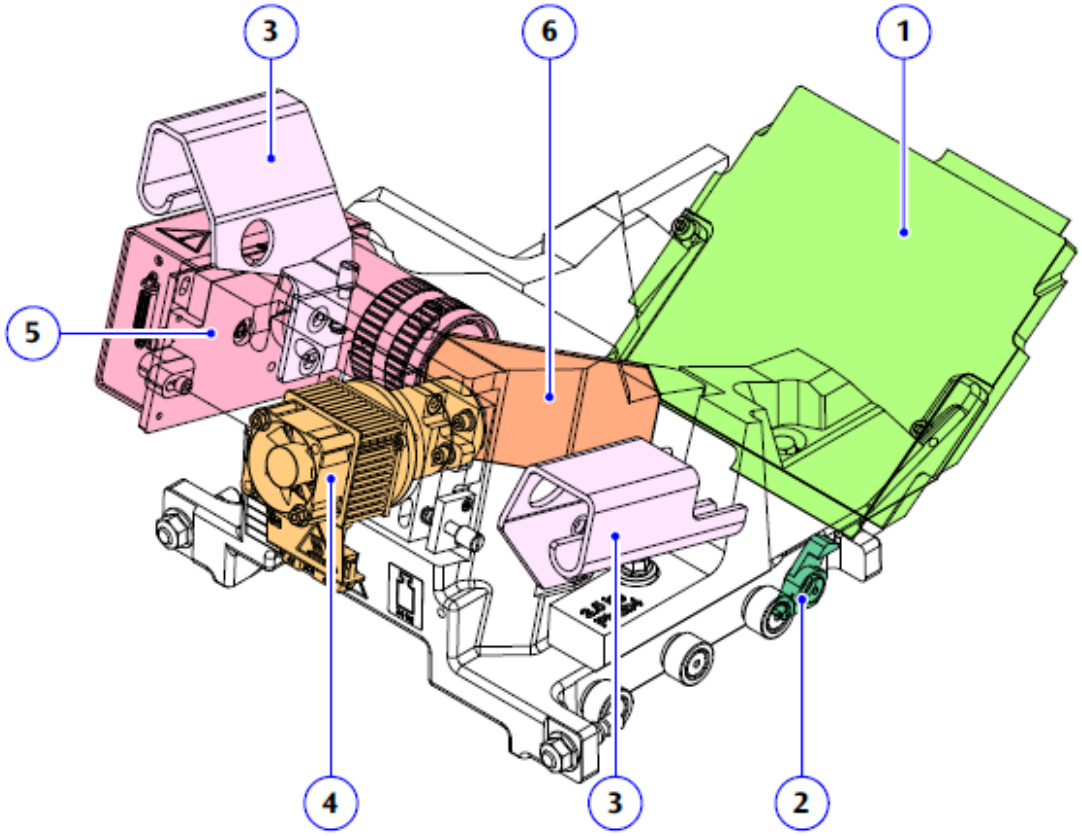


Figure 3.4 Retractable optics assembly

(1) Mylar® mirror
(2) Safety latch
(3) Lifting handle
(4) LED projector
(5) Camera
(6) Beam splitter mirror

Diagram taken from the Elekta CMM (Corrective Maintenance manual)

The rubies are made from Al_20_3:Cr (Aluminium Oxide doped with Chromium). This is a relatively inexpensive as they are grown in labs, rather than being a naturally occuring material. The rubies flouresce and the MLC control system can use this data to determine the position of the MLC leaves. The IR light is reflected by the beam splitter, rather than transmitted. This directs the IR light into an IR camera which converts the light into digitized data. The camera turns each pixel value into one of two possible numbers. 225 or 0. The 225 is for bright light and the 0 is for darkness or black. The position of the rubies are then compared to a set of 8 reference markers, which are made from the same material as the leaf rubies. The control system can then determine if the leaf is in the correct position, or if it isnt it can also adjust the position of the leaves until they are in the correct place.

[redacted]

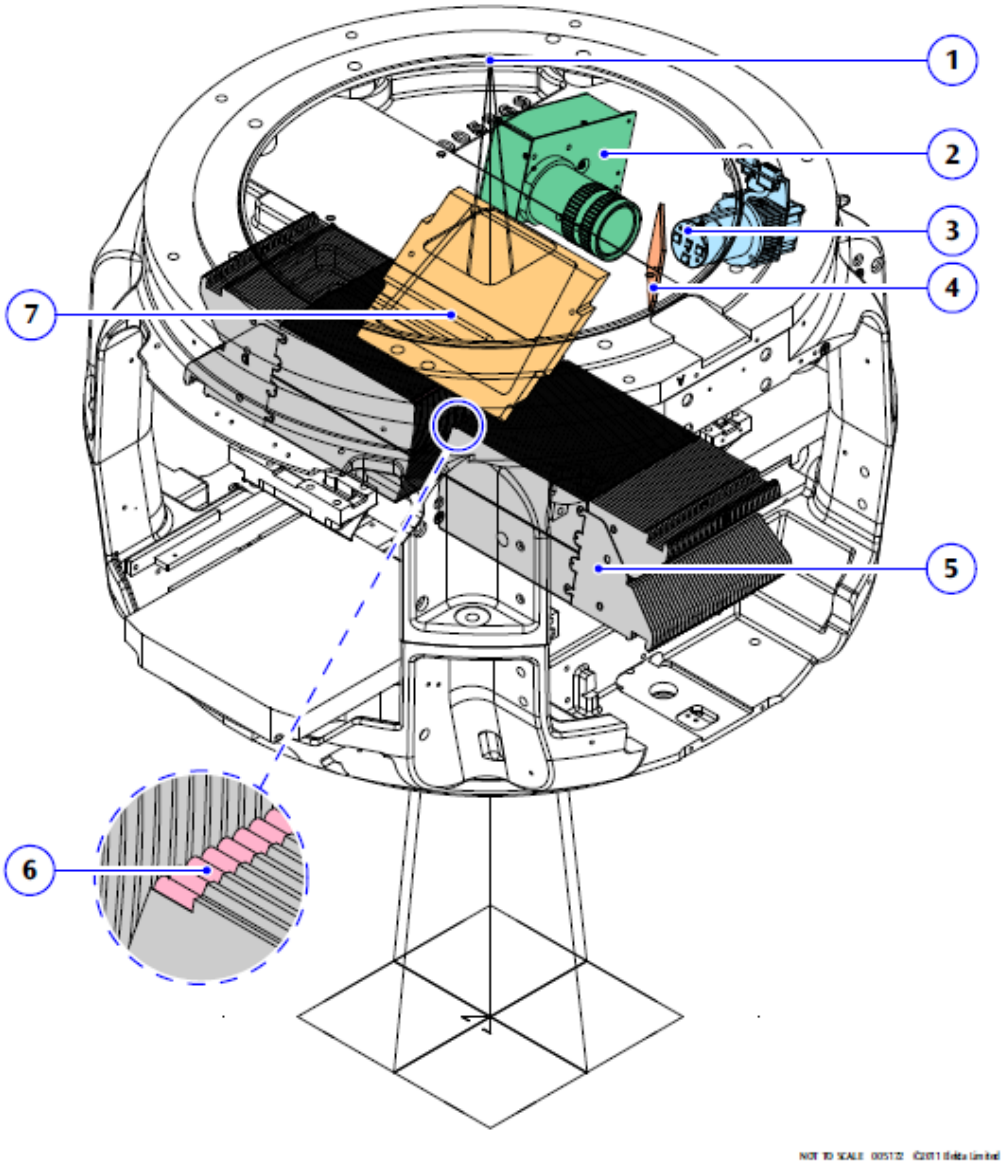


Figure 3.3 Optical system components

(1) Target
(2) Camera
(3) LED projector
(4) Beam splitter mirror
(5) Leafbank
(6) Leaf ruby reflectors
(7) Mylar mirror

Diagram taken from the Elekta CMM (Corrective Maintenance manual)

Before the MLC became the standard way to treat in Radiotherapy shadow trays were used. These clear plastic trays attached to the head of the machine and then lead blocks would be placed onto this. These weren't the best as the blocks would need to be set up every time by hand and so errors could happen, and the gantry wouldn't be able to rotate like in the newer treatment techniques. If treating with gantry rotation, spring loaded lead blocks were sandwiched between two plastic sheets so that the gantry could rotate without the blocks moving. Before the MLC only rectangular shapes were treated as they were simple to create using diaphragms and jaws. Now however healthy tissue is far better protected by the MLCs better definition of treatment shape. This reduces the negative side effects patients receive as a result of their treatments and focuses on only the cancerous tumour, improving treatment results.

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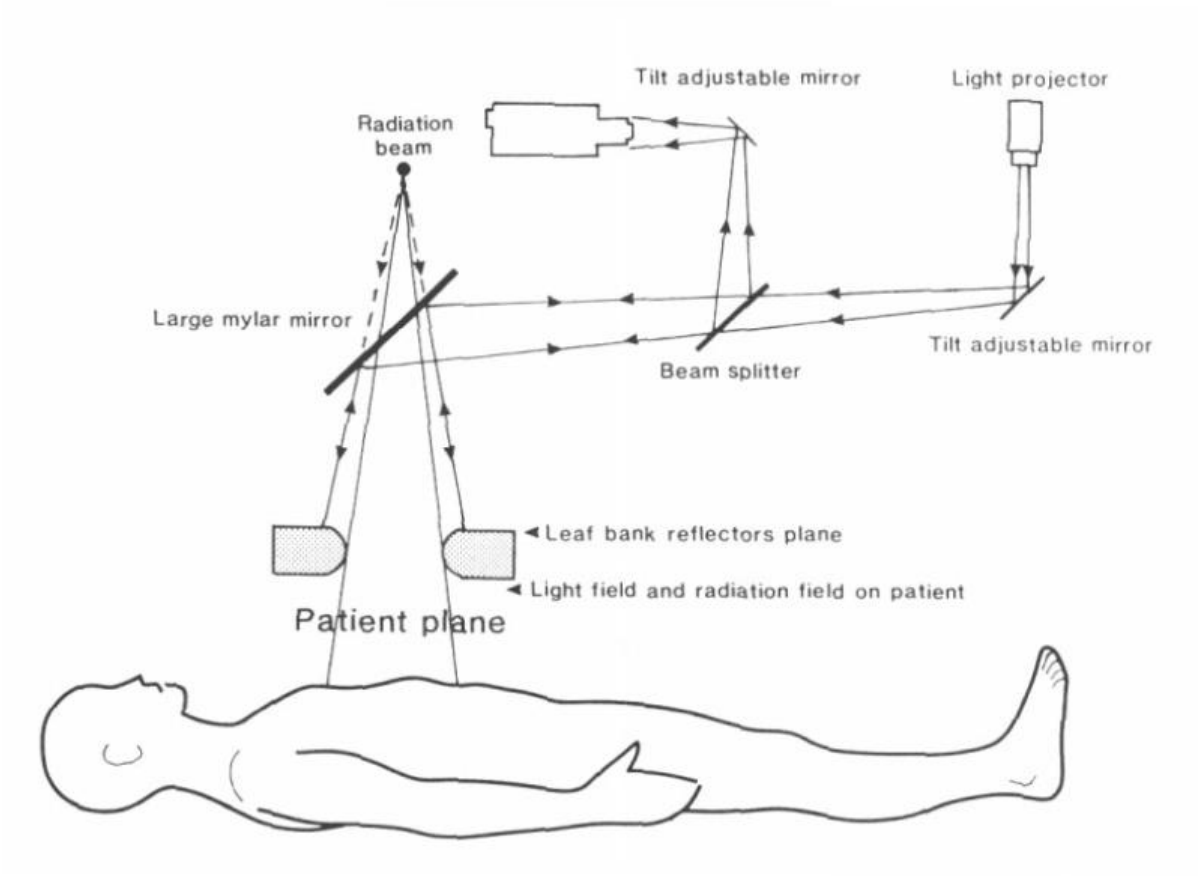

Figure 5. The optical arrangement for the video system used in leaf positioning.

The above screenshot shows a diagram of how the original optics system for the first Philips MLC worked. The overall system is very similar with only the type of light used being different. In the Agility MLC UV light is flooded into the MLC, however the earlier versions used visible light, from a light projector or halogen lamp. Reflectors were positioned in a similar way to that of the Agility however they were made from a material that reflected the visible light, rather than by fluorescing. The mirror is only a one way mirror and so light from the projector is transmitted through the beam splitter, but light coming from the reflectors (the other direction) is reflected into the camera.

An advantage of the new Agility system is that the user gets a much more defined field edge with the new green LEDs used. This is because the green light is more obvious than the white light used previously. This makes lining up QC test tools much easier and therefore I think that this would also apply for when the radiographers are lining up patients for treatment.

Varian MLC – (Used at [redacted] Satellite Centre)

The MLC used on a Varian Linear Accelerator uses a very different system. The MLC is made up of 120 leaves, 60 per bank. Rather than an optical system like the Elekta machines use, the Varian system uses pulse width modulation (PWM) to control each motor. Each leaf has its own individual motor, as does the Elekta version, however the position of the Varian leaves are determined by an encoder that calculates the pulses made to the motor, and can then calculate an accurate leaf position. Also, there is a back-up system that uses a soft membrane potentiometer system. A wiper connected to each individual leaf applies pressure to the soft membrane and then a voltage is generated and used to determine the position of the leaf.

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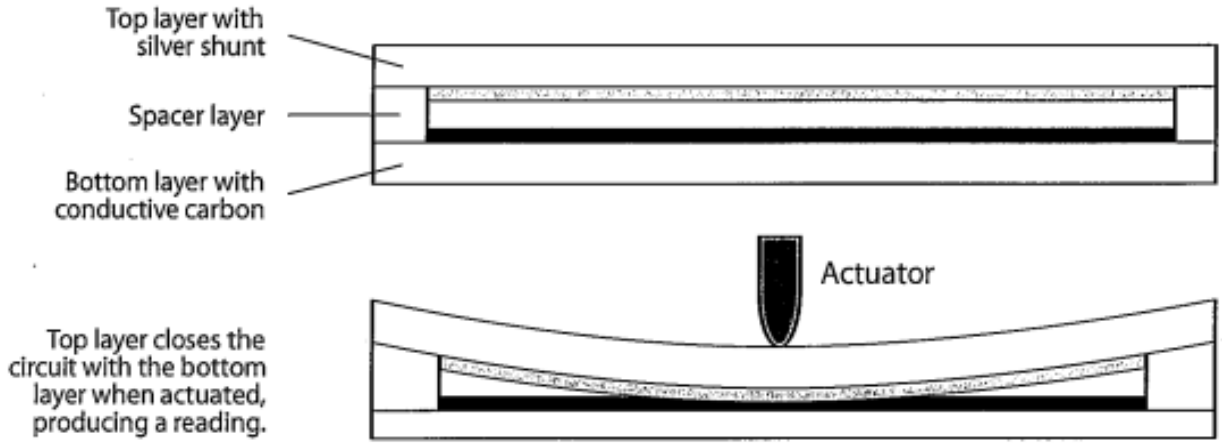


The above diagram shows a simple soft potetiometer system.

The potentiometer locks onto the leaf using an actuator system. Each leaf has an actuator made from beryllium and copper with a springy arm. On the end of the arm is a small plastic tip which actuates the soft pot, as shown in the diagram above. Before the actuators were used, a trailer hitch style system was used which connected the leaf into a hitch on the soft pot. The hitch would then push against the potentiometer so that the leaf position can be independently compared to the encoded PWM motors that drive and measure the position of the leaf.

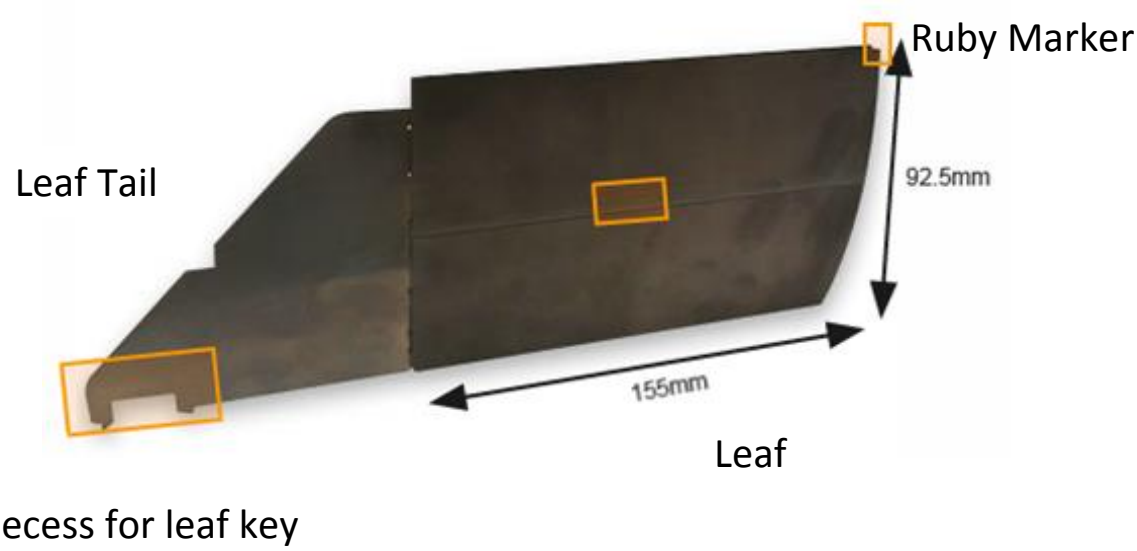
[redacted]

[redacted]

Section B – Contribute to the design, development, construction, commissioning, operation or maintenance of products, equipment, processes, systems or services.

B1- Identify problems and apply appropriate methods to identify causes and achieve satisfactory solutions.

Leaf Key Fault



The leaf tail is made from stainless steel to reduce manufacturing cost and to reduce the weight of the leaf and MLC overall. The leaf tail is never in the beam of radiation and so a less dense material can safely be used. The Ruby marker is flooded with UV light causing it to fluoresce, giving off IR light, which is then picked up by an infra-red camera in the optics system so that the control system can see at what position the leaf is, and then move it to the desired position when required.

The fault that I have been regularly seeing is where the leaf key snaps due to excess stress being put on it. The leaf key is designed to be the weak part of the system so that any collisions or excess stress cause this self-lubricating leaf key to break, rather than for a more major part of the assembly to break.

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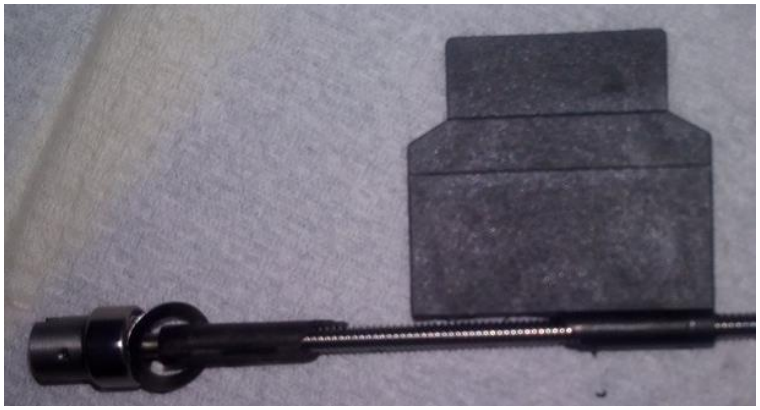

When arriving to a machine that has a leaf key fault, I am often told by the treatment staff that they have loaded a patient's prescription but that the machine has a leaf showing as out of tolerance. Another issue I have seen is that the leaf will move but very slowly, or that a leaf has jammed completely and will not move. To ensure that I am able to clearly identify the leaf causing the issue the machine can be taken out of the clinical mode and put into a service mode. This means that better diagnostic tools can be used to find the main cause of the issue. In this case the issue was that the leaf was stuck. Using the diagnostic tool in service mode I was able to select which individual leaf to drive, or to drive all of the leaves in one go.

To replace a broken leaf key can be quite a lengthy task as it involves stripping down a fairly complex assembly. The first step is to remove the covers to the head of the machine, this is where the MLC is located.

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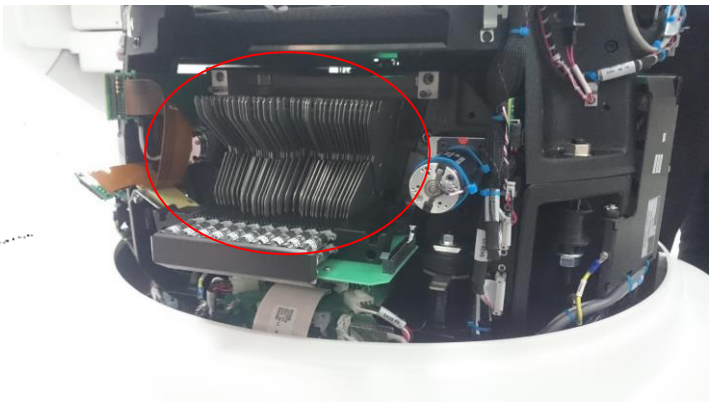
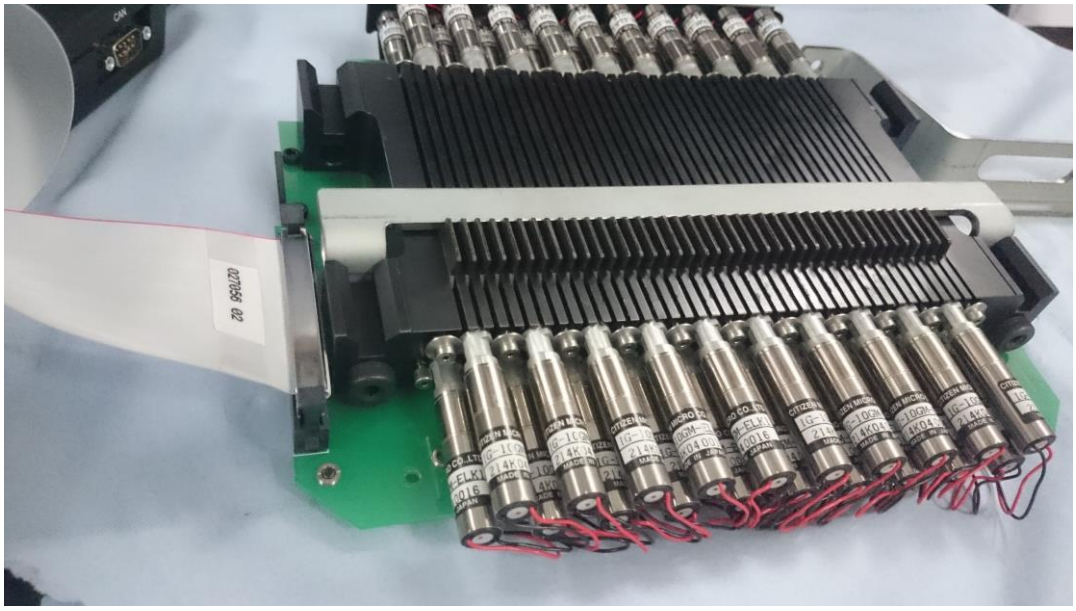


[redacted]

After removing the covers, which are held on by 4 Allen bolts or torques bolts, the MLC leaves can clearly be seen as shown in the above image. The MLC itself doesn't need to be removed. This is an advantage to the Agility system as only one of a possible four leaf banks will need to be removed. Using the diagnostic tool in service mode, I can identify which of the leaf banks needs to be removed. This is a great benefit as it saves causing any unnecessary damage to the rest of the MLC assembly. To remove the leaf bank with the broken leaf key, ribbon connectors and flexi PCBs need to be disconnected to ensure they are not damaged and they should also be put out of the way to prevent them becoming tangled up or broken in any way. Then a T shaped Allen key can be used to remove the large bolts holding the leaf bank in place. The T shaped tool needs to be used as a normal Allen key wouldn't be long enough to access the bolts. Once the bolts have been removed the leaf bank can carefully be lifted out, while taking extra care not to damage the PCBs or PCB cooling fans in the process. When lifting the leafbank out the leaves will come away from the leaf keys. These are not secured to each other as the key simply fits into the slot in the leaf.

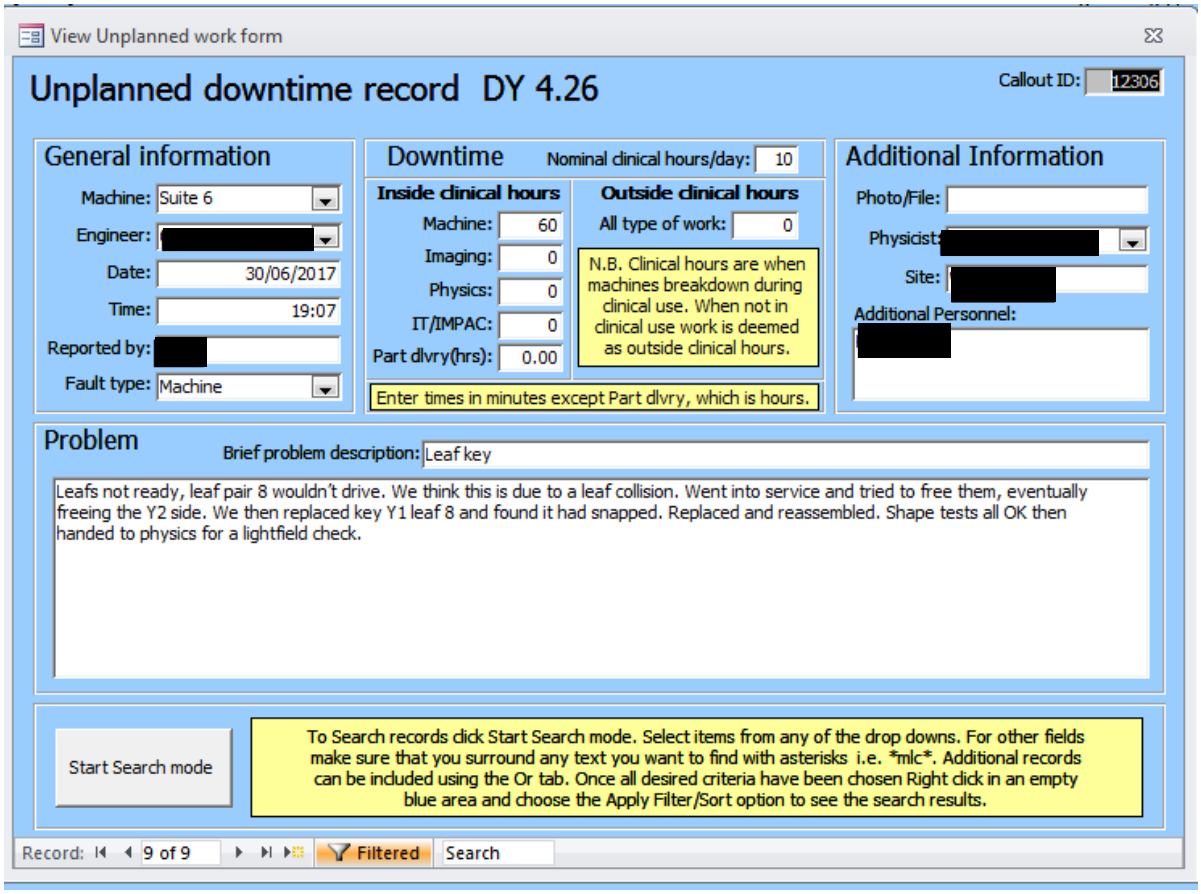


The leaf bank should then be set down onto a flat surface so that it can easily be worked on without putting too much stress on the PCBs as they could be damaged (shown in the image above). Each leaf and therefore leaf key has its own individual motor and gearbox which will need to be removed or the damaged leaf key. The motor turns a lead-screw which has the leaf key attached to it. The leaf key will then need to be taken off the lead-screw and a new leaf key put back onto the screw. To ensure the leaf key can move freely it is important to remove any debris, dust or excess grease from the lead screw and the track. The assembly can then be put back together in the reverse order.

After the machine has been reassembled it needs to be QC checked to ensure that the issue has been rectified and that no other areas of the machine have been damaged during the repair. This is done with a Physics test called a light field QC check. A member of the physics team or a trained

engineer is able to carry this out once they have been signed off as competent to do so. The test is done to ensure the MLC leaves are moving as they should, and to the correct position, ensuring that we haven't caused any accidental damage to the system during the repair. The MLC will also be run through a self-test to ensure the leaves are moving as they should and at the correct speed and to the correct position. This simply involves a number of shapes that test each leaf at all of the possible positions and only takes a couple of mins to complete. After this the machine can be handed back for clinical use. After every fault it is also very important that we record all of the details in our ISO9001 Quality System.

I have now worked on over 10 leaf key failures and so I feel I have become proficient at diagnosing and rectifying the fault. I have also trained new or less experienced members of staff on how to carry out the repair of this particular fault. Below I have included a screenshot of a database entry that I have made after attending a fault.



Due to the large number of leaf key issues we have been seeing, I have opened a case with the machines manufacturer to try and find out why it happens so often. To gather data, I have created a simple spreadsheet that should be updated by all of the engineers after they have seen an issue with a leaf key. I have included a screenshot below for one of the machines here at [redacted]. As you can see we have a high number of faults with leaf keys as this is just the data for a single machine, out of the 10 we have here. I think that gathering the data and opening the case with the machines manufacturer is a very important step in trying to fully resolve the issue to prevent downtime as much as we possibly can. It will also provide me with data that I can not only track, but make trends and see if there are any less obvious factors that could be playing a part in this issue.

[redacted]

F32

	A	B	C	D	E	F	G	H	I	J	K	
1	Suite 8											
2												
3		Date	Time in	Leaf Key Numb	Leaf Size (B	Patient Numb	Patient or Target Side (P	Gantry An	Head An	Treatment Techniq	Previous Patient Treatment Techniq	Extra Info
4		21/07/2016	15:32									
5		29/07/2016	14:45	Y1 76								
6		16/08/2016	15:00	Y1 74 ish								
7		08/08/2016	19:16	Y2 8								
8		19/08/2016	14:30	Y1 76			P			VMAT		
9		24/08/2016	16:57	Y1 8								Checked DLG couplings, found
10		26/08/2016	15:00	Y1 75								
11		14/11/2016	11:52	Y1 8								Case opened with Elekta
12		14/11/2016	18:56	Y1 76								Checked DLG couplings, found
13		20/10/2016	11:47	8								
14		24/10/2016	15:54	Y1 8								
15		25/10/2016	15:57	Y1 8								
16		23/01/2017	10:51	Y2 8								
17		31/10/2016	11:05	Y1 76								
18		08/02/2017	15:44	Y2 76								Also replaced adjacent leaf k
19												

While still gathering data, and still having quite a few leaf key faults, the machines manufacturer asked us to carry out a procedure to see what the spacing between the leaves was. This procedure can be seen below.

[redacted]

[redacted]

3.6 Check closed leaf separation gap

WARNING 3.3

Do not do work on the inner parts of the beam limiting device when the power is on. The power can cause the inner parts to move. If you ignore this warning, it can cause fatal injury.

WARNING 3.4

Do not look into the ultraviolet light without protective glasses when the Agility BLD covers or crosswires screen are removed. If you ignore this warning, it can cause serious injury to your eyes.

1. Rotate the gantry to 180°.
2. Load **Leaves Only** (**30 x 30**) shape.
3. Select **MLC**, then **Diagnostic Control**., move the diaphragms to their outer limit.
4. Undo all 8 T10 Torx screws securing the crosswire screen to the BLD accessory ring.
5. Remove the crosswires screen.
6. Use feeler guages to measure the closed leaf gap on both sides of the shape.
7. Calculate the average measured closed leaf gap.
8. Calculate the difference between the average measured closed leaf gap and the nominal 1 mm closed leaf gap.
9. Adjust **Item 2009 Leaf Control** part 132 so that the closed leaf gap is 1 mm.
   For example, if the average measured closed leaf gap is 0.8mm, increase part 132 by 0.2.
   The value entered is in mm.
10. Save the MLC Calibration.
11. Log out of Service mode, then log back in to reload the calibration data.
12. Reload **Leaves Only** (**30 x 30**) shape, then measure the closed leaf gap again.
13. Repeat steps 6 to 12 until the average measured closed leaf gap is 1 mm.
14. Refit the crosswire screen.

Procedure given to me by the Elekta Helpdesk team from an Elekta Agility Installation Manual.

I requested that all of the engineers here at [redacted] were aware of the issue so that they could then gather data for their machines on a service day. This will then be very useful data that can be fed back to the manufacturer allowing them and ourselves to come up with a solution or idea.

[redacted]

[redacted]

From: [redacted]
Sent: [redacted]
Subject: Leaf Speration Gap

Hi all,

As part of the Leaf key case currently open with Elekta, they have requested that we carry out the procedure attached. I have added it to the pending list on all agility machines. [redacted] has suggested it will be better to do this as part of a service day as it is quite lengthy and requires crosswire removal and physics checks after.

Please speak to [redacted] or myself once you have some results.

Thanks,

[redacted]

This procedure is still currently being undertaken, but I have found this to be a good opportunity for me to personally develop as I have taken the lead in training new members of staff and current members of staff in how to find and solve this fault, I am currently, along with my managers, leading the case and moving it forwards so that a solution can be found as soon as possible so that downtime is minimised, it can take well over an hour to replace a leafkey in some instances including the physics QC tests carried out afterwards. I also plan to bring up this issue, by means of my manager at a User Group Meeting for the machines, to see if any other centres have had similar issues or to see if anyone else has any knowledge or ideas that may help. This will also help me to develop working relationships with other engineers that are in the same field as myself, and therefore if we have other large scale faults or issues in the future it will be helpful to have this greater knowledge and experience to call on if needed.

Safety

UV light can be damaging to human eyes and therefore when working on the equipment we must follow specific guidelines. Once the machine head covers are removed and the power to the head is still on, we wear UV protection goggles. This is important as even when not staring directly at the UV LEDs it is still possible the optics system could cause issues to the human eyes. When investigating and repairing a leaf key issue, the engineers such as myself need to look into the head to identify any damage to the leaves. The best precaution we can take, however is to turn off the power to the head of the machine. This is very easy as it means just pulling out an IEC plug. The UV can also be turned off using a rocker switch, again this would be a better option that the goggles because if someone were to come into the room without goggles they could potentially be affected. If the power and/or UV is off then this won't be an issue.

[redacted]

[redacted]

B2- Identify, organise and use resources effectively to complete tasks, with consideration for cost, quality, safety, security and environmental impact.

Quality System Work Instruction Updated and Amended

I have updated a procedure that had previously been written by another of the engineers in my department. The procedure was a step by step on how to configure a medical imaging PC as an image transfer database using the medical protocol DICOM (Digital Imaging and Communications in Medicine). The reason for doing this is that once the medical imaging PC becomes old or obsolete, it can still be used for another purpose, which will cut down financial costs of having to buy a new PC, but it will also be better for the environment as more use is gained from the PC before it is decommissioned and scrapped but still useful enough to help me to complete a task. In reference to ensuring I kept to the patient confidentiality NHS policy, I ensured that the hard disk was wiped of all patient data that it may have contained. Similarly when disposing of an old hard drive I will ensure that it is destroyed beyond repair so that no one can access the patient data contained on the device. This could involve drilling through it or sawing it in half depending on the device being disposed of. It will also then be disposed of following the WEEE Regulations.

I felt that it was very important to update this work instruction procedure as in its old form, detail was lacking. I think that the reason for this is that the previous engineer had written it from memory rather than as a step by step procedure, written alongside carrying out the procedure showing any pitfalls and potential solutions. This procedure also needed to be updated to the best possible version as it is a Level 3 document in an ISO9001 Quality System. If the procedure wasn't easy to follow, or correct then this would make the procedure more difficult and the results might not have worked as intended. The ISO9001 QS is controlled and therefore any procedures on the QS are the final version that must be followed. The quality system is also audited regularly to ensure that it is up to scratch.

Issued by: [redacted]

Issued by: [redacted]

The first version of the document contained the initials of the manager who released it, along with the initials of the engineer who wrote the procedure. This has since been updated to my initials to reflect the changes that I have made.

Below is the updated procedure that I have created and had added to the quality system.

[redacted]

[redacted]

Technical Services Quality Manual.	TS.3.138
Work Instruction for Configuring an iView PC as a Dicom Transit DB	

Configuring an IView PC as Dicom Transit DB

1. It is essential that before connecting to the network that the pc is checked for any viruses (run KidoKiller, see TS.3.16e Appendix job 23) and check that it has the latest version of Kaspersky AV installed, this scans set to run out of hours.

2. The HDD should be partitioned into two partitions C: (48.8GB) and D: (184GB) with IView GT installed on the C: drive. When opening iView there may be an error message saying there is a license key required. This will automatically be found once the PC is plugged into the network when being tested.

3. If the current Dicom DB is on line then it is important that the PC being configured is not connected to the Network. Set up one of the LAN ports as DHCP to get necessary files from the network (from the W:\) and set up LAN2 as the IP address [redacted].

4. The following folders **dicomdb**, **Merge** and **MERGE.INI** should be copied from **W:\Dicom**, to **C:\iView\.** The host files from the current transit database PC will also be needed. **C:\Windows\system32\drivers\etc\hosts.**

5. Copy the **DICOM_db folder**, from **W:\Dicom**, to **D:**, ensure that it is shared.

6. Copy the **dicomdb** folder from **W:\Dicom**, to **D:\iView\.**

7. *The PC being configured needs to be set to allow Dicom to run automatically on boot up, to set this up navigate to:*

   C:\Documents and settings\All users\Start menu\Programs\Administrative [redacted]

   *This opens up the **Services** window.*

8. *Navigate to **DCOM Server Process Launcher** and double click; this opens the **DCOM Server Process Launcher** window.*

9. *In the **Display Name** text box check 'DCOM Server Process Launcher' is displayed.*

10. *In the **Description** text box check 'Provides launch functionality for DCOM services' is displayed.*

11. *In the **Path to executable** text box check **C:\WINDOWS\System32\svchost-k DcomLaunch**, is displayed.*

12. *From the drop down menu select **Automatic**.*

13. *Click **Apply** then **OK***

14. Repeat steps 8-14 for **iViewDicomStorageSCP**. (The description may be left blank.)

[redacted]

Technical Services Quality Manual.	TS.3.138
Work Instruction for Configuring an iView PC as a Dicom Transit DB	

To test:

Change the Host Name of the PC to iview-dicom, and ensure that the LAN not used for the W:\ network connection has the IP address set to [redacted].

Disconnect the current Dicom pc from the network (if not already done) and connect the replacement, contact Planning and ask [redacted] to send an image, to see if this is visible go to another iView station and check that is available.

The main reason that the procedure really needed to be updated was mainly due to the fact a 'hot swap PC' was required. This means a PC that is ready to go, should an issue or fault occur with the one in use currently. If a hot swap is ready to go then this will minimise the downtime caused. The database is a requirement in training purposes for clinical staff and so is quite important. It can also be used clinically therefore if the PC were to break, it is much better to already have one that is ready to go rather than trying to set one up in a rush or the heat of the moment. The detailed and up to date procedure needed to be in place to ensure that if I wasn't present, someone else would be able to pick up the final stages of setting up the database in place, should they have needed to.

Brachytherapy UPS Battery Replacement

Another task that I was set was to replace replace a faulty UPS that is used on a Brachytherapy treatment machine. When trying to repair the UPS I discovered that the fault was that the battery no longer stored its charge. This also meant that the UPS would still work fine if the battery was replaced. Therefore rather than buying a new UPS and disposing of the old one, I was able to save on costs by not needing to purchase the new entire unit. Another area in which this was good, is that the UPS wasn't thrown into landfill as it could still be used, therefore this was also the better option for the environment. When it came to disposing the old battery I made sure to dispose of it in a suitable way. This meant I followed the WEEE (Waste Electrical and Electronic Equipment Recycling) Regulations. This involved ensuring that the battery was disposed of in an approved battery bin which would be collected by a company who specialise in recycling batteries. The battery I was disposing of contained lead and therefore as this is toxic and can damage the environment if sent to landfill, it was very important to dispose of it properly. The WEEE section of the refuse area at [redacted] is locked and therefore only autherised people who use electrical equipment can enter the WEEE compound.

When ordering the new battery I can only use suppliers from an approved list. The first place that I checked for the new UPS battery was on the [redacted] website as they usually have a good range of all products. I found the exact battery to replace the old one:

[redacted]

Before ordering the battery from [redacted] I decided to check other suppliers for batteries of the same physical size and rating so that I could see if this was a good deal or not, then if I found a better option I could order that instead, saving on the financial costs. Another approved supplier I found was recommended to me by a colleague who had used them in the past. When checking this company, I found an alternative battery at a much cheaper price. As you can see below the battery is of the same type and rating and at a substantially cheaper price. I have learnt from this as I now know that I should always check more than one supplier so that I can ultimately save the NHS money on items I need at work to carry out my job. This could also involve other parts, PPE and tools that I use. Saving resources in the workplace is very important, especially in some organisations such as [redacted] which gets some of its funding from charity work, therefore making the most of the money is extra important.

After replacing the UPS battery I tested it to ensure that it worked as it should. The UPS can now be put back into service, having minimalized the costs of the repair, by not having to buy a new unit and scrap the old one, but by simply replacing the battery.

[redacted]

[redacted]

[redacted]

Dear [redacted],

Thank you for your enquiry – please find our quotation below.

Quotation for : [redacted]

Contact: [redacted]

Date: 16/8/17

Quote Ref: [redacted]

Account:	[redacted]
Part No:	EE400258
Description:	APC RBC2 UPS / Compatible Battery
Order Quantity:	1
Price EACH:	£17.49
Price Validity:	Price valid for 30 days from date of this quotation
Availability:	Currently 1-2 weeks

Image:

[redacted]

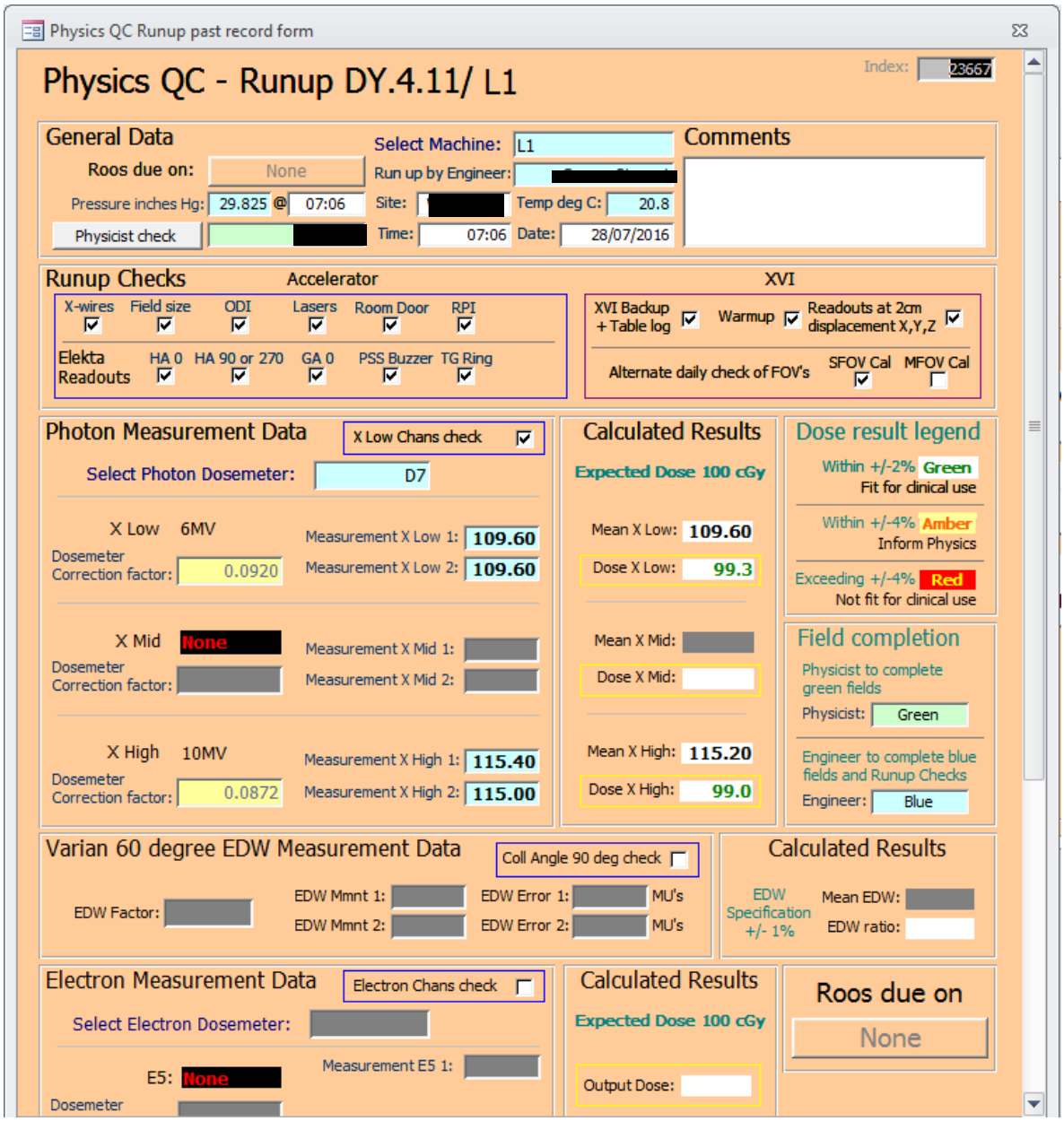
Section C – Accept and exercise personal responsibility.

C1 - Work reliably and effectively without close supervision, to the appropriate codes of practice.

Linear Accelerator Run Up Procedure

One of the areas of my job role in which I work unsupervised is when conducting a run up of a Linear Accelerator. This is a procedure that involves carrying out daily checks and tests on the linac before it is ready for clinical use. I conduct the run up on my own and therefore have the responsibility in making sure the machine is fit for clinical use within the permitted 1 hour time slot. With the aid of the Physics QC database there is a checklist which involves both manual movement checks along with safety checks and dosage checks on the machine. To ensure that I was competent to fulfil this role, I was trained by other engineers and signed of in the competency section of the ISO9001 QS.

Figure C1.1 below shows a run up form that I have completed unsupervised. There is both a tick box checklist and a section for recording dosages. It is important that all of these checks are carried out before the machine can go clinical.

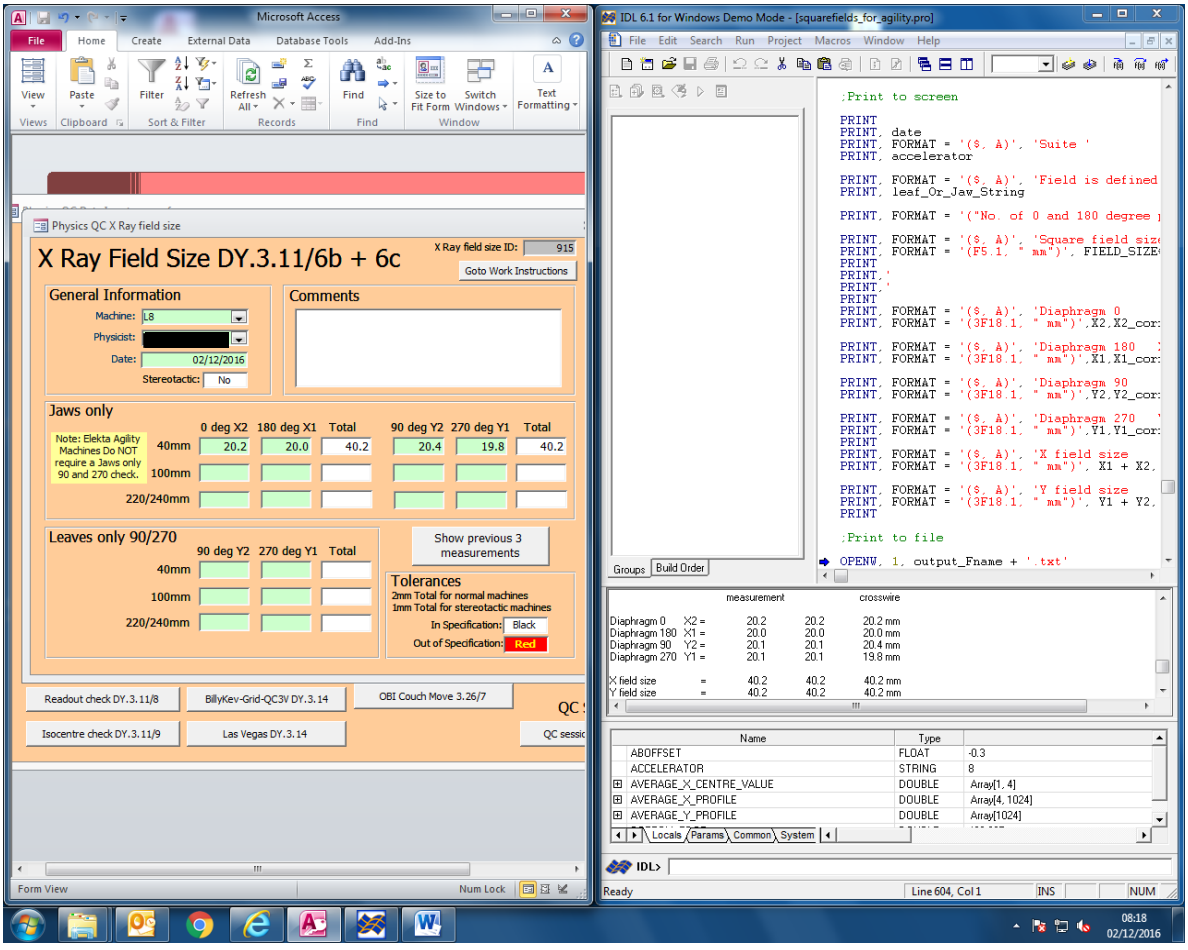


[redacted]

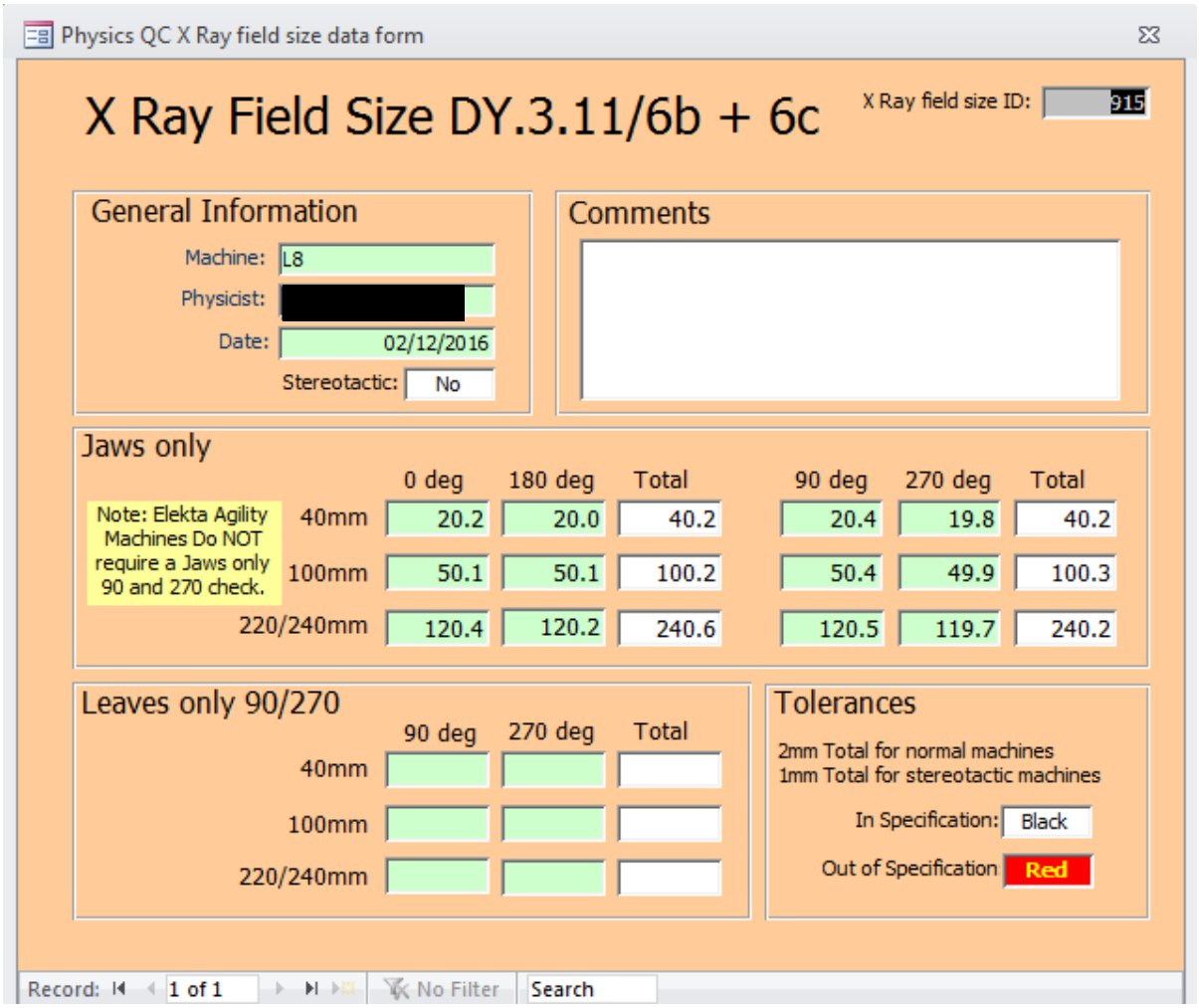
X-Ray Field Size QC

One of the planned QC tasks we carry out is to ensure that the dimensions of the X-ray field size made by the machine, match the size set out by the software. The image below shows the software programme called IDL which is used to analyse the QC images I took. On the left hand side is the QC database entry form that must be filled in with the results after the QC job has been done. This database allows the results to be tracked so that trends and relationships can be found, along with using the data for fault finding and tracking issues.

On the right hand side is the sodtware programme used to analyse the images. This is called IDL and has been coded by members of the physics team to ask for certain details such as the machine number and where the images to be analysed are located. Once it has all of the required information the programme gives a set of results in the form of a table.

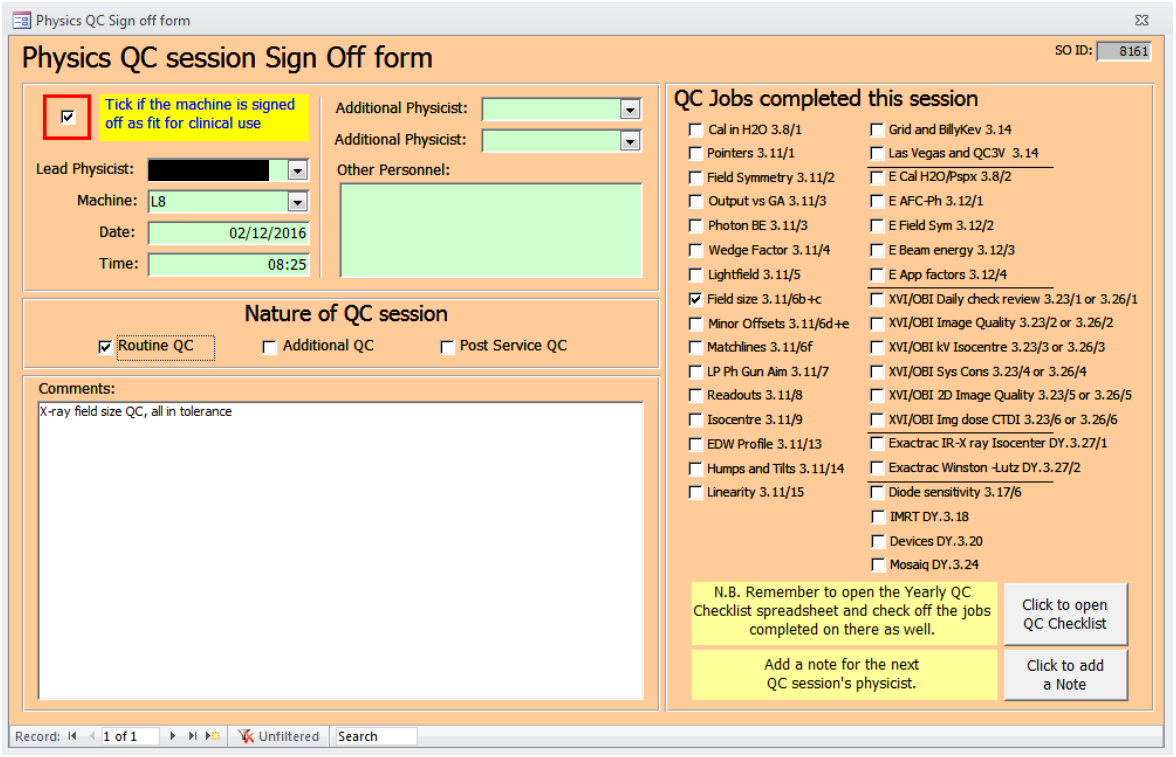


[redacted]

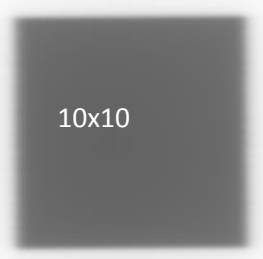


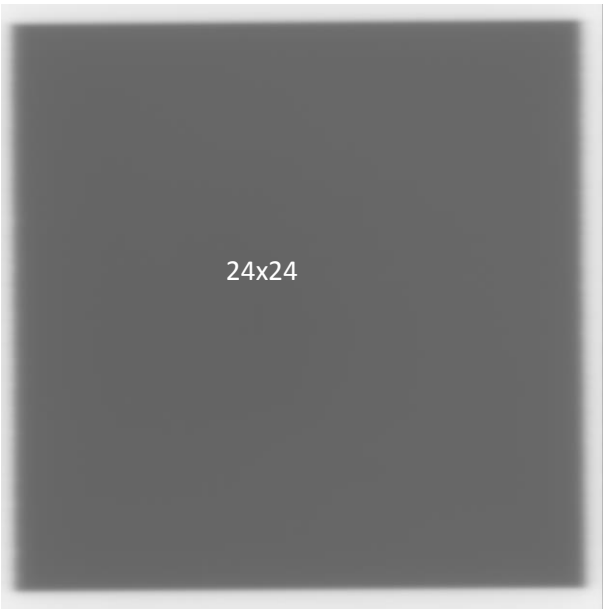
Once I have added the data from the QC job that I have carried out into the Physics QC database, it is my job to ensure that the results are within a set specification, outlined by a Medical Physics Expert in accordance with the machines manufacturers guidelines. Once I am happy the machine is in a state that is fit to be used clinically, and ensuring that the QC has been passed, I am able to sign the machine over for clinical use. The form shown below is used to sign off a QC session as completed, also showing what QC job(s) have been done. If I find any results that are not in the required specification tolerances then it is my duty and responsibility to report this to a member of the physics team who can then investigate the issue, or refer it back to the engineering team if they feel it is an issue with the machine. I would also then leave the decision down to the physicist as to whether they felt the machine was fit for clinical use and so I wouldn't click the tick box.

[redacted]



This shows all 3 of the field sizes that we take an image of during the QC test. We do this to ensure the field sizes are accurate at all sizes, to ensure the leaves are exercised to a good range of motion – also checking at various sizes looks for both Offset and Gain errors. The sizes are already loaded into a program used to run patients prescriptions. After taking an image of each of the sizes at both head angle 0^{o} and 180^{o}, software called IDL can be used to analyse the images accurately to determine the true result of the field size. This is an important test because if the field size was too big, the patient is likely to receive a higher dose of radiation causing an extra risk to the healthy tissue surrounding the tumour, and longer lasting side effects. Also if the field size is too small then the tumour won't receive the required dose to give maximum benefit to the patient.





[redacted]

[redacted]

C2 - Accept responsibility for work of self or others.

Linear Accelerator QC

In accepting work for myself, I had to be signed off as competent to carry out the work, before being allowed to carry it out unsupervised. Once a more senior member of staff had observed me carrying out a task and deemed me to be competent, a member of the physics team could sign me off in the competency database that we have here at [redacted] As you can see below I have now been signed off for a number of QC jobs and so I can now carry these out on my own, unsupervised. Once signed off, and countersigned by myself, it is my own responsibility to stick to the procedures that are used as a part of an ISO9001 Quality System. I therefore have to accept responsibility should anything go wrong in a QC job I am carrying out.

Competencies for : [redacted]

DY 2.04 Linear Accelerator Inspection & Testing

Ref	Description	Supervisor	Date	MySignature
2.07,2.08,3.11/5	Light Field Size	[redacted]	24/07/2018	02/01/2018
2.07,2.08,3.11/12	EDW Profiles in Water			
2.07,2.08,3.11/13	EDW Profiles v Gantry Angle			
2.07,2.08,3.11/14	Photon Error Signals			
2.07,2.08,3.12/4	Electron Applicator Factors			
2.07,2.08,2.10,3.17/6	Diode Sensitivity	[redacted]	24/07/2018	18/04/2018
2.05, 3.08/1	Output check at photon energies		24/07/2018	14/03/2018
2.05, 3.08/2	Output check at electron energies		24/07/2018	14/03/2018
2.05	Output check using QuickCheck devices			
2.05, 3.08/1	Recalibration of output at photon energies			
2.05, 3.08/2	Recalibration of output at electron energies			
2.07, 2.08, 3.11/1	Pointers	[redacted]	24/07/2018	18/04/2018
2.07, 2.08, 3.11/8	Digital readouts			
2.07, 2.08, 3.11/9	Isocentricity of movements			
2.07, 2.08, 3.11/2	Photon beam symmetry			
2.07, 2.08, 3.12/2	Electron beam symmetry			
2.07, 2.08, 3.11/3	Photon beam energy	[redacted]	24/07/2018	14/03/2018
2.07, 2.08, 3.12/3	Electron beam energy			
2.07, 2.08, 3.11/4	Wedge factor			
2.07, 2.08, 3.11/4	Wedge factor at all gantry angles			

Competencies for : [redacted]

DY 2.04 Linear Accelerator Inspection & Testing

Ref	Description	Supervisor	Date	MySignature
2.07, 2.08, 3.11/6	X-ray field size	[redacted]	24/07/2018	14/03/2018
2.07, 2.08, 3.11/6	Minor offsets			
2.07, 2.08, 3.11/6	Matchlines	[redacted]	24/07/2018	16/03/2018
2.07, 2.08, 3.11/6	X-ray field size measurement using film			
2.07, 2.08, 3.11/7	Magnetron and phase control tuning - photons			
2.07, 2.08, 3.11/7	Magnetron and phase control tuning - electrons			
2.07, 2.08, 3.08/1	Photon output in water			
2.07, 2.08, 3.08/2	Electron output in water			
2.07, 2.08, 3.12/3	Electron energy checks in water			
2.07, 2.08, 3.14	EPID checks - grid/billykev	[redacted]	24/07/2018	14/03/2018
2.07, 2.08, 3.14	EPID checks - qc3V/las vegas		24/07/2018	14/03/2018
2.07, 2.08, 3.11/15	Linearity			

[redacted]

Bi Weekly CT SIM QC

At [redacted] we have 2 Phillips Brilliance Big bore CT Scanners. As part of the planned maintenance shedule the machine needs to be calibrated at least twice a week. The main job we do is called an Air Calibration. This involves calibrating the machine during the day while it is at operating temperatures and while the air pressure is consistent with that of when the machine is being used for treatments. The air cal consists of the scanner taking 69 images of just the air so that it has a reference to compare clinical images to. It is a way of measuring background noise or radiation so that this will not be picked up during a clinical image, potentially causing an obstruction or lower quality in image.

Another of the QC checks done twice a week per machine is the Quick IQ Check. This involves setting a phantom onto the bed and lining it up to the lasers. The main idea of this test is to ensure that the Lasers and X-rays are lined up correctly. If the lasers are out of tolerance, then the scanner will fail the test, indicating which laser isn't lining up as it should. The automatic test also measures a number of parameters shown in the results below such as the contrast visibility, calculated by the software automatically. When the test is passed a table of results is generated which can then be added to the database so that they have been properly recorded. The screenshot below shows a database entry of the results.

[redacted]

[redacted]

CTSim QuickIQ form

CT Sim Quick IQ check

ID: 1576

General data

Date: 05/01/2017

Select CTSim: CT Sim 1 [redacted]

Select Eng Name: [redacted]

Measurements				
CT Number	Maximum:	1.5	Allowed Max:	4.0
Units CT	Average:	1.5	☑ Pass	
	Minimum:	1.4	Allowed Min:	-4.0

Measurements				
CT Uniformity	Maximum:	1.4	Allowed Max:	4.0
Units CT	Average:	1.2	☑ Pass	
	Minimum:	1.1	Allowed Min:	-4.0

Measurements				
CT Noise	Maximum:	3.7	Allowed Max:	4.1
Units CT	Average:	3.6	☑ Pass	
	Minimum:	3.6	Allowed Min:	3.3

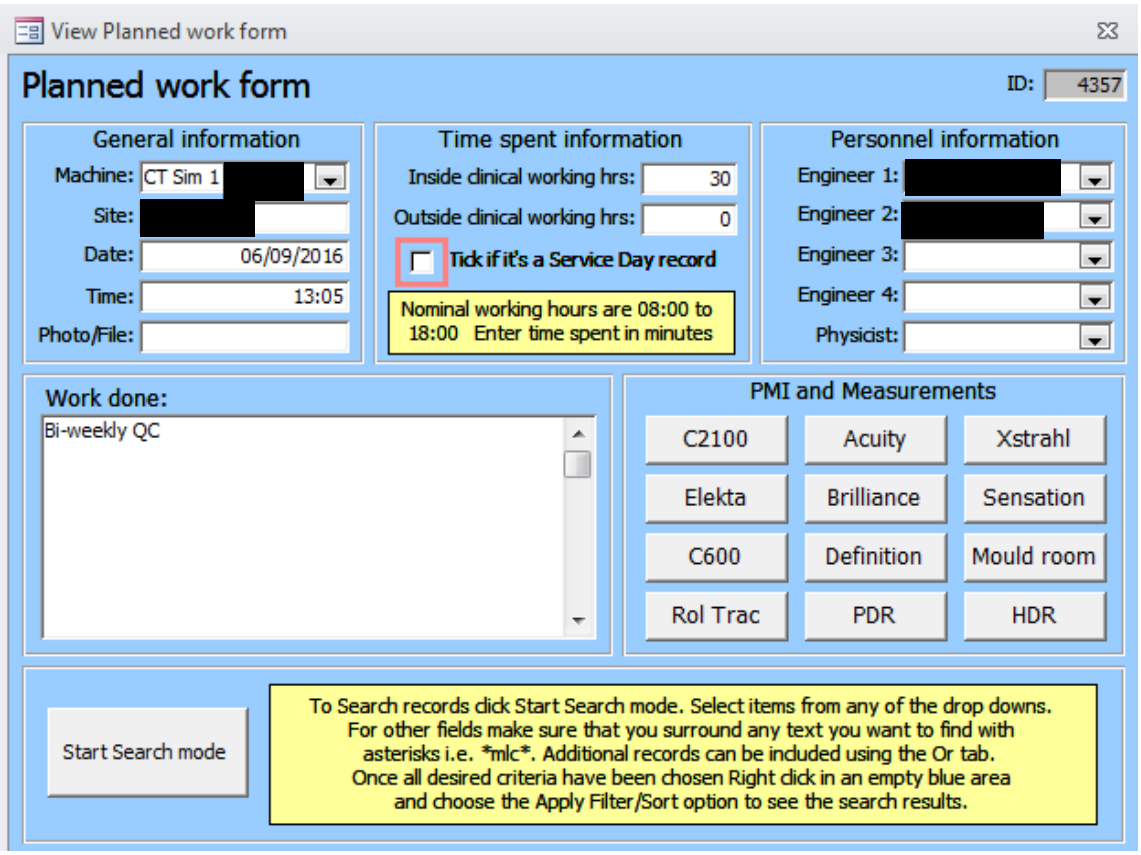
Measurements				
CT Low Contrast	Maximum:	5.0	Allowed Max:	5.7
Units mm	Average:	4.9	☑ Pass	
	Minimum:	4.7	Allowed Min:	3.3

The final bi-weekly QC check involves taking a scan of a phantom called the Tombstone. The main idea of this is to check the the bed is level. The process involves lining the phantom up to the lasers and taking a preset QA scan. The scanner takes a series of images, and then reconstructs them and the slice (individual image) where the holes in the tombstone can be seen is selected. Using the

crosshair tool on the screen, a straight line can be drawn to ensure that both ends of the phantom line up. Another quick check that can be done is to check the actual bed is level using the same method.

Once the QC has been completed it can be added to the database so that engineers time on the machine, along with a record of the jobs completed can be kept.

8	27/10/2016	[redacted]	1.08	Check Air calibration (Tue and Thur each week)
9	27/10/2016	[redacted]	1.09	Check Quick IQ/Tombstone

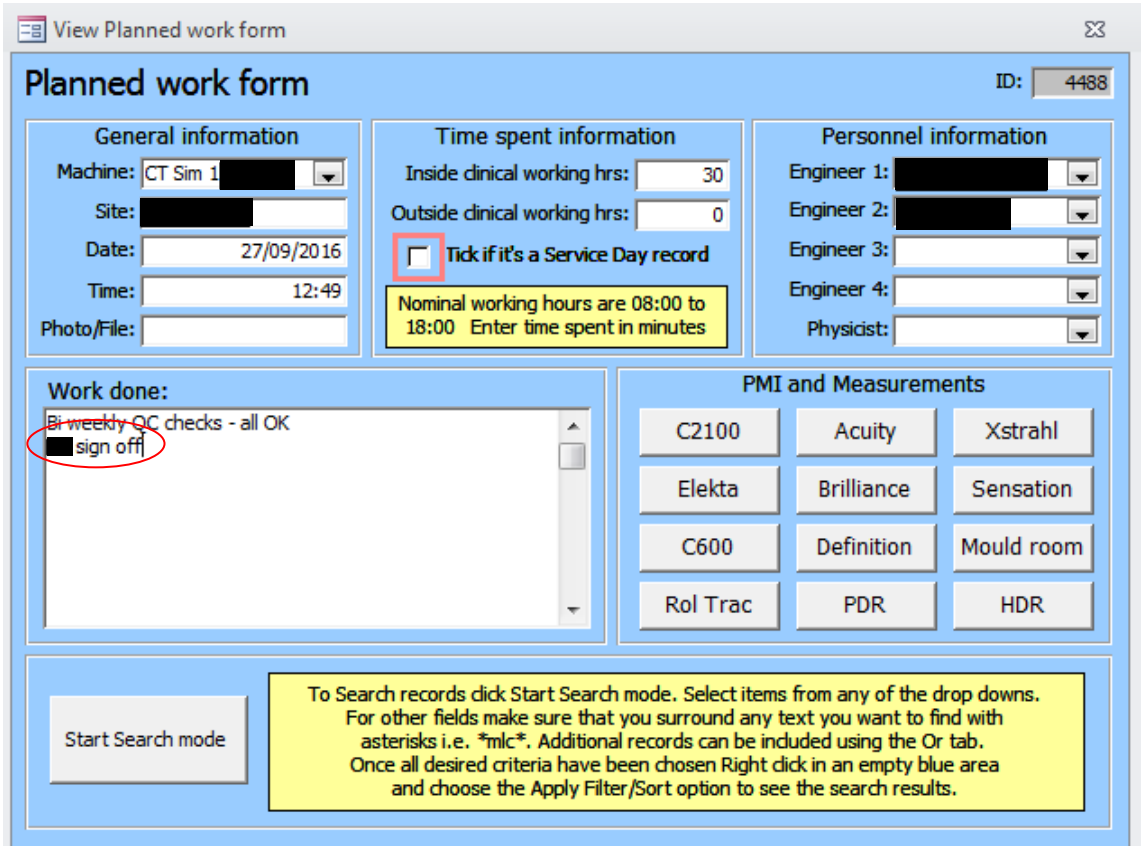


The image above shows a database entry while I was being trained. I observed the CT QC procedure and then was supervised carrying out the procedure by a more experienced engineer.

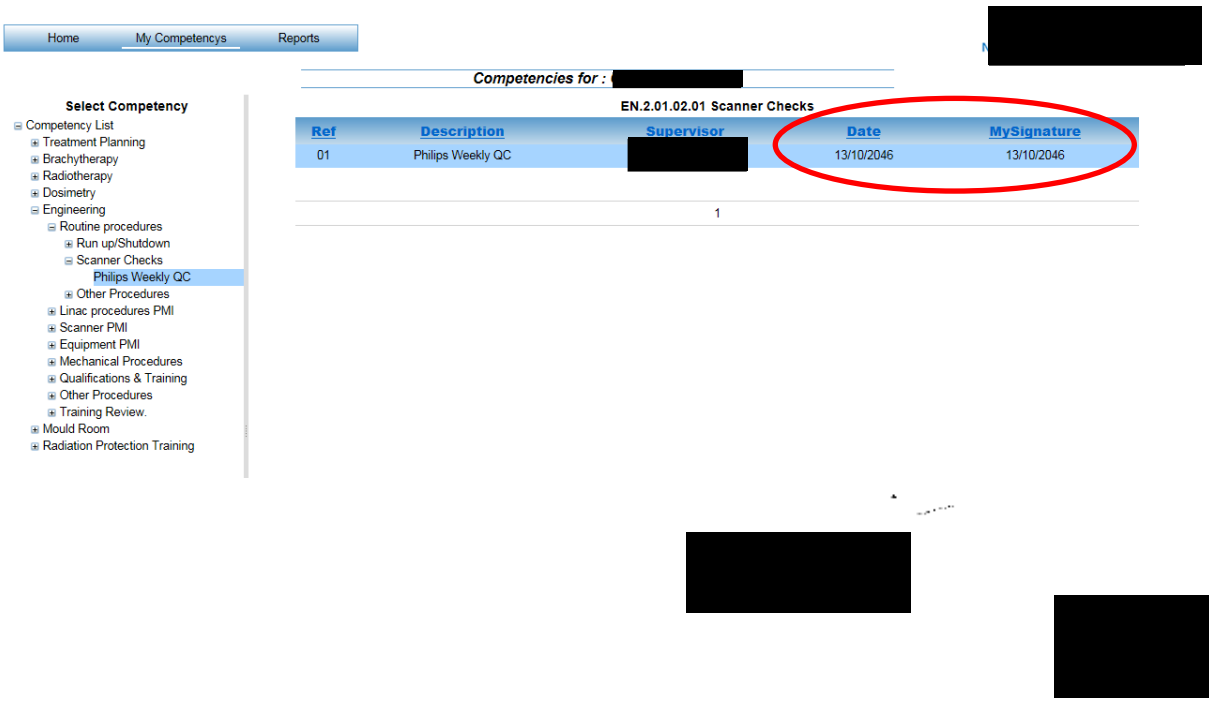
[redacted]

[redacted]

Planned Maintenance

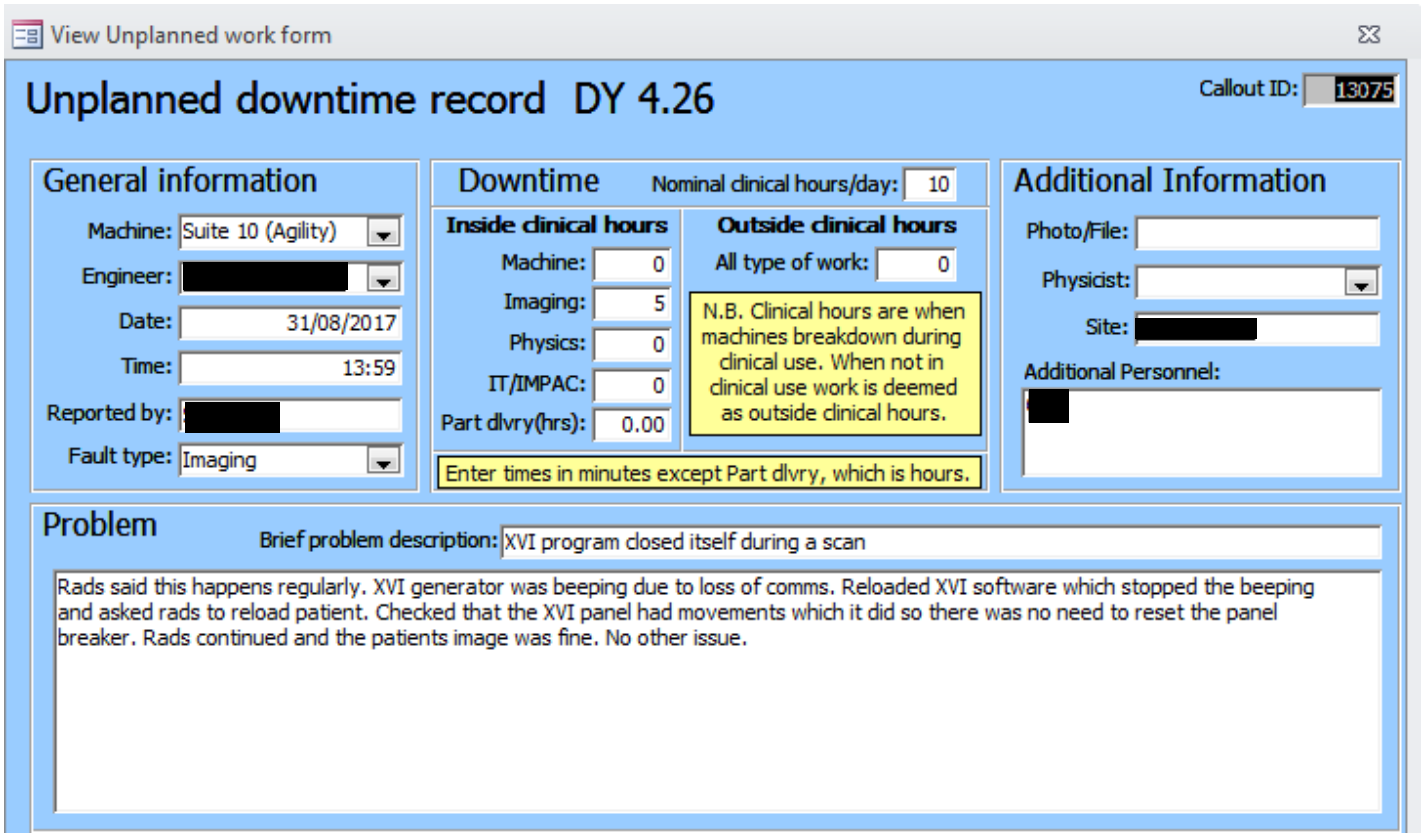


This time is when I carried the procedure out unassisted however with supervision from a more experienced engineer, the idea being that he could then see if I was competent or not to carry the procuedure out unassisted. He then decided that I was competent to be able to carry out the procedure on my own without supervision. I was therefore signed off in the Competency Database as shown in the screenshot below meaning that I can now carry out the CTSIM QC on my own.



Unplanned Maintenance

One of the main and most important parts of my current job role is to be the first line in responding to machine faults or issues. Throughout the clinical day, the radiographers call our workshop to inform us of any machine related issues and faults they have had. Some issues can be non-urgent and so a note can be made and a planned job or procedure carried out at a later, more convenient time. However if the issue is urgent, such as a major machine fault or breakdown, then we must act immediately to reduce downtime. Throughout my apprenticeship I have gained experience from attending call outs with more experienced colleagues and shadowed them on many occasions. After attending my manufacturer first line training course I am now able to attend faults on my own unsupervised. This involves taking responsibility for my own actions as I need to ensure that I am happy for a treatment to continue after I have reset or fixed a fault. I also now train new members of staff on some call outs so that they too can gain experience in common faults and how to fix them, along with how the machine works. I have included an example below of an unplanned callout to a machine that had a fault during a clinical treatment:

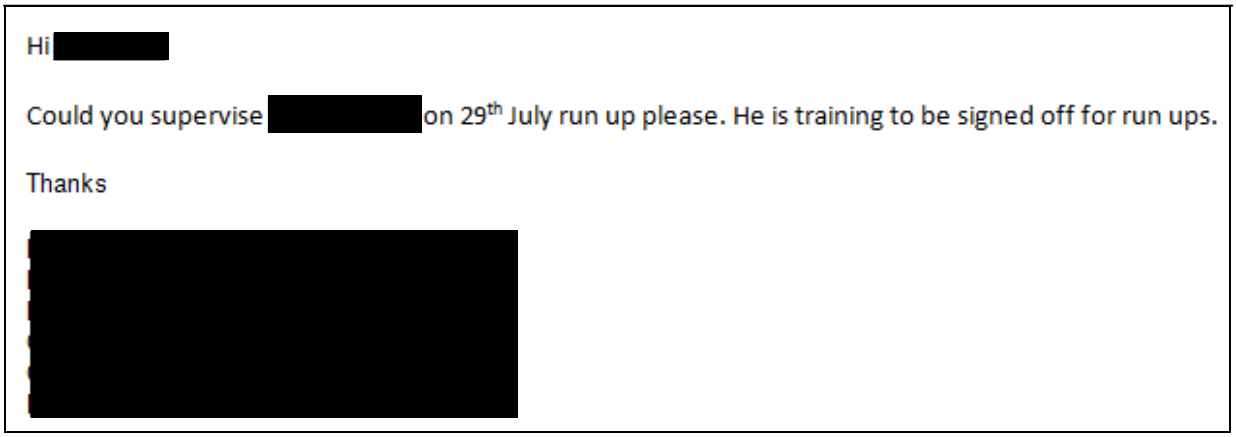


The database entry above shows a fault with the machines imaging system that I was called out to during a clinical treatment. It was important that I was quick about solving the issue, as there was a patient on the bed waiting to receive treatment, however it is vitally important that I was happy the machine was in a safe condition to continue, so as not to cause a mistreatment to the patient, and therefore an extra, unnecesary dose to them.

C3* - *Accept, allocate and supervise technical and other tasks.

One way in which I have been able to supervise a technical task was to be involved in training new starters in how to conduct the daily morning run up of a Linear Accelerator. This task involves the new starter shadowing me as I conducted the morning run up, and also carrying out some of the tasks himself while under supervision from myself. This allowed the new starter to see the procedure done numerous times, helping him to gain an understanding of how the task is carried out, and also allowing him to ask any questions he may have. The supervision also meant that he could become familiar with the computer systems used, how they are set out and where things are located in the bunker without having the responsibility for the task to be completed; therefore he could spend more time learning and developing new skills. Once the person had become more confident in the procedure of running up the machine, and they have gained more knowledge, my role changed to allow him to carry out the procedure on his own, while under my supervision as I will have to sign off the run up as completed to the correct standard. The reason for this is that the machine was still used clinically and therefore it was vitally important that the run up checks were all completed properly. Once the new starter has been supervised a few times, and it is decided that they are confident and competent to carry out the procedure, they can be signed off to do the run ups on their own, without supervision.

Figure C3.1- shows the email from the group manager requesting that I supervised the new starter on a morning run up, so that he can continue with his run up training. During the training of a new engineer, it is important that they are able to observe a process before they carry it out. That way, they can ask any questions they may have and also be taught the correct way to carry out certain procedures.

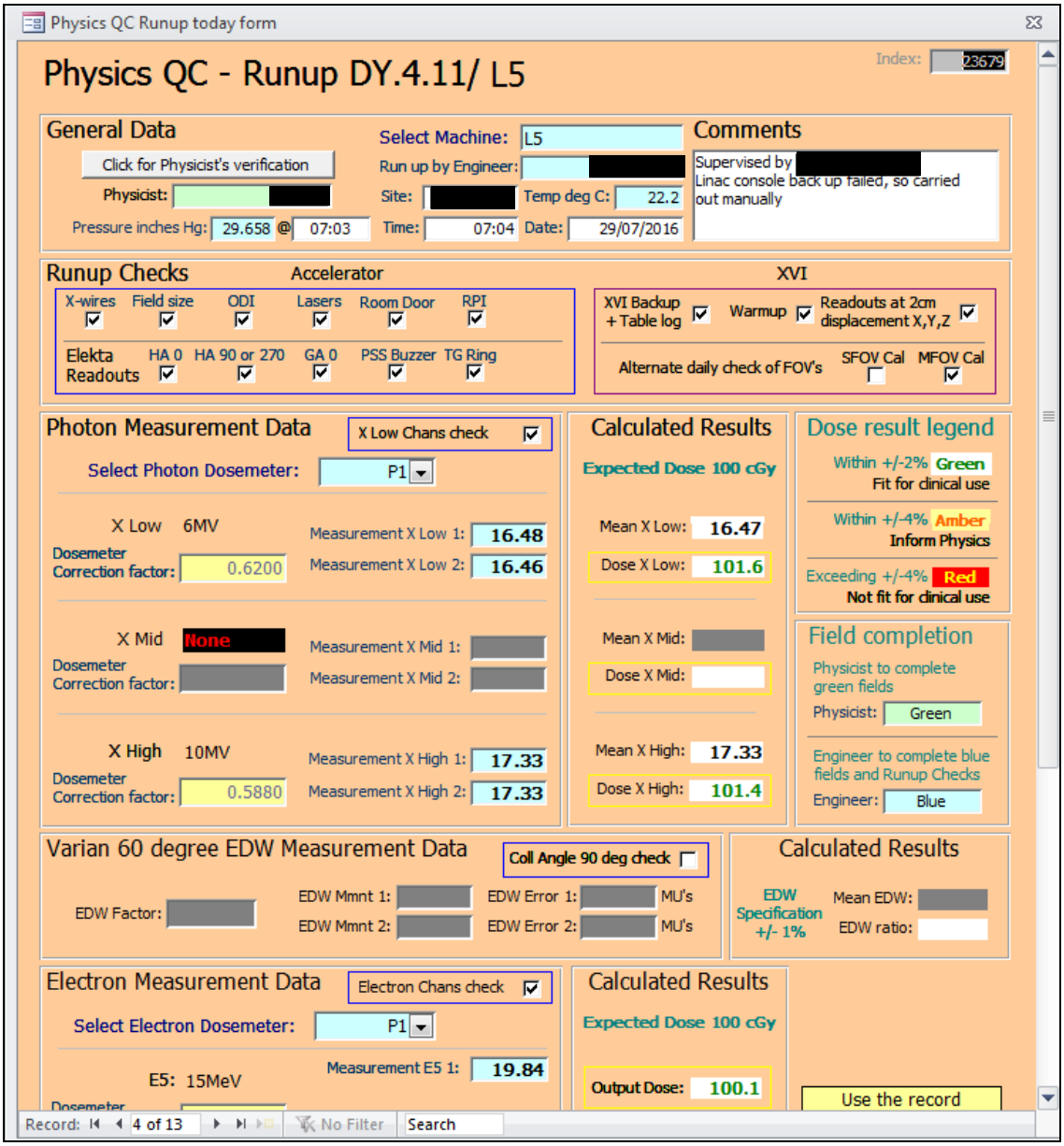

Hi [redacted]

Could you supervise [redacted] on 29th July run up please. He is training to be signed off for run ups.

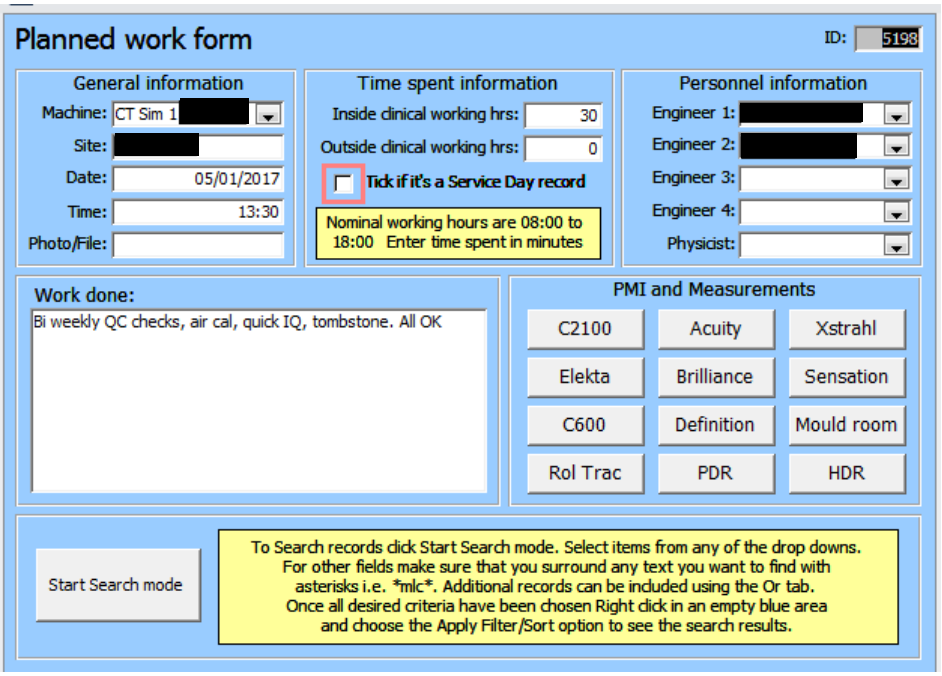
Thanks

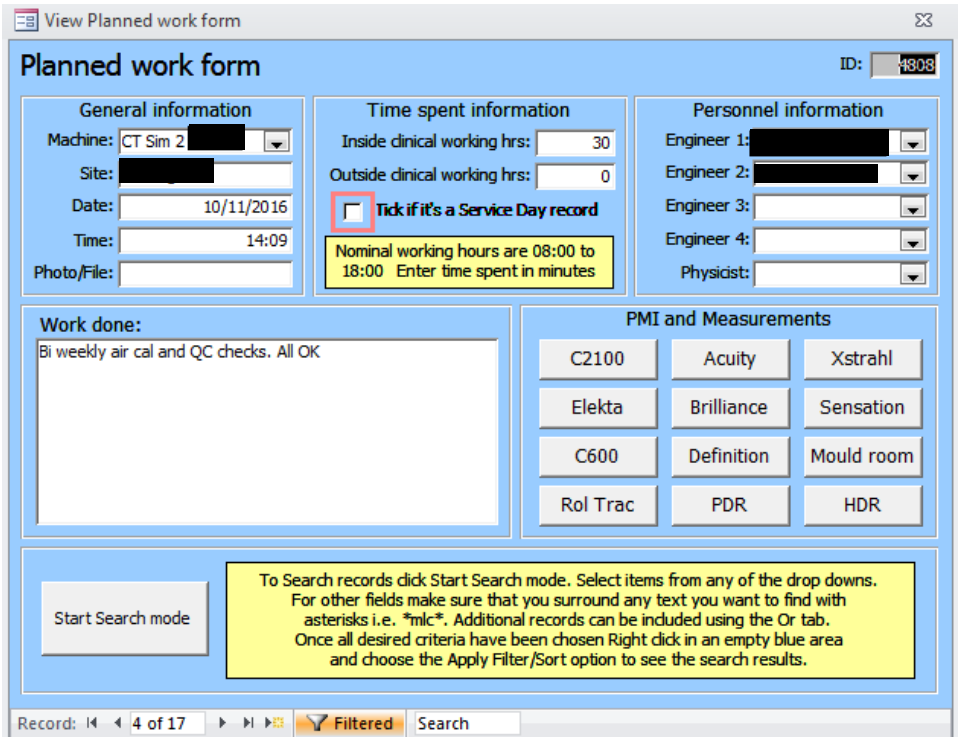
[redacted]

Figure C3.2- shows the completed run up form which I was responsible for ensuring the new starter had filled out correctly, and that all of the checks they had carried out were conducted properly. If there was an issue with this run up procedure I would have been held accountable as I was the person fully trained to carry out the task. This is part of the ISO9000 Quality System we use and is a level 4 document meaning that it is a means to input data into the quality system. The reason that this form is used is to ensure that if there was a fault or an issue with the Linear Accelerators output dosage then it can be flagged up before the machine is used clinically. Also if there is an issue then then it can be traced back to see if there are any trends or previous issues, and this form would provide us as engineers with a record of this.


Physics QC Runup today form
Physics QC - Runup DY.4.11/ L5
Index: 23679
General Data
Click for Physicist's verification
Physicist:
Pressure inches Hg: 29.658 @ 07:03
Select Machine: L5
Run up by Engineer:
Site:
Temp deg C: 22.2
Time: 07:04 Date: 29/07/2016
Comments
Supervised by
Linac console back up failed, so carried out manually
Runup Checks
Accelerator
X-wires Field size ODI Lasers Room Door RPI
Elekta Readouts HA 0 HA 90 or 270 GA 0 PSS Buzzer TG Ring
XVI
XVI Backup + Table log
Warmup
Readouts at 2cm displacement X,Y,Z
Alternate daily check of FOV's
SFOV Cal
MFOV Cal
Photon Measurement Data
X Low Chans check
Select Photon Dosemeter: P1
X Low 6MV
Dosemeter Correction factor: 0.6200
Measurement X Low 1: 16.48
Measurement X Low 2: 16.46
X Mid None
Dosemeter Correction factor:
Measurement X Mid 1:
Measurement X Mid 2:
X High 10MV
Dosemeter Correction factor: 0.5880
Measurement X High 1: 17.33
Measurement X High 2: 17.33
Calculated Results
Expected Dose 100 cGy
Mean X Low: 16.47
Dose X Low: 101.6
Mean X Mid:
Dose X Mid:
Mean X High: 17.33
Dose X High: 101.4
Dose result legend
Within +/-2% Green
Fit for clinical use
Within +/-4% Amber
Inform Physics
Exceeding +/-4% Red
Not fit for clinical use
Field completion
Physicist to complete green fields
Physicist: Green
Engineer to complete blue fields and Runup Checks
Engineer: Blue
Varian 60 degree EDW Measurement Data
Coll Angle 90 deg check
EDW Factor:
EDW Mmnt 1:
EDW Mmnt 2:
EDW Error 1: MU's
EDW Error 2: MU's
Calculated Results
EDW Specification +/- 1%
Mean EDW:
EDW ratio:
Electron Measurement Data
Electron Chans check
Select Electron Dosemeter: P1
E5: 15MeV
Measurement E5 1: 19.84
Calculated Results
Expected Dose 100 cGy
Output Dose: 100.1
Use the record
Record: 4 of 13
No Filter
Search

Below are some more screenshots showing the different engineers that I have trained and supervised when carrying out the CT Simulator Bi-weekly QC procedure. This shows how I have trained various new staff members. I feel that I have learnt a lot from this as training my colleagues is very good experience for my future career as an engineer. I have included a number of screenshots as it shows that I have trained quite a few new members of staff and so I feel that I have become fairly competent at doing this.





[redacted] EngTech Application

Hi [redacted]

I would like [redacted] to get signed off for the Philips CT Sim QC please. They require this for their IPEM Diploma plus they will all be looking after the CT Sims in the future. Whenever you are going to a CT Sim QC could you take them over please.

It might be difficult for all three to attend at once so use common sense.

Thanks

[redacted]g

Tel:
[redacted]

theRCT the Register of Clinical Technologists

professional standards authority
accredited register

[redacted]

[redacted]

Section D – Use effective communication and interpersonal skills.

D1 – Use oral, written and electronic methods for the communication in English of technical and other information.

Weekly Physics Meetings

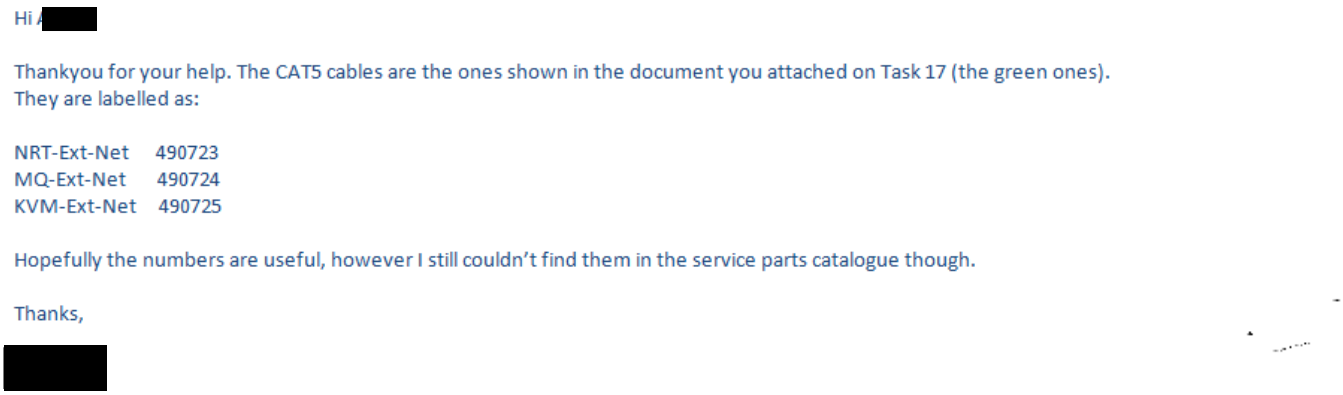
One of the regular ways in which I have used oral communication is during the weekly departmental physics meetings. Once per week the physics and engineering team both meet to discuss the various machine faults and ongoing issues throughout the department. Before the meeting I print out from our database a list of all the call outs for faults, and also a list of all the planned work that has been done by the engineers. When leading the meeting, which I have done on a number of occasions, I verbally feedback the issues to the physics staff present. We as engineers can then discuss and put action plans into place so that the issues can be resolved as quickly as possible.

Presentations

Another area in which I have used verbal communication is when giving presentations. A few examples of these are a presentation to college students to encourage them to look at engineering apprenticeships as a career option. Another example is when carrying out my BTEC Level 3 project I was required to give a short presentation to my colleagues about how my project has developed and the outcomes of this. I was then given feedback on how to improve for the next time I deliver a presentation.

Emails

An area that I use daily in my job role is the electronic communication of email. I email a variety of people from college assessors, colleagues and manufacturer staff members. An example of this is shown below when I spoke to the helpdesk team at the machine manufacturers to arrange for a spare medical part to be ordered and delivered. When communicating via email it is important to ensure to be clear and concise using proper English and punctuation to correctly convey ideas and to also help the recipient to easily understand what is being said.



Hi [redacted]

Thankyou for your help. The CAT5 cables are the ones shown in the document you attached on Task 17 (the green ones). They are labelled as:

NRT-Ext-Net 490723
MQ-Ext-Net 490724
KVM-Ext-Net 490725

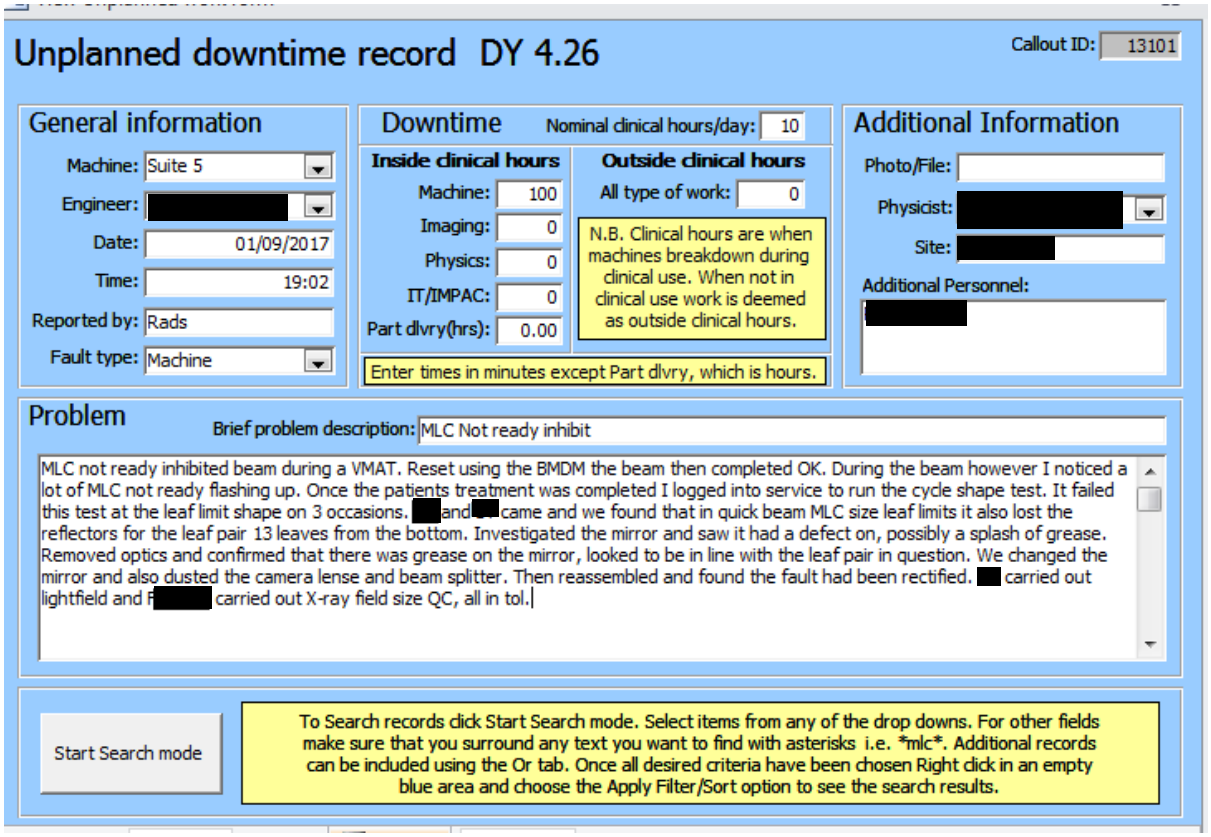
Hopefully the numbers are useful, however I still couldn't find them in the service parts catalogue though.

Thanks,

[redacted]

Job entries

When entering a job into the database I use effective written communication. This is very imporant as other engineers will often be called to the fault again, and so it is important to document exactly what fault I attended, and what I did to resolve it. Particularly with reccurrent or ongoing faults it is vital for other engineers to see what has already been done and what observations were made so that they have the best chance of rectifying the fault, causing the least amount of clinical downtime possible. Therefore I try to use good structure and clear consice language when describing a fault, especially when using technical language that can sometimes be harder to understand.



Unplanned downtime record DY 4.26

Callout ID: 13101

General information

Machine: Suite 5
Engineer: [redacted]
Date: 01/09/2017
Time: 19:02
Reported by: Rads
Fault type: Machine

Downtime

Nominal clinical hours/day: 10

Inside clinical hours		Outside clinical hours	
Machine:	100	All type of work:	0
Imaging:	0		
Physics:	0		
IT/IMPAC:	0		
Part dlvry(hrs):	0.00		

N.B. Clinical hours are when machines breakdown during clinical use. When not in clinical use work is deemed as outside clinical hours.

Enter times in minutes except Part dlvry, which is hours.

Additional Information

Photo/File:
Physicist: [redacted]
Site: [redacted]
Additional Personnel: [redacted]

Problem

Brief problem description: MLC Not ready inhibit

MLC not ready inhibited beam during a VMAT. Reset using the BMDM the beam then completed OK. During the beam however I noticed a lot of MLC not ready flashing up. Once the patients treatment was completed I logged into service to run the cycle shape test. It failed this test at the leaf limit shape on 3 occasions. [redacted] and [redacted] came and we found that in quick beam MLC size leaf limits it also lost the reflectors for the leaf pair 13 leaves from the bottom. Investigated the mirror and saw it had a defect on, possibly a splash of grease. Removed optics and confirmed that there was grease on the mirror, looked to be in line with the leaf pair in question. We changed the mirror and also dusted the camera lense and beam splitter. Then reassembled and found the fault had been rectified. [redacted] carried out lightfield and [redacted] carried out X-ray field size QC, all in tol.

Start Search mode

To Search records click Start Search mode. Select items from any of the drop downs. For other fields make sure that you surround any text you want to find with asterisks i.e. *mlc*. Additional records can be included using the Or tab. Once all desired criteria have been chosen Right click in an empty blue area and choose the Apply Filter/Sort option to see the search results.

***D2* – Work effectively with colleagues, clients, suppliers or the public, and be aware of the needs and concerns of others, especially where related to diversity and equality.**

Colleagues

I work with colleagues on a day to day basis in my current role as part of an engineering team from a variety of backgrounds such as mechanical engineers, electrical engineers and physics based academic learning along with IT based qualifications. In a clinical environment it is very important to ensure that downtime is kept to a minimum. This can sometimes mean holding off meetings or other jobs when a higher priority issue arises, such as a major machine fault. Therefore good communication, especially verbal and written through emails is very important. To ensure this is easier to achieve I feel that it is very important to have a good working relationship with colleagues. This could mean that when a disagreement occurs, I would always ensure not to upset or offend colleagues and that the working relationships are kept. This means that machines issues can be resolved easily without personal issues getting in the way. Working as part of a team can help to get more service work done and also to get some faults fixed quicker, however sometimes there can be too many people in the way of each other. It is therefore very important to be able to see when there are too many people and to either step aside and let others solve the issue or to politely suggest this to others.

Clients (Radiographers)

On a day to day basis I also deal with radiographers. When they have an issue with a machine we as engineers are called to it. This can often be a high pressure situation as there can be an unwell patient on the bed waiting for treatment, usually in an uncomfortable position. Therefore the radiographers can be concerned so it is important for us to assess the situation quickly and advise the radiographers what we plan to do. Sometimes it can be a quick software reset, other times it can be a major part fault that could take hours to resolve. We therefore need to be calm and patient with them and ensure we are constantly communicating the status of the machine as any downtime has the potential to cause major delays throughout the department, which if the radiographers are not fully aware of can dramatically increase patient waiting time.

Suppliers ([redacted])

When attending training courses I was representing [redacted] at a private company who were providing my training. Therefore it was important that I acted professionally and I ensure when dealing with others that I am polite and as helpful as possible. I also deal with manufacturers staff when ordering spare parts, which again if there is a machine down, can be a high pressure situation. Again I always make sure not to become worked up or stressed but to remain calm and try to be clear when putting information across to the person trying to help. Service engineers can also come from the manufacturer during a machines warranty period so when talking face to face I observe basic manners.

Hello,

Please can I ask if there is any additional info or updates regarding this case? We are seeing an increased number of occurrences recently.
Please also find attached some info from our database as regards call outs to faults regarding this issue, as you can see it is fairly common.

Kind Regards,

[redacted]

Members of the Public (Patients)

In a hospital environment there are usually more patients than staff members. Therefore it is important to know how to deal with them correctly. I always offer assistance when a patient has a query, especially as they may be distressed and unwell. Even a simple request such as where a toilet is located can improve the patients experience and so being well mannered and helpful is a relatively easy but good way to ensure they have a good experience at [redacted]

E1* – *Comply with the code of conduct of your institution.

IPEM Code of Professional and Ethical Conduct

As an [redacted] member of IPEM I follow the code of conduct of the institute. The IPEM Code of Professional and Ethical Conduct is split into 3 main sections. The first section is called Patients, Clients and Users. As an Engineer I am not involved in direct patient contact as often as healthcare workers however I still ensure that I treat patients with dignity and I am aware safeguarding issues. For example, when entering a treatment room due to a fault, when the patient is present I will ensure that the radiographers have asked the patient if they are comfortable with me going into the room. Quite often patients will have had clothes removed and so may feel embarrassed. This sometimes means that the patient would rather be covered up or taken down from the treatment bed before I enter which requires patience on my behalf. I have also attended a trust run training session to ensure that I am aware of the safeguarding issues for both adults and children. This can apply to both other staff members and also to patients. I feel that I should also always be patient and polite when dealing with patients who may ask me for directions or for help.

Rigour, Responsibility, Honesty and Integrity is the second section. An area in which I am honest is when completing overtime forms and lieu time. This means that I would never twist the truth or lie about hours I have worked which would not only be fraudulent but also dishonest. The area also covers only carrying out work that I am competent and trained to do so. Therefore I would never sign a machine off as fit for use if I wasn't competent to do so and signed off for in the competency database. If I was not sure on a fault or issue then I would again not carry out procedures where I could harm a patent or user without a second opinion of a more senior staff member. I also aim to keep up to date with all training and to make sure to keep my professional competence as good as possible.

Respect for life, the law, colleagues and the public good is the final section. This includes working well with colleagues which I feel I do and I also approach them for discussions and I am always kind and polite when dealing with them. To prevent unnecessary risk I carry out risk assessments whenever I see a potential issue with the work being carried out.

[redacted] Commitment

As a staff member at [redacted] I adhere to their code of conduct called [redacted] Below is how I feel I have demonstrated sticking to each area.

Communication - I talk to colleagues when answering the phone to attend faults. I feel that I am able to communicate clearly and respectfully when on the phone. I also speak to colleagues when attending faults. In a busy treatment environment I try to be clear and to answer any questions they may have as best I can and to be accurate when doing so.

Personal and people development - I work well as part of a team and get on well with my colleagues. I could be more proactive in putting myself forward for tasks so that I haven't done before so that I can gain more experience from the other engineers around me.

Health, safety and security - I make sure to follow safe working practices and when necessary I keep to following work instructions. This is to reduce the chances that I will make a mistake. When I am unsure of something I ask a more senior or more experienced staff member for assistance to ensure that all safety requirements are met.

Service improvement - If I see something that can be improved I may ask a more senior member of staff about it, and may make a suggestion as to how it could be improved. An example of this was to amending a work instruction that was difficult to follow and had some information missing from it.

Quality - I try to make sure that I am always efficient by working to a high standard. When a machine is down I try to help as best I can in a way that assists my colleagues in getting the machine in working order as quickly as possible, but while also making sure a high level of respect and a high quality of work.

Equality and Diversity - I ensure that I treat everyone with respect and dignity, no matter their age, race, gender or background. I work with some members of staff who are from a different background and ethnicity to myself and I get on with them well.

I am also a member of the IMechE and so follow a similar code of conduct to that of IPEM. A summarised version can be seen below:

Code of Conduct – abbreviated summary

This summary provides a framework for members of the Institution of Mechanical Engineers to use when exercising their judgement. Members' personal standards of behaviour are inevitably linked to their professional practice because both affect the ability to act as ambassadors for the profession and the Institution. It is important not to bring either into disrepute.

This summary is not intended to be a full or exhaustive list of the situations and circumstances which may comprise compliance and non-compliance with the Code of Conduct.

Ethical conduct requires judgement, interpretation and balanced decision making in context.

- **Practice competently and maintain up-to-date knowledge and skills**

  We should act with care and competence

  - Should take reasonable steps to maintain our professional knowledge and maintain a record of continuing professional development.
  - Only undertake professional services in areas of current competence.
  - Should disclose any relevant limitations on our competence to undertake professional work.
  - Quantify and limit risk in all aspects of professional work, including with those who are working under our authority.
  - Ensure that we maintain adequate professional indemnity insurance either via employer or personally.

- **Act with integrity and respect for others**

  We should act with integrity and in a reliable and trustworthy manner

  - Do not knowingly mislead nor allow others to be misled.
  - Should respect confidentiality obligations express or implied.
  - Present and review engineering evidence, theory and interpretation honestly, accurately and without bias.
  - Avoid deceptive acts and refrain from corrupt practices. Reject bribery and record gifts or hospitality received.
  - Declare conflicts of interest.
  - Do not implicate the Institution in oral or written correspondence.

- **Promote sustainability**

  We should engage responsibly with the environment

  - Recognise the importance of socioeconomic and environmental factors.
  - Comply with obligations for health and safety and environmental protection.
  - Take account of the needs of a diverse environment, while never knowingly or deliberately exploiting natural resources.
  - Balance the needs of the present with the needs for future generations.

- **Exercise engineering leadership**

  We should contribute positively to the public perception of the profession

  - Contribute to public discussion on engineering matters within own area of competence and in an objective, clear and truthful manner.
  - Take positive action when we encounter unmanaged risk or malpractice.
  - Advocate and support the extension of ethical practices and respect the rights and reputations of others.
  - Support and encourage diversity within the industry.

E2 – Manage and apply safe systems of work.

Health and Safety at Work Act

The Health and Safety at Work Act is the main piece of legislation covering the wellbeing of all employees in Great Britain. It is mainly enforced by the Health and Safety Executive (HSE). The HSAWA is used as the basis for creating and implimenting many of the other regulations and guidances used to protect the safety of people throughout their occupational workplace. It is a legal obligation for both employers and employees, with each reponsibility outlined and explained. The Health and Safety at Work Act also offers employers help on the measures that may be suitable for them to use to prevent hazards becoming issues. An example of this is Regulation 3 which covers the use of risk assessments in the work place. Another important regulation is Regulation 13 which makes it a legal requirement for all employers to provide suitable training for employees. This is especially important in the medical engineering sector as if someone not sufficiently trained to work on a certain device then they could potentially be putting lives at risk for both patients and users when carrying out repair or maintenance work.

IRMER (Presentation Notes from Radiographer Presentation)

Order of Responsibility

1. Board
2. Chief Executive
3. RPA
4. RPS
5. Department Manager
6. Employee

IRR is patient focused and is therefore primarily aimed at protecting them and ensuring they do not receive the incorrect treatment. IRR is a criminal law and therefore those working under it are prosecutable.

Employer – Responsible in training people and signing them off as competent to carry out the correct following of procedures. To ensure that procedures are set into place (in the Christie we have a ISO 9000 QS that contains all of the procedures used in the radiotherapy department). It is also their responsibility to ensure operating procedures are correct. They must also keep an up to date inventory of equipment that is capable of giving out a radiation exposure.

Referrer – This is traditionally a GP or Clinical Oncologist. They must provide a sufficient amount of medical evidence to support an exposure.

Practitioner – This is the person who acts on the evidence provided to determine if an exposure is needed, and on what type of exposure is required. This can be the same person as the practitioner, however they must be a registered health professional and at the Christie, Band 7 Radiographers are able to authorise kV images and rescans. This person's main responsibility is to ensure that the benefits outweigh the risks.

Operator – An operator is classed as someone who may influence the patient's dose in a **practical** way. For example this can include:

- Physics
- Engineers (**me**)
- Clinicians
- Mould Room Staff
- Treatment Planning Staff

Clinical Operator

They must ensure that the exposure has the relevant justification. According to IR(ME)R 2000 the clinicians should ask female patients before every single treatment, whether there is a chance of them being pregnant. However as this isn't necessarily very practical, they are asked before treatment planning exposures, and again before the first treatment exposure. They are educated to ensure that if they feel they may be pregnant or that anything has changed then they must inform a member of the treatment staff. Women between the ages of 12 and 55 should be asked in accordance with IRMER regulations.

Pre-sets, Contrast and QA are all areas in which the operators could potentially affect the dose a patient receives.

Due Diligence

It is expected that humans will make errors at some point, and no matter how many measures are put into place, there will still be mistakes. This is why procedures are put into place so that staff have a set method to follow and show that they are in fact taking due diligence when they are carrying out their duties. Even if a procedure is deemed to be inadequate, it should be followed until it is corrected, or until the member of staff is retrained to see that the procedure is correct, depending on the circumstances. If a staff member has a concern it should be raised so that corrective measures can be put into place, such as those mentioned above.

The CQC can enforce and check IRMER compliance and they will investigate reported incidents that are made. Currently only over exposures need to be reported, however many centres also report near misses, and under exposures so that they can learn from them and prevent them from happening again. Likely causes of errors in treatment are:

- Automaticity
- Over-reliance on technology

Automaticity means that a person carrying out a procedure regularly, or often in a short space of time could become complacent and may not make as detailed checks as would be required. People could also become distracted in what they are doing and so it is important to observe general manners and to not interrupt someone while they are carrying out a task. There was an instance in the US where an over reliance on technology led to a computer crashing and a plan not being fully completed. Therefore when experiencing an error or fault with a piece of technology (including treatment planning PC's etc.) the user should run through the procedure again to check that the plan or procedure has been stuck to and the fault hasn't created any causes for concern.

IRMER and IRR(99) (Notes From Engineers Presentation)

Ionising Radiation regulations 1999 are enforced under the Health and Safety Act 1974 and are designed to protect staff members. The purpose of the regulations are to establish a framework to ensure that exposure to ionising radiation is kept as low as is reasonably practicable for the safety of employees.

IRR 99 applies to me in my job role. The local rules used in the radiotherapy department are used to outline the responsibilities of employees such as myself, and to make sure that people are aware of the risks, control measures and procedures to keep staff and patients safe. This includes controlled and supervised areas, the signs and warning lights permit to work systems and hand over documents. I have a yearly dose limit of 2mSv set out by the RPA. If the level of radiation I received was higher than this then there would be an investigation to see why this was. I also learnt that it is the role of the RPS to ensure that the local rules are enforced in a particular department. I also learnt that the dosimeter all staff members in radiotherapy wear is part of the PPE we use. This is because it is used to measure the dose we receive and so is very important to our safety.

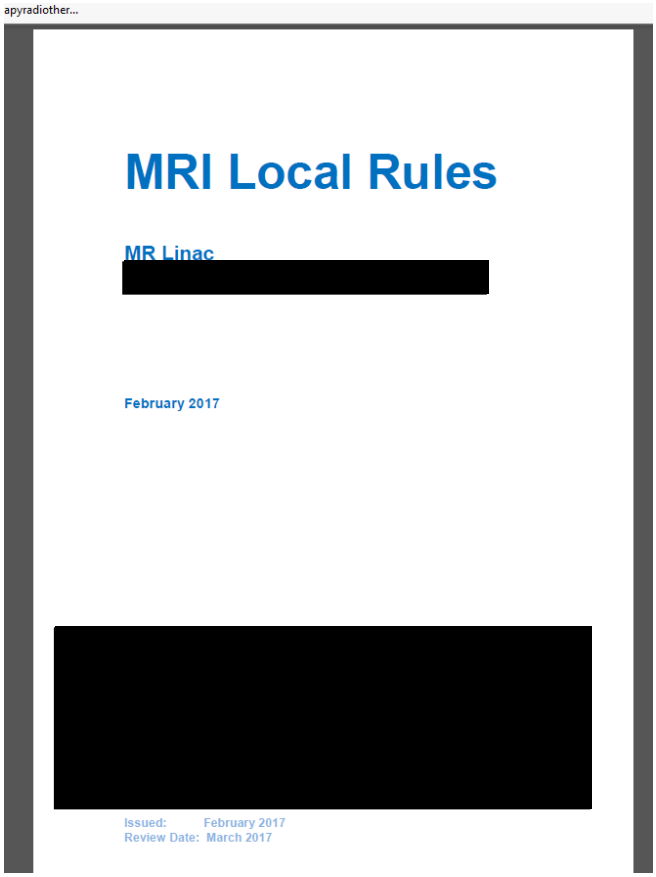
IRMER 2000 stands for the (Ionising Radiation Medical Exposure Regulations). Again these regulations are enforced under the Health and Safety at Work Act 1974. This legislation is a criminal law and so people in breach of the regulations can be prosecuted. The aim of the regulations is to ensure the safety of patients.

Under IRMER I as an engineer would be classed as an operator. This means that I am responsible for making sure that the machine is in a safe and working condition when handed over to clinical or physics staff. It is also important that I comply with all of the written procedures that are made to ensure procedures are carried out properly and safely. They are part of the group's quality system. The quality system is a requirement of IRMER. All off my training must be carried out so that I am competent to carry out the job role in a safe way. Once I have been signed off as competent to carry out a particular task, a record must be made for if there are any problems in the future.

ALARP is a common abbreviation used in regulations and in legislation. It stands for "As Low as Reasonably Practicable." This means that there should be measures in place to limit all exposure to the hazard of ionising radiation to as low a value as possible, with the exception of if it would be too unreasonable, meaning that it would be silly or too impractical to lower further.

Due Diligence is set out because everyone, even when fully trained, is likely to make mistakes. The idea of the quality system in accordance with IRMER is that any of these mistakes should be picked up before a colleague or patient's safety is put at risk. This also means that the Quality System should always be followed. If there is a problem with the QS then the relevant person should be informed to ensure this is corrected. The procedure should not be carried out if it isn't in the QS or if it is found to contain mistakes.

MR Linear Accelerator Safe Systems of Work


apyradiother...

MRI Local Rules

MR Linac [redacted]

February 2017

[redacted]

Issued: February 2017
Review Date: March 2017

When working in the MR Linac bunker it is vital that I follow a number of safe working procedures. One of these which is shown above is the MRI Local Rules for the MR Linac. This is a document in accordance with IRR99 that outlines the local working practices and any risks or hazards that could be posed when working in the area. To be allowed to enter the MR Linac bunker I had to be screened by a trained engineer to ensure that it was safe for me to enter the presence of the magnet. This involved filling out a form to ensure I hadn't had any implants or health issues that could potentially endanger myself and others around me. Along with reading the local rules document, and being screened, I also attended a presentation given by an MRI lead radiographer. The purpose of this was again to ensure I knew the hazards and measures to prevent risks, before entering the bunker. I have copied my notes to this presentation below:

[redacted] EngTech Application

Presentation: MR Safety

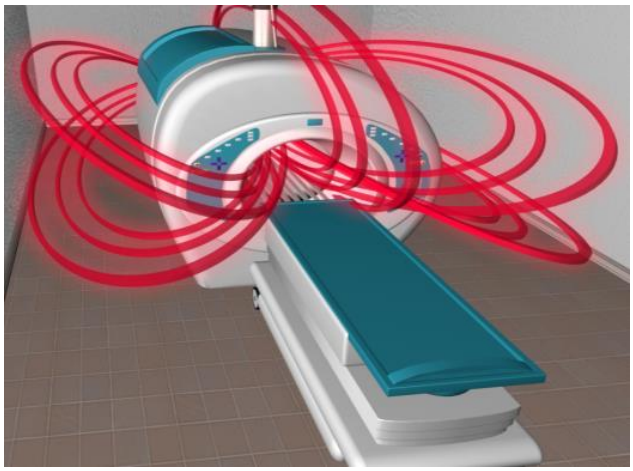
Delivered by: [redacted]

The main purpose of this talk was to give the engineers, clinical staff and physics staff a good overview of the safety concerns and issues raised when entering an MR zone, due to the new MRLinac being installed at the hospital. MRI stands for Magnetic Resonance Imaging. The magnets used are usually either 1.5Tesla (T), or 3T. This means that there is a strong magnetic field present in the room, even when the machine is turned off.

Warning Signs

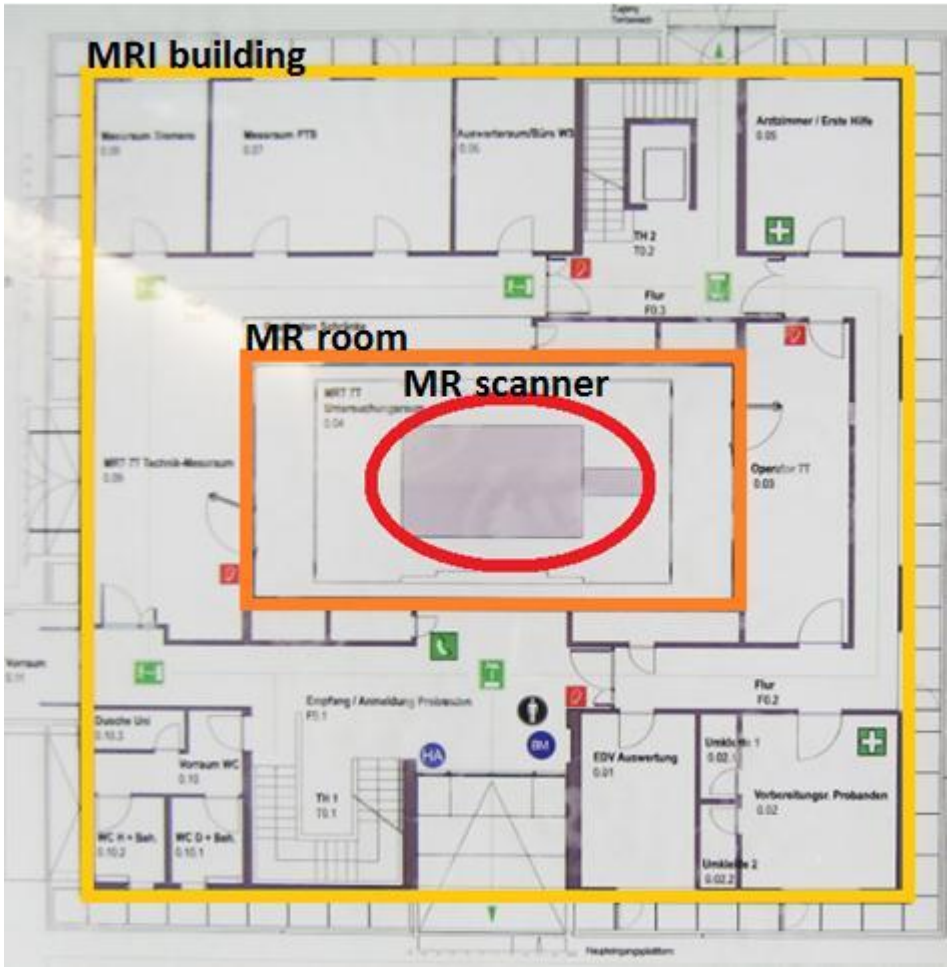
As the image shows, there is a set standard labelling for items that are taken into an MR room. The system works on a traffic light system so that it is clear and easy to understand, and therefore languages are also not a barrier. The green means that the item is MR safe and so can be taken into the room. The Red shows that the item cannot go into the MR room under any circumstances. The yellow sign shows that the item may only enter the MR room under an agreed set of conditions, which are agreed to by MR protection staff in accordance with the suitable regulations.

The MR scanner has a magnetic field as can be seen in the image below. Due to the nature of the magnetic field anything that is ferrous would be pulled into the bore of the machine (hole in the centre). This is obviously a huge safety problem as the patient's life would be in danger as soon as there was a ferrous item present, especially if large or sharp.



The area in which the MR scanner is located will be split up into sub locations as mentioned above, depending on the strength of the magnet. The red line in the image below represents an area where the magnetic flux is at 30 Gauss. This is called the projectile zone. As the name suggests, this means

that the field is strong enough here to cause ferrous items to be pulled to the magnet at such a force they are a projectile. The orange line shows the MR environment. This means that the magnetic field still has a direct influence on the room. No ferrous metals are allowed in this area, along with bank cards, metal implants, mechanical watches and keys. These items are however allowed in the building. The yellow line on the diagram shows the MR building. This area isn't as dangerous due to the magnetic field being relatively weak. However, people who have pacemakers, insulin pumps, or metal implants are generally not allowed in this yellow area. The reason for this is that the magnetic field can still cause interference to these sensitive devices, therefore causing danger to the health of these people.



Orange Line ≈ 5 Gauss

Red Line ≈ 30 Gauss

Centre of the MRI Bore ≈ 15000 Gauss

High Tension Electrical Equipment

When working on high tension areas of the machine, we have a no lone worker policy. This means that there must be at least 2 engineers present when the covers are removed from the high voltage equipment areas. Only engineers may access these areas and they are locked shut with a key when the engineers aren't present. The buddy system is to ensure if something does go wrong, there is someone watching who can quickly raise the alarm.

Electricity at Work Regulations 1989

The Electricity at Work Act imposes duties to the employer to limit the risks with electricity. Electricity is a major hazard as it can not only cause injury or death by electric shock but faults can also cause fire and explosions. The act covers any electrical equipment which is defined as anything used to generate, provide, transmit, transform, rectify, convert, conduct, distribute, control, store, measure and use electrical energy. Therefore the regulations cover a very wide variety of equipment and so sometimes the regulations can be seen as very general.

The regulations place the responsibility on employers, employees and self-employed workers to comply with the regulations as far as is in their control. The main duty of the employees is to comply with their employers control measures as much as is possible.

One of the key regulations is Regulation 4. This covers general safety and includes both the set up and maintenance of the equipment. PPE must be worn when required as directed by the employer. This can include items such as rubber mats and gloves which act as insulators. Maintenance can include regular services and checks to prevent systems becoming dangerous.

Another is Regulation 7 which states any conductors must be adequately insulated or protected by covers. As I mentioned above this is another quite general regulation which covers many different areas and types of equipment. This can include large items such as mains transformers and substations down to relatively small circuits such as ring mains in a home.

Formal Safety Training

I have received formal Health and Safety training from when studying my BTEC Level 3. As well as trust Health and Safety Training I have also booked onto a CITB Course to work towards gaining a CSCS card. I will be doing this course on the 26/09/17.

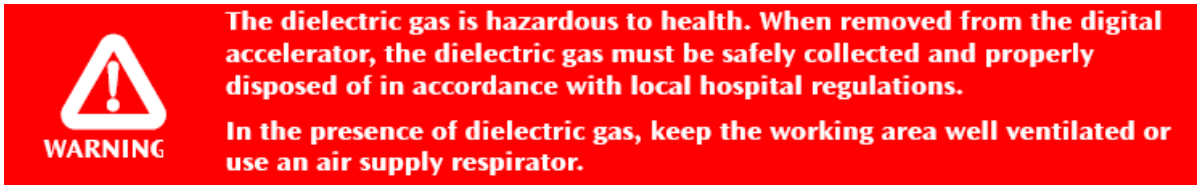
E3* – *Undertake engineering work in a way that contributes to sustainable development.

Magnetron Change

A fairly standard job that I carry out with my colleagues is when changing the magnetron on a machine. A linear accelerator has a lifespan of around 10 years, however the magnetron will often need to be changed during this lifetime, although it can vary depending on the machine. A magnetron, at the end of its life will either be sent back to the manufacturer, or disposed of in accordance with the WEEE Regulations (Waste Electrical and Electronic Equipment Recycling Regulations). If the magnetron is relatively new and shouldn't have come to the end of its life then the manufacturer will usually ask for it to be returned to them so that they can conduct tests to see why it hasn't lasted as long as expected. I think that this is a good way to contribute to a sustainable development as both me as the user, and the manufacturer can play a part in actively trying to increase the lifespan of a prodect that is made from finite resources. If it has overrun its expected life span then the magnetron will be disposed of in the hospitals waste and refuse area. It will be placed in a WEEE bin, meaning that it is in a secure locked compound and will be disposed of by a professional contractor in such a way that it will have a minimal effect on the environment.

Another sustainability issue that arises when changing a magnetron is the SF6 gas that is used in the system. SF6 (Sulphur Hexafluoride) is one of the most potent greenhouse gasses that is known at the moment, and is about 23,900 times more damaging that CO_2 and is therefore heavily regulated to prevent damaging consequences to the atmosphere. SF6 is used due to its dielectric capabilities. We use it in Linear Accelerators to prevent high voltage equipment from electrically arcing. In keeping with the F gas regulations, we have an engineer on site that is trained in the safe handling of SF6. As per EU regulations, SF6 cannot be released into the atmosphere due to its damaging capabilities, and so must be recycled.

When working with SF6 at [redacted] we follow a work instruction that is part of an ISO9001 quality system and that was written by the SF6 trained engineer. This specifies how to safely remove SF6 from the machines, how to store and dispose it, and also how to put it back into the machine. Specialist equipment is used such as an SF6 collection bag and an SF6 detector.



Below is the risk assessment used to cover the removal of SF6 from a Linear Accelerator. Before carrying out the procedure I made sure that I was familiar with the risk assessment and I had also observed the SF6 trained engineer carrying out the procedure before. In the future I would like to attend the course myself so that I can ensure I am working to the best practice when carrying out the procedure myself.

TS.4.34 Non Medical Device Risk Assessment form

R.T.S.G RISK ASSESSMENT FOR:	Site:	Telephone No:	Customer Name:	Date:
Sulphur hexafluoride (SF6).Sf6 gas reclamation equipment.	[redacted]	3554	[redacted]	5th oct 2011
			job No	ERA No 36

HAZARDS:
The possibility of an uncontrolled Sf6 gas escape from the reclamation equipment during gas transfer or storage due to accidental damage or catastrophic failure of the equipment.

PEOPLE AT RISK FROM ABOVE HAZARDS/USE
RTSG and Estates personnel

CONTROLS AND REQUIRED ACTION :

Equipment to be operated by suitably qualified personnel, and relevant work instructions followed.
The cylinder is to be stored in a secure manner in a well ventilated area.

INTENDED USE:	Benefits:	Training /instruction
[redacted]	Compliance with DEFRA regulations. To allow the continued supply of Sf6 gas.	External training by registered training body.

Review Date:	Sheet:	Assessor:	Customer	M.P.E
Oct 2012	1 of 3	Signature [redacted]	Signature: [redacted]	Issue No: 1
		Date: 5th oct 2011	Date: 5th oct 2011	Device Life Expectancy:

TS.4.34 Issue 1 Date 09/01/2010 Issued By: SA

WEEE Regulations

Another area in which I need to ensure I work sustainably is when disposing of other waste electrical equipment, for example batteries may contain hazardous and toxic materials such as lead acid. Again I would dispose of these in the correct way and following the WEEE regulations.

Lead

The use of lead is needed in the radiotherapy department due to the fact we use ionising radiation to treat patients. Lead is used as a shielding material, and so when working on certain parts of the machine we wear gloves and use safety footwear. The use of this PPE is important to protect the user, gloves will prevent the material from being ingested accidentally or causing skin irritations and safety boots will protect the user's feet in the event the lead is dropped, since it is a very dense material. When removing lead we also fill out a lead removal form to ensure all lead is put back on.

Risk Assessment Training and Writing Risk Assessments Safety

An area in which I have undertaken a task involving safety is when my college tutor needed to observe me carrying out a procedure that he could then assess and decide on whether I was competent at working to instructions and carrying out planned procedures. One of the procedures that he decided to observe was a morning run up on a Linear Accelerator. This was a good procedure for me to show him however some safety questions arose. The main issues were down to radiation protection as my college tutor has a rounded knowledge of engineering however didn't have any experience in radiation. It was therefore decided that I should write a risk assessment to evaluate whether the benefit of his visit was more than the risks posed by the visit. To do this I used a General Risk assessment form that is on our ISO9001 quality system so that I could be sure that I was using a suitable and up to date document.

I was decided to be competent when carrying out the risk assessment as I had attended an NHS Trust Risk Assessment Course where we were taught how to write a suitable risk assessment. I have attached an image of my competency signatures after attending this event below:

Competencies for : [redacted]

EN.2.06.03 Other Training

Ref	Description	Supervisor	Date	MySignature
01	MEIGaN			
02	Laser Protection Supervisor			
04	SF6 Handler			
09	Asbestos Awareness Training	[redacted]	01/03/2017	23/06/2017
10	Introduction to Networking			
11	IR(ME)R Awareness Training	[redacted]	23/06/2046	23/06/2046
03	PBT Chilled Water Systems (Estates Training)			
05	PBT Technical Gases (Estates Training)			
06	PBT Compressed Air (Estates Training)			
07	PBT Heating Systems (Estates Training)			
08	PBT Ventilation (Estates Training)			
12	PBT DX Cooling (Estates Training)			
13	PBT Kone Lift (Estates Training)			
14	PBT Platform Lift (Estates Training)			
15	Pellaby Crane (Estates Training)			
16	Beam Line Crane (Estates Training)			
17	IR(ME)R Radiotherapy In-house session			
18	Standardised Radiotherapy Prep Training (1)			
19	Standardised Radiotherapy Prep Training (2)			
20	Writing Risk Assessments (Trust course)	[redacted]	29/06/2027	29/06/2027

Below is a risk assessment that I carried out for a college tutor to come and assess me following a safe working procedure. The example is for a Linear Accelerator run up procedure.

EngTech Application

[redacted] Risk Assessment:

TS.4.34 General Risk Assessment form

R.T.S.G RISK ASSESSMENT FOR:	Site:	Telephone No:	Customer Name:	Date:
[redacted] visit to observe Run up procedure	[redacted]	[redacted]	job No	T.R.A No

HAZARDS:

- (1) Radiation
- (2) High Tension
- (3) Infectious Disease
- (4) College Tutor
- (5) Patient Data

PEOPLE AT RISK FROM ABOVE HAZARDS/USE

[redacted]
College Tutor [redacted]

CONTROLS AND REQUIRED ACTION :

- Check the equipment door is locked at the start of the run up procedure
- [redacted] will have read local rules and confirmed this via an email. This will inform him of the radiation hazards in accordance with IRR99.
- [redacted] will be supervised at all times by a trained engineer who is signed off and competent to carry out the run up procedure.
- Radiographers and cleaners responsibility to ensure that around the machine is clean and no bodily fluids are present from the day before.
- Explain hand washing and provide alcohol gel
- Only the trained engineer will operate the machine. Dave will only observe.
- No patient data will be on display as only QC prescriptions are used during the run up procedure
- Covers, Guards and Machine interlocks are all in place to prevent injury and damage to the machine

INTENDED USE:	Benefits:	Training /instruction
RTSG	Academic Progression for [redacted]	n/a

Review Date: N/A (One off event)	Sheet:	Assessor: [redacted]	Customer: [redacted]	M.P.E
		Signature: [redacted]	Signature: [redacted]	Issue No:

	1 of	Date: 18/08/17	Date: 18/08/17	Device Life Expectancy:

STAGE 2

To quantify the relative risks we must look at the likelihood of an event and the consequence of the event, using the 5 x 5 matrix below.

Likelihood (L)	Score		Consequence (C)	Score
Certain	5		Fatalities / Trust disruption / Loss / Prosecution	5
Likely	4		Fatality/Service disruption/Loss/Prohibition	4
Possible	3		Major injury/Disruption/Loss/Improvement	3
Unlikely	2		Serious injury/Disruption/Loss/Recommendation	2
Rare	1		Minor injury/Disruption/Loss/Advice	1
Impossible	0		Negligible injury/Disruption/Loss/-	0

Risk Ranking: (L x C) =

15-25	High
8-14	Significant
4-6	Moderate
1-3	Low
0	No risk

Take all **applicable** device characteristic that could impact on safety and quantify the risks in the table below:

Potential Hazard	Likeli-hood (L)	Conse-quence (C)	Risk Score	Risk reduction measures taken	Amended score
1. Radiation	2	2	4	Local Rules Supervision	2
2. HT Equipment	3	4	12	Supervision	4
3. Infectious Disease	3	3	9	Cleaned the night before and informed of hand washing techniques	3
4. College Tutor	3	4	12	Supervision	4
5. Patient Data	4	5	20	Supervision and QC prescriptions used	5

TS.4.34 General Risk Assessment form

STAGE 3

SUMMARY

List residual risk of the device / accessory after risk reduction measures taken.

1. 2
2. 4
3. 3
4. 4
5. 5

Overall risk assessment:

Risks outweigh patient benefits: ☐

Benefits outweigh patient risk ☐

Approvals:

[redacted]

Engineering _____ Date 18/08/17

Customer [redacted] Date 18/8/17

MPE _____ Date _____

TS.4.34 Issue 1 Date 28/07/2016 Issued By: [redacted]

After completing the risk assessment I added it to the relevant places. In this case it was on a shared access computer drive and a physical copy in the workshop risk assessment folder. I also had to allocate it a tracking number for reference if it was ever needed again in the future.

E4 – Carry out and record CPD necessary to maintain and enhance competence in own area of practice including:

My development needs

A key time when I review my own development needs is when attending college. After completing my GCSEs I continued education in a 6th form environment. This was useful to me as it gave me the chance to focus on the theory of subjects, I completed Maths, Physics, Product Design and Geography and found that especially Physics has continued to help me in my current job role as a Radiotherapy Engineer as it has given me a good basis as to how particles interact and also a basic understanding of the concept of Radiation. After completing my A-Levels I decided that I wanted to go down the route of an Apprenticeship. The reason for this is that I had a good idea of the theory side of engineering but I also wanted to develop good practical skills. Therefore I started my Apprenticeship and have so far completed NVQ Level 2, and BTEC Level 3 in Engineering Operations and Maintenance. I have achieved a Distinction grade in this. I am still continuing my CPD in an academic way as I will shortly be starting a HNC in Electrical/ Electronic Engineering.

Personal and Organisational Objectives

At [redacted] Hospital, we are obliged to continue with CPD in a variety of areas, not always job specific. As can be seen below I have attended training sessions for a range of subjects. For example, Anti-Fraud awareness, Radiation Protection, Personal Safety and Security, Infection Prevention, Safeguarding Children and Manual Handling. I have a compliance matrix below, green showing completed and in date, Blue showing extra training. Some of these sessions will need to be done again and I will attend refresher courses to ensure I keep up with the latest advice.

Details	Competency Name	Competence Level	Min Req	Essential	Expiry Date	Compliance Status	Find Learning	Edit
Show	413|LOCAL|Anti Fraud Awareness|Core			Y	05-Oct-2018			
Show	413|LOCAL|Corporate Trust Induction|Core			Y	No Expiry			
Show	413|LOCAL|Local Induction Checklist|Core			Y	No Expiry			
Show	413|LOCAL|Radiation Protection & MR Scanner Awareness|			Y	28-Nov-2019			
Show	413|LOCAL|Understanding Personal Safety & Security|			Y	No Expiry			
Show	NHS|CSTF|Equality, Diversity and Human Rights - 3 Years|			Y	05-Oct-2018			
Show	NHS|CSTF|Fire Safety - 3 Years|			Y	05-Oct-2018			
Show	NHS|CSTF|Health, Safety and Welfare - 3 Years|			Y	05-Oct-2018			
Show	NHS|CSTF|Infection Prevention and Control - Level 1 - 3 Years|			Y	05-Oct-2018			
Show	NHS|CSTF|Information Governance - 2 Years|			Y	05-Apr-2019			
Show	NHS|CSTF|Moving and Handling - Level 1 - 3 Years|			Y	05-Oct-2018			
Show	NHS|CSTF|Preventing Radicalisation - Levels 1 & 2 (Basic Prevent Awareness) - 3 Years|			Y	21-Jan-2019			
Show	NHS|CSTF|Resuscitation - Level 1 - No Specified Renewal|				No Expiry			
Show	NHS|CSTF|Safeguarding Adults - Level 1 - 3 Years|			Y	05-Oct-2018			
Show	NHS|CSTF|Safeguarding Children (Version 2) - Level 1 - 3 Years|			Y	05-Oct-2018			
Show	NHS|CSTF|Safeguarding Children (Version 2) - Level 2 - 3 Years|				05-Oct-2018			

To meet personal and organisational objectives I have a meeting called a Personal Development Review (PDR). This is a meeting with my line manager where I can discuss any training needs I feel I have and also to set targets that I can work to before my next review.

Planned and Unplanned CPD

The main way in which I carry out planned CPD is by attending presentations and lectures given in my work place. An example of this is a presentation about Radiotherapy, given by the lead Radiographer at the time. This was designed to help give me a basic understanding of what radiotherapy is from a clinical, patient orientated view. I have attended a number of presentations and always write up a reflective piece after attending, making notes of what I have learnt and how it will affect me in my job role, such as having a greater understanding of the issues/ frustrations radiographers can have, helping me to become better at my job. Here is an example of a presentation reflection:

[redacted] 12/12/16

Presentation: Introduction to Radiotherapy

Presented by: [redacted]

This was the first presentation I attended at [redacted] and was very useful as an introduction into radiotherapy, especially for someone such as myself who had no prior knowledge.

Radiotherapy is the treatment of tumours (usually malignant meaning it can spread to other parts of the body) using ionising radiation. Ionising radiation is produced by removing electrons from the atomic shells of the target material in the head of the Linear Accelerator. The target is made from Tungsten. This ionising radiation is measured by a unit that takes into account the energy absorbed by a certain part of the body. The unit gray, (Gy) is one Joule deposited per kg of mass.

Around 50% of cancer patients receive radiotherapy as a part of their treatment and around 40% of patients will be cured of the cancer thanks to radiotherapy. The radiation disrupts cells growth and division. This will therefore cause damage to healthy cells also, but the healthy cells are more effective at repairing themselves.

Radiotherapy is delivered in a number of separate treatments called fractions. This involves spreading the treatment over a certain period of time. A typical patient may receive 30 fractions and therefore will have treatment on 30 consecutive days (excluding weekends) and so the cancer will receive a dose of radiation at the most effective time during its cell cycle, leading to maximum effect in curing or reducing the cancer.

5 R's of Radiotherapy

- Radiosensitivity

  Not all tumours have the same sensitivity, depending on the type and location of the tumour. Other parts of the body near to the tumour that will be affected by the radiation also need to be taken into account. For example the eyes, urea and ovaries are areas that have high radiation sensitivity and are likely to be damaged irreparably if they receive too much dose.

- Repopulation

  Cells will repopulate quicker once a dose of radiation has been delivered. This tends to be after about 3-4 weeks. The fractionation allows healthy cells the time to recover sufficiently and for the cancerous cells to not have enough time to recover, causing them more damage i.e. killing the cancer.

- Re-oxygenation

  Sensitivity to radiation increases with the oxygen content of a cell. Tumours that are under 1mm in size tend to be made up of fully oxic (oxygenated) cell, however once a tumour is above this size it can start to develop hypoxic areas. Cells that were hypoxic (lacking oxygen)

[redacted] 12/12/16

are able to reoxgenate and therefore not cure the cancer. Fractionation damages the cells continuously before they are able to reoxgenate, as they would if it was a one off dose of radiation.

- Re-assortment

  Cells change as regards how sensitive they are to radiation depending on the stage they are at during the cell cycle. Cells in mitosis are twice as sensitive as cells at the end of the DNA synthesis.

- Recovery

  Once the course of radiotherapy is complete the cancerous tumour should have reduced in size or gone completely. Healthy tissue surrounding the location of the tumour will recover at different rates depending on the type of tissue and the dosage of radiation it received. Cancerous tissue will take a longer amount of time to heal than healthy tissue. This means that between fractions of treatments the healthy tissue has a chance to repair itself, but the cancerous cells do not. Over the prolonged treatment and a number of fractions the cancer cells will be at an irreparable level but the healthy tissue will be able to fully repair over time.

External Beam Radiotherapy

The most common way to deliver radiotherapy treatment is by using external radiation beams. They are produced by a machine called a Linear Accelerator which can produce both Photon and Electron types of radiation. These are both produced electrically, rather than by containing a live source. Traditionally linear accelerators used Cobal-60 to produce gamma rays. They are still used in some countries however in the UK anti-terrorism laws would cause issues in obtaining and storing a live source.

Superficial X-rays

This type of machine is used to treat low energies of 50kV – 160 kV, however at the Christie we treat 40kV- 80kV.

Evidence of Competence Development

To ensure that I am competent in my job role I have continued to improve my knowledge of the Linear Accelerators that I work on, whenever I have the opportunity to do so. An example of this is when I attended a manufacturer training course for a 2 week period, also completing about 1 weeks worth of preliminary training on an online training website. The certificate below shows that I am now deemed competent to work on the Linear accelerators unsupervised on both faults and service work. I can also sign the machine off as safe. Having completed the course (Elekta Oncology Engineer 1) I have also been signed off as competent in the Competency database that we use to keep track of competencies here at [redacted] I am now looking into the Elekta Oncology Engineer Line 2 course which I hope to attend in 2018, and I will also be looking at attending other training courses such as servicing Brachytherapy Afterloader equipment and health and safety courses to keep my knowledge up to date.

Certificate of Completion

EKP-0443-7891-1610-9696

[redacted]

Elekta Oncology Engineer 1 [1st Line Transition]

June 16, 2017

[redacted]

Head of Techincal Training, Comprehensive Oncology Solutions

ELEKTA

Assisting Others in CPD

Assisting others in CPD is very important as it helps my colleagues to gain experience and understanding in key areas to do with our job. Sharing knowledge helps to ensure a wider skill base and a wider range of knowledge that can then help to make sure machine downtime is kept to an absolute minimum. An example of when I carried out CPD for the benefit of my colleagues was when I ran a QC training session. To be allowed to carry out QC, staff members must be signed off as competent to do so and so practice sessions are run to ensure that they have had enough practice to become familiar with the procedure. I carried out a session for new starters and ran through a few procedures that they then were able to observe. There were 4 trainee engineers watching me on this QC session.

Associate Member of IPEM

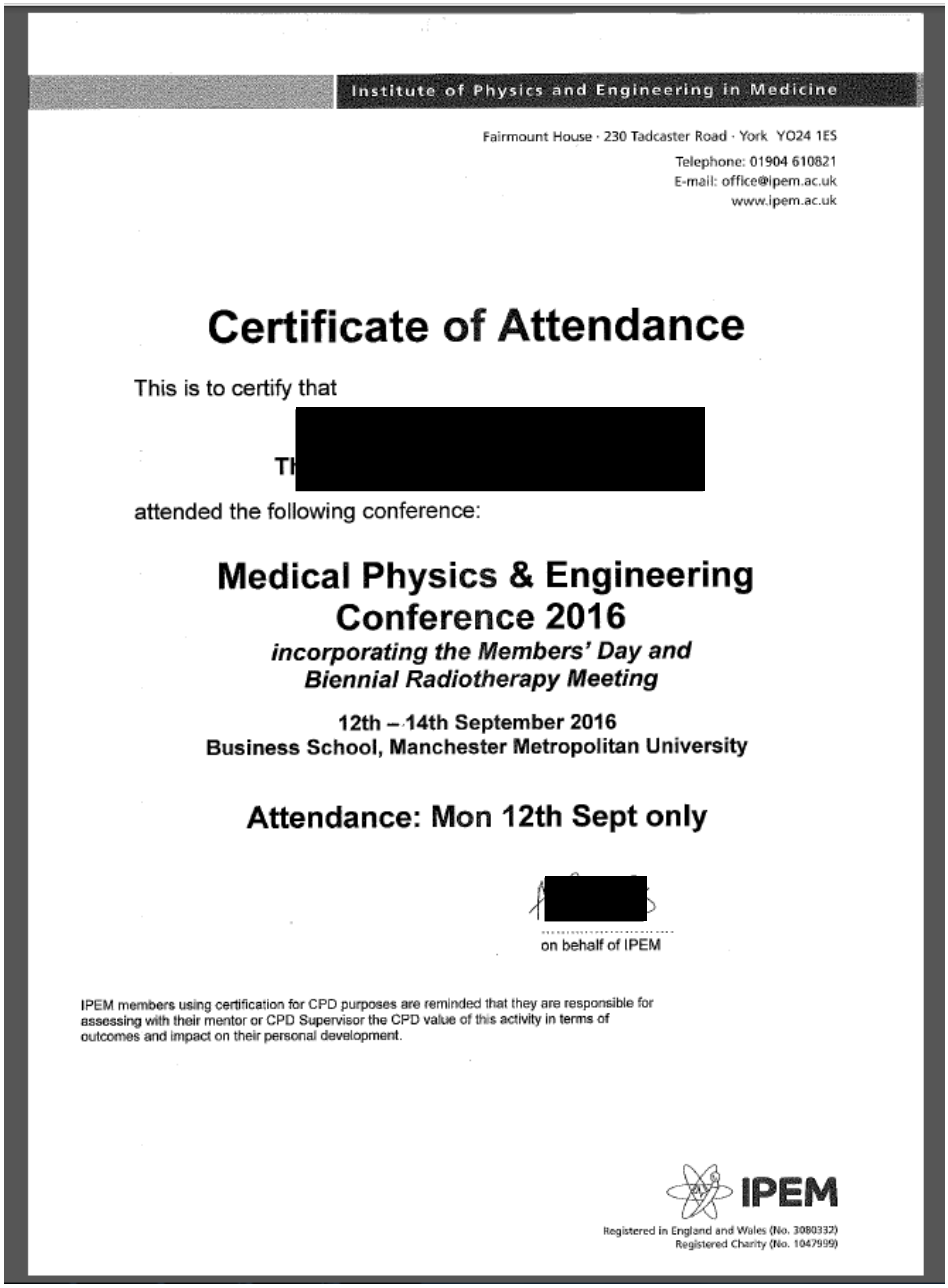
The email screenshot below shows how I have become a member of the Institute of Physics and Engineering in Medicine.

Dear [redacted]

As CEO of IPEM, I would like to welcome you and wish you a long and fruitful membership of our organisation. Attached to this mail is the e-member handbook, which has lots of useful information and links to get you started.

As well as becoming an associate member to a professional institution, I have been actively involved in the institution. I have attended MPEC 2016, a conference organised by IPEM and also listened to varius presentations about our role, and also an interesting session on the register of clinical technologists, which I one day hope to work towards. I also plan on continuing my CPD with the intitute by completeing the IPEM training scheme which covers a wide range of job related subjects such as understanding how cancer works, and how the treatment we offer helps, along with the health and safety aspects we need to look at, and how the machines we work on function. I feel that

all of this will be relevent to me in my future career and so it will be good experience for me to carry out the training scheme portfolio.



Institute of Physics and Engineering in Medicine

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Telephone: 01904 610821
E-mail: office@ipem.ac.uk
www.ipem.ac.uk

Certificate of Attendance

This is to certify that

TH[redacted]

attended the following conference:

Medical Physics & Engineering Conference 2016

incorporating the Members' Day and Biennial Radiotherapy Meeting

12th – 14th September 2016
Business School, Manchester Metropolitan University

Attendance: Mon 12th Sept only

[redacted]
on behalf of IPEM

IPEM members using certification for CPD purposes are reminded that they are responsible for assessing with their mentor or CPD Supervisor the CPD value of this activity in terms of outcomes and impact on their personal development.

IPEM
Registered in England and Wales (No. 3080332)
Registered Charity (No. 1047999)

Recording CPD

One of the ways that I record the CPD that I carry out is to fill in a log of experience everyday. This is kept up to date and includes faults I attend, services, planned work, presentations and external visits to conferences or other linac sites. I have been filling this out since I started my current role, therefore I have built up quite a good record. If a particular CPD session is particularly interesting then I will also create a reflective practice document, outlining what I have learnt and how I feel this will help me to improve in the future. Here is a screenshot of my work log from when I first started in my position:

Work Log

Date	Activity
23/02/16	• Observed morning run up with [redacted] • Reference reflector data in S12 with [redacted]. • Worked on college assignment about electric motors.
24/02/16	• College assignment about generators. • Checked radiation on lights in suite 10. • Walk round suite 10 with [redacted] and [redacted] • Mechanical workshop: Moved equipment back into the welding room after asbestos removal. Built a frame to stand welding equipment on.
25/02/16	• Suite 12 reference reflector data with [redacted] • Mechanical workshop, technical drawing (by hand) of tool makers clamps.
26/02/16	• Run up with [redacted] • Walk round S10 with [redacted] (preliminary training for Elekta EOE1 course). • Started to make the bolts for the tool maker's clamp.
01/03/16	• Observed QC with [redacted]. Mechanical workshop, finished bolts and made handles for bolts. Started to mill the main sections down to size.
02/03/16	• Run-up and beam strength QC with [redacted] Fault on S6. Mosaic issue and bed movement error. Bed movement cabinet had a power supply cable loose. Continued milling and started to file tool maker's clamp in the mechanical workshop.
03/03/16	• Observed billykev QC and run-up with [redacted]
04/03/16	• Observed gun aim QC and carried out the run up with [redacted] Started to use Auto CAD to draw out the tool maker's clamp.
08/03/16	• Observed QC and run-up with [redacted] • S12 CAN link fault with [redacted] • Made a centre punch in mechanical workshop and started to draw it out using

E5 – Exercise responsibilities in an ethical manner.

Statement of Ethical Principles (UK Spec)

Accuracy and Rigour – An area in my current job role that shows I am accurate and thorough is when I am entering data into the database after planned maintenance or an unplanned callout to a machine. The reason I need to be very accurate is because it is an official record of a fault or job, and so if looked back on it needs to be accurate and correct. If for example it wasn't accurate, someone using what I had written to give them an idea of the fault would get the wrong idea, and so it may not be useful in helping them to solve an issue, or it may make it more difficult to sort the issue.

I show respect for the **public good** by ensuring that I keep to patient confidentiality. This means when I come across patient data in my day to day job, I have to ensure I act responsibly with the information and in accordance with the Data Protection Act, the Human Rights Act and the NHS Act 2006. For example when a college tutor came to observe me carrying out a machine run up procedure, I carried out a risk assessment that included patient data, and put measures into place to ensure that the tutor wouldn't be able to take photos of or have access to this data. When disposing of old computers or faulty equipment I also ensure that the hard drive or memory capabilities have been destroyed beyond salvage so that no one will be able to access this patient data. I will also ensure that I keep up to date with the latest patient confidentiality training given to me by the Information Governance course offered by [redacted]

NHS|CSTF|Information Governance - 2 Years|			Y	05-Apr-2019	

A screenshot from my training compliance matrix showing that my Information Governance training is up to date, but will need to be renewed in 2019.

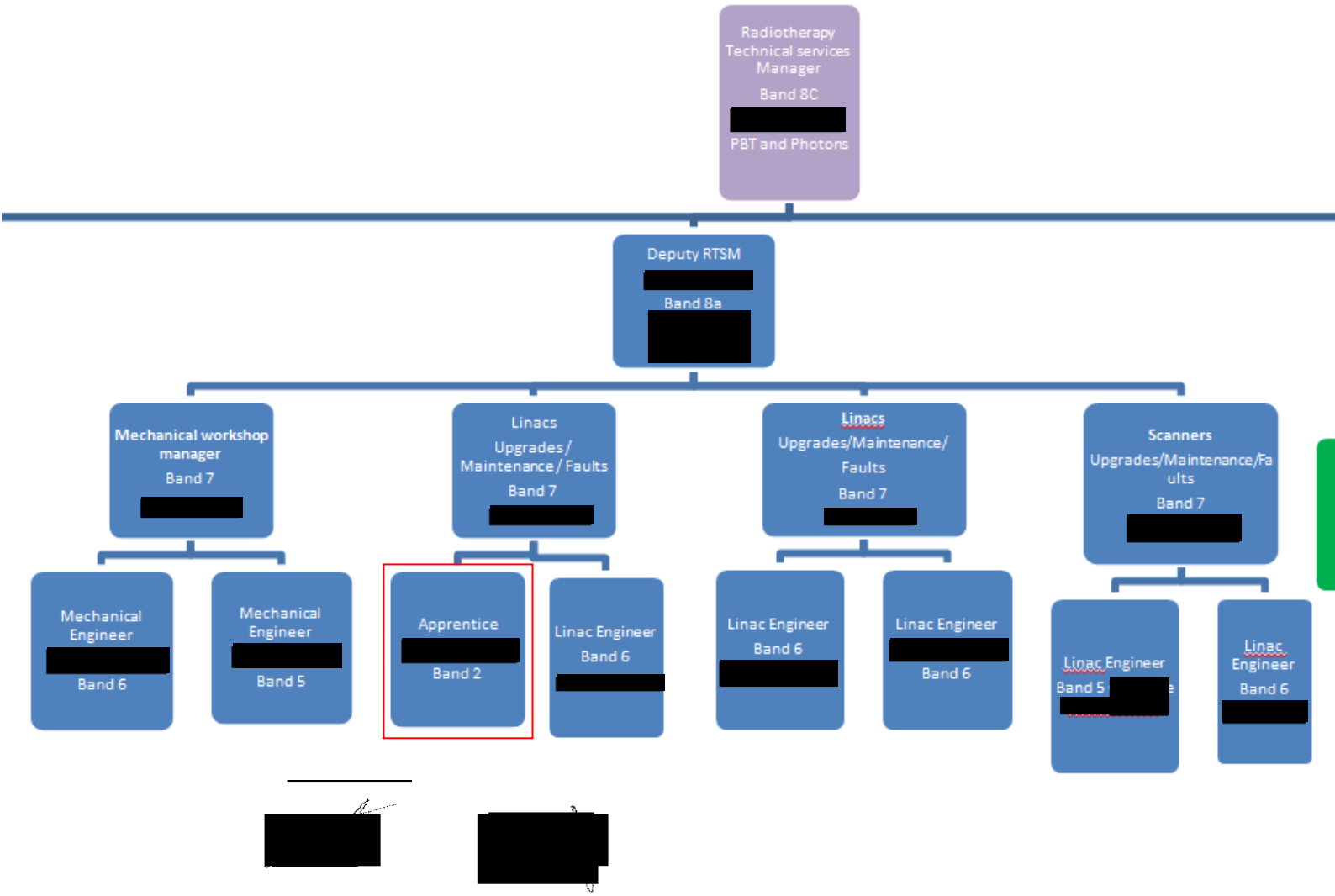
On completion of the IPEM portfolio I plan to register on the Register of Clinical Technologists (RCT). This will mean I will work to another professional standard and prove that I plan to continue in CPD and ensuring that I can be at the top of my profession especially in regards to exercising my responsibilities in an ethical manner.

[redacted]

[redacted]

EngTech Application

RTSG Department Structure



Certificate of Completion

EKP-0443-7891-1610-9696

[redacted]

Elekta Oncology Engineer 1 [1st Line Transition]

June 16, 2017

[redacted]

Head of Techincal Training, Comprehensive Oncology Solutions

ELEKTA

[redacted] [redacted]