COMMISSIONER: This afternoon we return tot topic 11, "The Effects and Threats of Radiation" and I welcome from the United Kingdom, Mr Steve Fisher from the Nuclear Decommissioning Authority. Mr Fisher, thank you very much for joining us on our last public session for 2015.

MR FISHER: Thank you.

COMMISSIONER: Counsel.

MR JACOBI: Mr Steven Fisher is an estate safety assurance manager at the NDA in the United Kingdom. In this role he liaises with regulators, managers and operators of the NDA's nuclear science on a variety of safety issues including radiation protection. He has over 20 years experience in nuclear and radiation industries, including as an operator at nuclear facilities and as a nuclear regulator for the Environment Agency, where he inspects radiation protection measures in place at those facilities. Mr Fisher is the NDA representative in a number of industry groups in the UK, including the National Dose Assessment Working Group and the Nuclear Science Energy Forum. He is a physicist by training and the Commission calls Mr Steven Fisher.

COMMISSIONER: Mr Fisher, if I could start, we are interested, as you are well aware, on public and occupational radiation exposure. So perhaps that we get in context, can you briefly go through the facilities in the UK that – so that we can get some understanding of the breadth of the activities and we might then address any particular facilities typical or atypical. I have one in mind. So I might ask you some questions there but broadly, what are we looking at in the UK?

MR FISHER: Well, we have a range of facilities in the UK. We have what effectively is the first generation of nuclear power reactors which are the Magnox stations. They are fifties and sixties and operated up to the late nineties and in to the 2000s. They are particular, mainly to the UK. We also have second generation nuclear power stations which are the stations run by British Energy. They are coming to the end of their lives but still have several years. So that is the electricity generation side. Associated that there are a few sites that have – well, are sponsored by government to look in to nuclear technologies, new research reactors effectively, of how we develop in to the future. Again, those are from the sixties. We also have a near surface disposal facility called the low-level waste facility which is near – up in Drigg in Cumbria. That is where the lowest level of – or low-level radioactive waste is disposed of in to engineered trenches, at the surface. Currently we do not have a deep geological facility for disposing of the highest level, intermediate level waste. That is still under development and is something that the government and the UK is working on.

The last one I want to talk about is Summerfield, that is where in the UK an awful lot of fuel reprocessing, some development, some fuel manufacture is done. It is a very complex and quite tight facility in the north-west of England on the (indistinct) Cumbria. I am sure we will talk about that because it is a very unusual thing. We do have on the fuel fabrication side, we have a site near Preston, very close to where I am in fact, called Springfields where the Magnox fuel for the power reactors and some of the fuel for the second-generation reactors were made. And near Chester there is a uranium enrichment facility where the earlier stages of fuel manufacture, where the uranium is taken and processed to higher enrichment factor for suitable for making in to fuel that then can be placed in to the power reactors. We do have various military facilities but I believe that is – they are not within the scope of this Commission.

COMMISSIONER: Yes, that is quite correct. All right. That is a good start. Can we then move on to public doses? What are the limits in the UK and perhaps counsel might want to walk you through some of those details.

MR JACOBI: I am just wondering – I think we have got a slide that picks it up, that you have supplied us. I am just wondering whether you could walk us broadly through what the public dose limits are in the UK and then perhaps we can place those limits in context.

MR FISHER: Right. Well, the main public dose limit in the UK is one millisievert; that is a radiation doses to the public. We also have in the UK, a couple of extra limits that we work to. One is that for any single site, while there is a whole range – any single site is 0.5, half a millisievert and for any new source, which might be just a single facility on a site, 0.3. So those are below the specific new facilities or sites where the annual limit that we work to is one millisievert. It is interesting to put it in to context in respect of that annual limit of one millisievert compare it to the average radiation exposure in the UK is 2.7 millisieverts. So the public limit is well below the UK average exposure. That is an average exposure in the UK. There are certain parts of the UK, such as Cornwall in the extreme south west of the UK, because they are granite areas, Cornwall is a granite area, there is big radar(?) problem and the average dose in Cornwall is 7.8 millisieverts. I didn't put that on the graph because it would make everything too small to see.

MR JACOBI: Right. Can I - - -

MR FISHER: That gives a context that it is much bigger than even the average dose in the UK.

MR JACOBI: Can I - - -

MR FISHER: So that is what limits we work to.

MR JACOBI: Can I just pick up the .5 figure. In terms of thinking about what the additional dose is to a member of the public of .5 of a millisievert, how is that measured, or where is that measured? Is that – in terms of a particular individual that might be exposed?

MR FISHER: That is – sorry, say again?

MR JACOBI: Sorry. I am just keen to pick up, what is the reference point that is used in order to evaluate the .5 figure? How would one know that one has exceeded it?

MR FISHER: There is a range of measures that we do for that and we can maybe come on to that in the next slide.

MR JACOBI: Right.

MR FISHER: But it is from direct radiation from the site, i.e., somebody who is living in a house outside – just outside the site boundary. There is also discharges both gaseous and liquid and the food that they eat in the environment. And to some extent their activities because if you are a – we have a term (indistinct) who goes out basically – sorry, it's a duck hunter. If you are going out and hunting ducks, you are crawling around on the mud and sediment, there might be radioactive that's in there, you can be picking it up. So there is a range of (indistinct) that we take and look at what people are doing.

MR JACOBI: Yes. And so a duck hunter is just one of a range of reference cases that you can use for evaluation?

MR FISHER: That's right, yes.

MR JACOBI: Now can I just take - - -

MR FISHER: We have like a - - -

MR JACOBI: Sorry.

MR FISHER: No.

MR JACOBI: Can I - - -

MR FISHER: We have a range of what we call reference persons, those who

might be – their particular activity, whether they are beachcombers, duck hunters, whether they are living very close to a site, like the site boundary, or they might be eating a lot of a particular type of food, in particular seafood and shellfish. They can concentrate radioactivity and we know that they do that, so we measure shellfish, assess how much of those types of food people eat and therefore give them effectively what we consider the dose they might (indistinct) discharges and that is what we then compare against the dose limits.

MR JACOBI: Yes. Can I just pick up on the three brown columns that appear on the right most of that chart and I am just interested to understand whether you can offer us an interpretation of what is shown for both Sellafield, for Magnox and for Capenhurst?

MR FISHER: Yes, the brown bars on the right hand side of that slide are actual doses that we are measuring and calculating from certain sites. Sellafield is the - slightly the – just the biggest bar there but well below the dose limit. That is for reference people outside and living near Sellafield. In fact, the biggest part component of that bar is from historic discharges and they are fish eaters and shellfish eaters - - -

MR JACOBI: Right.

MR FISHER: - - - around in the areas of Sellafield. Now - - -

MR JACOBI: That is the greatest possible reference case is that right?

MR FISHER: That is the biggest one in - - -

MR JACOBI: Right.

MR FISHER: - - - the UK, that is right. However, I will just qualify that. That is – when we say it is from Summerfield, it's actually a reference person living around Summerfield. A lot, and in fact the majority of that dose that somebody gets is not from the Sellafield site, it is from historic discharges from the phosphate factory that was slightly up the road that did chemicals and phosphate detergents, they process phosphate and that natural radioactivity from the phosphates was flushed out in to the sea. That concentrates in the fish and that is where the majority of the dose from somebody living and eating shellfish around Sellafield gets it from. It's not from the nuclear site.

MR JACOBI: Right. Can I just come quickly then to the Magnox, is that an operating Magnox reactor that (indistinct) or is that a decommissioned?

MR FISHER: That is a decommissioned, it's under decommissioning, it's

been defueled, it's not operational but that covers some of the discharges that are still going on, some direct shine(?).

MR JACOBI: Yes.

MR FISHER: I have chosen that one as the highest dose at 0.027.

MR JACOBI: Right.

MR FISHER: That Hartlepool one is the one that is the highest and it is mainly from direct shine not from gaseous discharges or liquid discharges.

MR JACOBI: Right. And Capenhurst?

MR FISHER: The third one there - - -

MR JACOBI: Yes.

MR FISHER: Sorry?

MR JACOBI: Yes, can you go to the third one.

MR FISHER: Capenhurst, that is an unusual one. It is no longer operational, it has been decommissioned, it is now a uranium storage site. So we, in the UK, have quite a lot of what we call cylinders of uranium hexafluoride which was used to transport the uranium around for processing in to fuel. Capenhurst is now a site that has a lot of these stored out on concrete rafts. That is why this – I have labelled that down as direct shine. If you have even a slight elevated radiation dose, if somebody is living – if there is a house next door, and there is a house just outside the site boundary, we assume and – that somebody is living there for effectively 18 hours a day.

MR JACOBI: Yes. Well, I think - - -

MR FISHER: And the (indistinct) for that time of 365 days of the year or 300 days in the year, we let them go away on holiday, that is the kind of dose that they could get. It's not from discharges; it's from the very slight extra background gamma shine that they are there for a long time.

MR JACOBI: All right. I think what you have just explained might be picked up conceptually in slide number 4 and that is a conceptualisation and I am just interested, perhaps you could explain just by reference to, I think the orange column, the total dose, just what the steps are in making the calculations? Just very briefly.

MR FISHER: Very briefly, we want to make sure that we capture all the sources that somebody might be exposed to. So we are looking at the doses from the site by gaseous discharges, the liquid discharges and the direct radiation which we can actually then measure. We need to work out what pathway those exposures can get to them by what they are eating, how long they might be doing a certain activity, like living by the site, by walking on the beach. We use the monitoring data that is collected from the foodstuffs and seafood. We measure the radioactive content and then assume that is something that they then eat and we normally take that they are quite high, not excessive, but quite high eaters of particular food. So for fish eaters that is their main component of food. They are not eating it for breakfast, dinner and tea but they are eating it quite a lot. Habit surveys, where the organisations who do these calculations, work out and go out to local and they use national data as well, and find out – because we find that if you're a fisherman, you are more likely to eat fish because you have just caught it. So we do survey people and find out how much fish they eat. It is just not a random thing that we have made up. You actually base it on data from people who are there.

So you can calculate what their exposures are to a particularly – the highest person, a representative person, what we used to call the critical group, but is a representative person of the most exposed group so we can actually then compare that person against the dose limits.

MR JACOBI: So the idea of a total dose gives you the most conservative possible outcome?

MR FISHER: It is conservative; it's not the most conservative. But it is based on real data. There is a requirement under law to make the dose assessment realistic and therefore we also take some – quite a lot of conservatism but it's not the average person. Where we say somebody is a fish eater, they eat a lot of fish but they are not eating, you know 10 kilos a day, they might be eating several kilos a week but that is still quite a lot of fish and seafood that they are eating. But there are, or could potentially – that is the thing to remember on this, is that we don't actually have to find a particular person like that, we think well it could be somebody like that. There might have been somebody in the past where we talk about Capenhurst, we are assuming somebody is living there 18 hours a day; it might be that they are going 30 miles to work and they are only living there a few hours a day. We say that they could be living there for 18 hours a day; therefore we calculate it on that as a maximum cautious assessment.

MR JACOBI: All right. Well, picking up Capenhurst and those sites, I think what we are interested to understand is the key points in terms of these measurements of total exposure or total doses. And perhaps dealing with it first in relation to nuclear fuel production and reprocessing sites, so that picks

up Sellafield, Springfields and Capenhurst. I think we have got a slide that picks it up, slide 5.

MR FISHER: Okay. What we have done is we have – there is a lot of interest in this kind of data, so it goes back many years. It isn't just a new thing that we have done. On slide 5 there is a representation there of the doses and if you note it only goes up to 0.75 so it – even in that below the public dose limit of one millisievert. The three sites there are Sellafield, is fuel only processing, sorry Springfields is where the fuel is manufactured and Capenhurst is a storage and the enrichment facility. The bars there are over years. In general, the trend has I suppose dropped down. There is a few years that they go up and that can be a variation in either what the radio nuclear concentration is in a particular (indistinct) environment or a change in the habit survey. We don't just use the same habit survey. There is a – as part of this monitoring programme, we go around and check what the habits of people around in the local to that site. Summerfield is unusual, we do that every year. Other sites they are done on a risk-based approach, dependent on how variable we think the arrangements are and what the doses are.

The reason for saying Capenhurst, which is the bottom one there, jumping up a little bit in the last year, is because not a change in the habit but more material started to be stored there and therefore – and in a different place, closer to the fence. Therefore the radiation dose outside the fence increased a slight bit but of course when you times it through by the 18 hours a day, 300 days a year, therefore there is an extra increase dose there. In general Sellafield doses, which is at the top, have dropped over years as changes to the processes have done, improvements. The last jump was due to a change in the habit survey. There was a change to some of the shellfish consumer; they were eating different types of shellfish and more of it. Therefore that is shown in the assessment, although it is still well below the public dose limit of one millisievert.

MR JACOBI: All right. Can I just come to nuclear power stations? And skipping over on to slide number 7, I think we have got a map of the UK against which they are plotted and it might be easier in due course to read it from the table but perhaps just by reference to that, could you identify a currently operating second generation reactor from that set?

MR FISHER: Second generation is the second one down on the left hand side, labelled - - -

MR JACOBI: Heysham.

MR FISHER: Heysham.

MR JACOBI: Yes.

MR FISHER: That is right. A lot of these are Magnox stations and there are (indistinct) on the left hand side – sorry, the right hand side, is Sizewell B - - -

MR JACOBI: Yes.

MR FISHER: - - - that is also a newer station. So those doses are very low.

MR JACOBI: All right. Could we perhaps – perhaps if we come to slide number 8, we can actually read the figures from slide number 8.

MR FISHER: Yes. So Heysham power station that is 0.03, so well below the one millisievert and the contributors there you can see, this is where that value is made up. So it's fish from the discharges when they are eaten and molluscs and also the gamma dose rate from the sediment. It builds up in the sand and the sediment. If it's very fine sediment it tends to accumulate more surface area on fine grains. That picks up the radioactivity potentially and therefore there is a slightly raised background. From Sizewell, that was 0.02 and that direct radiation, the discharges to the air and to the sea are going to be low but the direct radiation, the gamma shine from either the reactor itself, or from any storage of material around but for Sizewell it will be the actual reactor itself. When it's operating it gives off a little bit of radiation and if somebody is living there for – at the site boundary for many hours, that can build up. But of course it is still very, very low.

MR JACOBI: And I think then moving on, I think you mentioned the Drigg low-level waste facility, and I think we have picked that up in the next slide, which is slide number 9.

MR FISHER: Yes. The low-level waste facility is important for the UK because it is where our low-level waste is disposed of. It is an engineer (indistinct) engineered concrete vaults. The waste goes in to isocontainers like shipping containers first and might be in drums as well, they are grouted up and they go and get placed in that facility. Some of the older disposals weren't quite that good. That is an engineered facility but it is a nuclear facility, although it's not an operating reactor, it is there as a disposal facility and it can be either direct radiation shine from that, but of course while it is operating it open to the air, so that potentially could be a gaseous discharge but there (indistinct) all sealed. What we do monitor though is the rainwater runoff. Because the trenches are open, it rains in Cumbria, it's the Lake District, it rains a lot unfortunately. But we collect the rainwater. That is held up, sampled to make sure it's okay before discharging out to sea through a pipeline. But because that goes out to sea, there is a potential (indistinct) to people walking on the beach say and certainly to fish eaters and that is where

we calculate the dose. It is very similar to Summerfield because they are very close. And we say somebody is eating the same food as for Summerfield as for ALARA(?) and again, the majority of that, if we look at it, on the table, it is crustaceans and molluscs, polonium 210. That is from the old phosphate factory that I spoke to before. It's a chemical processing; it's not actually from discharges from the nuclear industry. But somebody in that area, potentially, that representative person eating quite a lot of molluscs, quite a lot of other seafood, could be getting that type of dose but it's still well below the one millisievert.

MR JACOBI: So the dose is .22 against a context of total UK doses of 2.7?

MR FISHER: And the dose limit, if you are a member of the public, of one millisievert. So it is less than a quarter.

MR JACOBI: All right. I think we have then got a map where we have picked up the total doses for all facilities and I am just wondering whether you could offer us any context with respect to that? This is on slide number 10.

MR FISHER: This is – on slide 10; this is a representation of the size of the bar in represents the maximum dose from the calculated sources and compares it to the big blue bar on the right hand side, which is the public dose limit. And as you can see, think it is Summerfield and also Capenhurst there tend to be the biggest ones but they are much smaller than the total blue bar. This could be either the doses from the sites, could either be direct shine, they could be from food, they could be from discharges, but that represents from certain site – all the sites there and it compares it to the dose limit. Would you like to go back a couple of slides and compare those to the – what other kind of doses members of the public can get, slide 3.

MR JACOBI: Yes.

MR FISHER: If that's okay, put it in to context, the UK has a regulatory system that is quite (indistinct) but when we put it in to context here, this is a comparison of some of the other kind of radiation sources that people are exposed to in the UK. We have chest x-ray is 0.14 so that is similar to what somebody might get from direct shine. The average power station worker, we are going to talk about them later, is 0.18. As we go through, we have more medical interventions that CT scan of the chest is 6.6 millisieverts and it goes up for a whole spine. So that puts it in to context. And the slide – on there, the one that we compare it to more is the average UK annual radiation dose of 2.7 millisievert. That is what the average person gets in the UK and as I mentioned before, if you put on Cornwell there, people in Cornwell get 7.8 millisieverts. So that is much larger than the annual dose limit of one.

MR JACOBI: Now can we just come then to the issue of occupational limits and I think we have got a slide, slide number 11 picks up the limits as they apply in the United Kingdom.

RESPONDENT: On slide 11.

MR JACOBI: Yes.

MR FISHER: The annual work dose limit is 20 millisievert and I have compared that to, on the extreme left hand side, to the public dose limit of one millisievert. That is not a limit we use for the workers but it is just to put it in to context because workers, they (indistinct) work controls, so it's slightly different from a member of the public who doesn't have a say in it. We then have other limits for trainees, who are under 18 because they are trainee, they tend to be younger, we make sure that they don't get exposed over six millisieverts. We have a range – although we have a limit of 20, we say – we designate radiation workers where we think they might get over six millisieverts. If you are a radiation worker, there is more controls you have, pre-employment medicals, you have annual medical assessments, your doses are tracked. So there is a lot more things if you are a classified radiation worker and that is (indistinct) happens there.

Slightly strange we have a big green bar measured ALARA(?); we have a concept in the UK that we keep doses as low as reasonably practicable. We don't get up to close to the dose limit and then do something. You probably have this in Australia, it's a fairly standard radiation - - -

MR JACOBI: Yes, that's the case.

MR FISHER: (indistinct) You try and keep the doses down as low as you possibly can and in fact, you potentially – that even if you have a very small dose, well below the dose limit, if you don't apply the LAR principle, you could be prosecuted by enforcement authorities. Because if you are lazy, if you are slack, if you give somebody a dose that they really shouldn't have received, even if it is a very small dose, well below the public dose limit, because the LAR principle is important, you could be prosecuted. So always this downward pressure. Going across, the next one is what we call an operator constraint. That is like a self-imposed dose limit. Now that can vary between operators but they say well although the dose limit is 20 (indistinct) say we don't want to give any of our workers more than 10. Now you might say, well we might in certain circumstances give somebody more than 10 but it might have to be authorised by your managing director or chief operating officer. And it will have to go through a process for that approval, so there is an extra limit to push those doses down.

Now the last two on that slide are the maximum doses, in recent years, have come from Summerfield and an operating reactor Heysham 2. These are the maximum doses received by those – by people. They are not typical; they will be the maximum dose. Out of Summerfield was about 11,000 people on the Summerfield site. The maximum dose, that one person got was effectively 9.3 - - -

MR JACOBI: And when you refer to - - -

MR FISHER: - - - now they will be – sorry.

MR JACOBI: When you refer to a person, you mean a worker?

MR FISHER: A worker. Sorry, yes.

MR JACOBI: Yes.

MR FISHER: A worker on the site. This is worker dose. They would have been doing something in particular. We find that specialist group, specialist people like weld inspectors, or (indistinct) myself as a health and safety person, someone going in to do a very specialist job might be the one who gets the biggest dose in the whole group/organisation or site. And that is the case for Heysham 2 which is an operating power station. That person was a weld inspector because we want to make sure the reactor is safe. There is a lot of pipe work. Once the welding has been done by someone, the weld inspector will go in, because it's an operating one – or they won't – don't (indistinct) they will go in close to the reactor, quite high dose rates, they will go in and check because they are the specialist to make sure it is done. And that is the type of work will accrue these types of doses. For Summerfield it might have been someone doing some decontamination work in a high dose rate area, or work in a high dose rate area but that is the maximum that somebody has received at those sites.

MR JACOBI: Just to pick up - - -

MR FISHER: (indistinct)

MR JACOBI: Just to pick up the - - -

MR FISHER: (indistinct) year to year, depending on what work they are doing, what the cycle is. For power reactors currently, they tend to operate fairly steadily over like a three-year period. Once every three years they have a shutdown, they have a major maintenance period and they go in to the reactor vessel sometimes, or very close to it and do these welds, inspections, change valves and that is when they get some dose. So Heysham 2 might have been

very low, it might have been less than one millisievert for the last two years; this bit of work is a special bit of work and therefore the dose goes up, but still well managed, it's planned.

MR JACOBI: Now just to pick up the difference between what a particular individual might experience as a maximum and against the wider subset, I think we have got a slide that picks up averages for the Sellafield site. I think it's slide number 12.

MR FISHER: Yes. (indistinct) shows over a long time series, I seem to be breaking up a little bit here so please let me know if you can't hear. But over a long time series, we don't just do this once a year or anything; we do track this and have a great dose trend. But the trend there, it's shown that over time, the maximum individual dose is greater than the average dose per the worker's over the Sellafield site but in general they are going down. Now it might not be that maximum, which is the blue bar, the maximum individual worker probably won't be the same person. It goes between what work is being done, different areas of sites, there – Sellafield is kind of a complex site, a lot of things going on and so it won't be the same person – that one person who is receiving that maximum dose. But it is going down, there's a lot of pressure to make things better, to limit doses and you can see now that, it's dropped from – in the past it's been up to 14 and it's now going to around eight millisieverts a year. Of course that might vary but it's that one individual person, whereas the average dose per worker, for those 11,000 odd people, or those who are involved in the radiation work, I should say, because not everybody is, is very low and is tracking below half of a millisievert there.

COMMISSIONER: Yes. Mr Fisher, can I ask is there a regulation that talks about the aggregate dose that a worker can get over a lifetime?

MR FISHER: There is – in the UK we apply a 20 millisievert a year limit. The radiation (indistinct) radiation regulations we work to, allows a dose limit of 100 millisievert, averaged over five years. Now that comes from European legislation because it might be you might have a specialist welder from Europe where they do this apply this 100 millisievert over five years; they come in to the UK to do some work and you find that they are over the 20 millisieverts. Now we can't stop them coming in and doing work. But in the UK it is very strict, you have to apply to the regulator first, to anyone, to go over in to that (indistinct) We effectively have a 20 millisievert a year dose limit. As for a cumulative lifetime dose, there isn't a limit on that. What we do though is we track the people who have been in the UK industry for a long time, that there isn't a total lifetime dose. We try and keep it as low as possible and certainly these days it is very unusual to have anyone even over a 40-year lifetime to get up in to the 100 millisieverts. That is very unusual. There will be some, and again, it relates to their total lifetime dose and as mentioned before, what was

the limits 30 years ago, were much greater. But they don't – we don't have a total lifetime dose in the UK.

MR JACOBI: Can I just take you just to perhaps round out the issue of occupational exposures? We have done Sellafield and in fact I think we picked up the EDF Heysham but we have got some other sites on another graph that show some comparisons across types of facilities and that is slide number 13 and I am just wondering whether you could offer some insight in to what the Dounreay research reactor is in comparison and offer that in comparison to the URENCO enrichment facility.

MR FISHER: Yes, there is some data here; it's not totality (indistinct) able to get some data, more recent data in. We found that the doses are particular to operators and we don't have a central registry in the UK, like we do for the public dose limits, the RIFE report that we looked through earlier. However, there is a lot of sharing in the UK and this is a graph on slide 13, the maximum dose to a worker compared to the average and in general you can see that the average is much, much lower than the one individual maximum (indistinct) site. Dounreay is a research reactor where a lot of development work was done. That is now in to decommissioning. Excuse me. The URENCO UK is an enrichment site where they take uranium and enrich it and develop subsequent fuel fabrication at Springfields. Summerfield is a complex site we talked about. There is the operating reactor at Heysham 2 and as I spoke before, that was the maximum dose from a weld inspector. Near surface disposal, because it is moving waste packages around, there is very little dosage there. That is why the dose to the maximum dose there is very low, as is the average.

And the next one there, the last one is the Hinkley Paint. The average doses across the Magnox stations are very low but again there might be this one person who is involved in specialist work, decommissioning of ponds and the high dose rate areas. So what we find in the UK is the maximum is higher than the average but is well within the dose limits but we do find that there are particular types of people, at particulars times of the cycle of a facility, where the maximum is much larger than the average.

MR JACOBI: Now in the RIFE report, the figures were calculated based on a typical pathway. Here for the workers, how are these particular doses aggregated or calculated?

MR FISHER: Well, if you are a radiation worker on a site, you have radiation dosimetry. Now that in the past was (indistinct) and exposed like a photographic film. These days we use TLDs or electronic personal dosimeters. So every time you go in, over the ones (indistinct) to the workface, you will be carrying a little electronic device. It adds up your radiation exposure. At the

end of the shift you put that back in to a reader and it adds it up. So it's personal to you, it adds it up. So every time you go in, maybe twice, three times a day, your radiation exposure is being monitored and it has been summed up by the computer and that is how we measure the radiation dose. Some sites still use thermoluminescent dosimeters; they are normally read on a monthly basis but because they are not direct reading, will not give you a real time readout. They tend to be in lower dose rate areas where we know that people are not going to be exposed to high dose rates.

So the dosimetry is focussed on the type work you are doing, what kind of doses you are likely to receive but they are not calculated as such, they are actually measured every day, all the time people are in the workplace.

MR JACOBI: Right. In the course of other evidence, the Commission has heard about the principles of justification optimisation limitation as it applies to managing radiation risk to workers. I am just interested in understanding, in practical terms in the sorts – given the sorts of facilities we have been talking about, power stations, reprocessing facilities. What is done to control the doses to workers?

MR FISHER: There are a range of control measures from starting from early planning through to control measures just to the individual. A lot now is on the risk assessment before people go in, work out what we can do, what was the best way to put in control measures. For new facilities we do the pre-build design. You try and make sure that people have low radiation areas; there is enough shielding, engineering controls. That people don't have to be exposed. So that is the early planning which for some of our facilities they didn't really have in the – didn't consider very well in the fifties and sixties. So we are struggling with that and certain buildings in the UK and certain facilities. But we have a culture, this culture about ALAR, keeping doses down. There is training. We do offer (indistinct) work where you know that there is going to be high dose rates. There is shielding in place. We might use the (indistinct) technology and if you are handling – well, you don't handle used fuel, you use remote cranes, the cells and you have remote manipulators where people have effectively remote hands and then there are the robot hands inside the cell. They are touching and moving the high dose rate items because you don't let people there. You make sure there is barriers between the people and the radiation sources. We make sure, as far as possible things are contained, things aren't dusted, there's ventilation. They are contained in glove boxes.

There's a lot of engineering keeping people away. We also limit the time that people are there for. If you have higher radiation areas, we will limit the time that people can go in. There will be permits of work that says you can only go through this type of work, for this length of time and then you must withdraw. There's (indistinct) and training, there's a lot of pre-job (indistinct) and if it's a

particular high dose (indistinct) area, we might have demonstration facilities where it looks like the right thing but we don't have the radioactivity and people go through and practice because that way you can practice, you get better, your time increases to do the work. You know what you're doing and therefore you might do a job in half an hour rather than four hours.

MR JACOBI: Sorry, just - - -

MR FISHER: (indistinct) in the hierarchy we put people in personal protective equipment. (indistinct) have lead aprons, you might have respiratory protective equipment in a dusty area. So there is a whole range of controls that we put in place based on the likely dose, the likely risk that people are going to be exposed. Higher dose rates, higher dose rate areas. You might get higher doses, the more control you put in place to stop that kind of dose.

MR JACOBI: You mentioned the planning and the construction of new facilities today. Has there been evidence of success in the way that those newer facilities have been engineered to reduce radiation exposures to workers in facilities as compared to older ones?

MR FISHER: There are both in the fuel fabrication, in the past there were more exposed, the more hands on, now they are – it's more automated the process. At Summerfield we have had a lot of success in putting in new facilities for handling radioactive effluent. Doing reprocessing of fuel, that has been more shielding, more engineering. Even to the extent of designing out maintenance, making maintenance easier. In the past it was all designed around operations, now we are very much more focussed on new facilities are – is it able to be maintained without putting people in to high dose rate areas. So there is shielding, there's maybe positioning of plant. And also looking now on very (indistinct) plant of how easy is it to decommission because some of the Magnox reactors that I'm involved with, because they were fifties and sixties technology, it was very much what can we do to keep the operator working, producing electricity. Now in the newer generation that are coming along, the third generation and the fourth generation of nuclear reactors, that decommissioning is being planned out early, so hopefully that the people will not be getting higher doses and exposures, the workers when they are decommissioning the plants in the future because we realised if you don't build that in at the start, it's far more difficult when you come to do it.

COMMISSIONER: Mr Fisher, thank you very much for your evidence. It was very clear. Very useful for us. That concludes the open sessions for 2015. Should there be need for further sessions; advance notice will be given via our website. We adjourn.

MATTER ADJOURNED AT 7.16 PM ACCORDINGLY