RESUMED **[5.43 pm]**

COMMISSIONER: Welcome back. I welcome Timo Aikas. Thank you again for joining us and good morning.

MR JACOBI: Posiva is the Finnish organisation responsible for the final disposal of spent nuclear fuel from nuclear reactors operating in Finland. Since being employed by Posiva from its establishment in 1995, Mr Timo Aikas retired in 2014 having held the positions of executive vice president and corporate adviser. He holds tertiary qualification in engineering geology and has worked in various aspects of geological disposal of spent nuclear fuel for almost three decades, including in site selection and the design and development of the underground rock characterisation facility, disposal facility and canisters to encapsulate spent fuel. Mr Aikas continues to provide consulting services to a range of clients and the Commission calls once again Mr Timo Aikas.

COMMISSIONER: Timo, if I could start, in Finland what's the source of the requirements for the safety case for the disposal of spent fuel?

MR AIKAS: Of course the main source is the legislation which is given in 1988 in the form of our Nuclear Energy Act which states that the nuclear wastes have to be taken care of safely and responsibly and they should never pose in the future more risk than we are ready to accept to ourselves today. This of course gives the justification for the nuclear safety authority which abbreviated, STUK, to deliver up more detailed guidelines and instructions. In between the STUK and its guidelines there are decrees that are called government decrees which actually give the outline to STUK to develop the more detailed instruction.

COMMISSIONER: I presume we're talking here about a safety case and the requirements of the safety case.

MR AIKAS: Yes. It's a bit - could I have the slide number 2 where the PRIS program is presented because it's a long-term evolution of the safety aspects and the safety case has been developed in our case, because since we started already in early 80s when actually the siting was started as well as the development of the disposal concept which we adopted from Sweden. So there has been conducted a series of safety assessments, how they were called in the early days.

Once the program has moved forward, the safety assessment or safety case has been a very important input for decision-making but at all times a kind of safety assessment which gives the evidence that disposal will be safe has been (indistinct) and in the beginning what caused the safety case was more generic response. It looked at the different alternatives like KBS-3 today and other disposal concepts or repository concepts.

Once we got to the year 1999 and submitted the first decision application, which is called Application for Decision in Principle in Finland, then the current repository KBS-3 was named and fixed. So after this decision, on the way towards the application for construction licence the guidelines to conduct the safety case and present it forward in terms of licensing has become more and more KBS-3 specific. So KBS-3 is a multi-barrier system and all the safety functions requirements today they pretty much are kind of developed in thinking the multi-barrier system, KBS-3, type.

So we'd say it's a long-term evolution how the repository system and disposal concept has been developed and at the same time the requirements for safety case has been developed.

COMMISSIONER: If I could just talk about the safety case then, is it the implementor who's responsible for the development of the safety case or is it STUK?

MR AIKAS: It's the implementor assess for STUK. Could I get the slide number 4. In this picture I have tried to illustrate the roles of both the government, the regulator and implementor. So in Finland, Posiva in this case was the implementor. In our case the responsibility for safe nuclear waste management and disposal rests with the implementor. So the implementor is in charge for developing both the disposal contract and the safety case to defend its safety and put the safety case into the decision-making documents. With these documents will be all forwarded to government and government, for its decision-making, gives the task to the regulator to review and look into the safety case in full fairness for the purposes of the safety case and that the requirements for safe disposal will be met.

Once the regulator gives the statement to government and, if it's possible, then government can make the decision. So the regulator has kind of a veto right if they don't accept the safety case and the implementor has always the responsibility to present the safety case and develop it to such an extent that it fulfils the guidelines of the regulator.

COMMISSIONER: In terms of the development of the safety case, where is Finland at the moment in relation to that?

MR AIKAS: I would say that we have advanced quite far since the safety case which was presented in 2012 as an attachment to an application for construction permit. That was reviewed between 2013 and 2015 and the government gave its consent to construction licence in late 2015. So one could say that this safety case has actually passed the needlepoint through the regulatory review. In this review the regulator has used of course external experts both from domestic and abroad and once we say that we can assess that we have fulfilled the requirements for safe disposal so we can say that the safety cases are developed.

COMMISSIONER: And the next part of the process? What's the next step after construction is complete?

MR AIKAS: The next step is for Posiva to apply for operation licence. Again, a whole safety case has to be appended to the application. We can easily think that the safety case forms three important bases: one is of course the scientific and technical argumentation and evidence which is commonly available and can be judged by experts. The second basis, the actual safety assessment: were the modelling and calculations made against the criteria set. Like in Finland we have a criteria that during the first several thousand years the most exposed persons shall not exceed 0.1 millisievert per year exposure. So the safety assessment has to fulfil that radiation exposures don't exceed the safety limits. The third base of the safety case will concern, "Can we do this in reality as the requirements present?" because if we can't exactly fulfil the requirements also by implementation then we can't know that it's really safe.

Where we are in Finland now, we are assessing that we can do everything in reality. I mean have canisters, construct the underground openings, we can install the buffer, we can manufacture the backfill and install the backfill as it's required and so forth. So the third base is the evidence that this can be done based on the requirements set. That's the task of Posiva now, to assess that in conjunction with operation licence that we can really manage to get what (indistinct) action and leave the canister at great depth for its journey to the future.

COMMISSIONER: I think we want go in a little more detail but can I just refresh the concept of the role of geology in the safety case and then perhaps to the barrier system as well - the key features.

MR AIKAS: Very briefly, so the repository system which comprises natural systems - that means the natural barrier, which is the host rock, and the engineered system, which is the multi-barriers or multi-barrier system. So the purpose of the bedrock is of course you isolate the waste at great depth and provide favourable conditions for engineered barriers to repay their containment properties. That is, the host rock acts more like a cacoon for engineered barriers and protects them against the conditions and processes which are preventing encroaching to the surface and also for human beings.

The safety function of engineered barriers are mainly to contain the waste for very long periods of time, like canister is the main component in this containment. Then the other engineered barriers like buffer and backfill, their role is also to contribute to the favourable conditions so that the canister will retain its good isolation and containment properties and also mechanically protect the canister from external events and the processes at the (indistinct)

COMMISSIONER: In your assessment there's obviously a scenario where it all works perfectly but I'm assuming that when you develop a safety case you also look at scenarios when some of these barriers fail. Could you just walk through the range of scenarios that you use that you model that you have to prove to the regulator that it's still safe despite unforeseen activities.

MR AIKAS: Before going into scenarios, could I have the slide number 3, please, because this actually presents how the safety case is being built at the safety case which was submitted as an attachment to the construction licence. So everything starts of course with the design basis in which we actually try to consider all the conditions and laws which have to be taken into account when designing the disposal system. Therefore we have to develop design basis scenarios, which is the kind of expected evolution, what will happen in geosphere with time. Then we, based on the safety functions of disposal system, we place performance targets on the engineered barriers and barrier properties on the geosphere. We don't really set requirements on the geosphere because it's a natural material which cannot be manufactured. So we can only say that we have some target properties which we're looking after. Then after we have - - -

COMMISSIONER: Mr Aikas, can I just interrupt you there. Could I get you to explain to what extent are those design bases criteria, the performance targets and the target properties specified by the regulator for you to meet.

MR AIKAS: Actually, the regulator, in their guidelines, they say that we have to assign - each barrier has a safety function that it provides for and the guidelines says that we have to assign performance targets on the safety functions and these performance targets shall be measurable, but that's where the regulator ends. Then the implementor has to develop functional requirement on this performance target to say that what does it really mean in reality.

If we take an example, for instance the - like the canister has to protect the spent fuel at all times. It has to also protect it against the ice age or a isostatic pressure of a continent of thick ice sheet. The performance target is of course that the canister is capable of doing this. The functional requirement we have to set is that it has to be designed in such a manner that it's capable of withstanding the moves of continent of ice. Once we come down to the design requirement, we have to put a number on it. Then we think that it's a seven kilometres thick ice sheet so therefore it has to tolerate 45 megapascales and what we have done actually in reality, the (indistinct) has been tested in the pressure chamber against this kind of huge (indistinct) that it really can withstand this loading. So it’s a kind of chilling (indistinct) regulators the former start it’s the functional requirements and (indistinct)

MR JACOBI: Yes. Can I come back to the top of the chain and deal with what specify – what you described as a guide, am I right in understanding that they are in effect, the legal requirement from the regulator as to what an implementor need to meet in order to be licensed?

MR AIKAS: Yes. The point is that – that it's very important to define the requirements in the very early stage. And therefore what we need is a description of the (indistinct) and the expected evolution to define the possible conditions and (indistinct) where the – where the components will be put in. And by this way we can give off this set of requirements and then work against this work requirements before fill them.

MR JACOBI: And so am I right in understanding that in terms of the – what you've described there and we'll come back to working our way through. I'm sorry - - -

MR AIKAS: Yes.

MR JACOBI: - - - we'll come back to working our way through the safety case image we've got. Is the concept of a safety case itself an expectation of the regulator?

MR AIKAS: Yes, that's true. That in – it's guideline, regulator has given a really good description of how the safety case shall be conducted today and what it shall contain. So that the – so that it's the kind of form of process today, if you like. So it's – because it's regulated, so (indistinct) on it.

MR JACOBI: Yes.

MR AIKAS: You can - - -

MR JACOBI: Now apologise, I've taken you out of sequence. I think we were at the point of you explaining – I think we're through the performance targets and target properties and how they were developed as part of the safety case. Do you want to continue on explaining the issues of design requirements and then how they then lead in to assessment?

MR AIKAS: Well yes, they were (indistinct) in slide number three, is the performance assessment, so it's vitally important that – that the former assessment we're looking with this system and the components, how they will survive the conditions ESU, based on ratio it's no (indistinct) now I need (indistinct) at the great depth in the background. And – and performance assessment is in a kind of tool so show how well the requirements will be met. So that it also includes the different kind of assumptions that there will be some defect or – or a mistake in the installation and how this would affect the system performance. And the outcome of the performance assessment is an important tool to establish the scenario for safety assessment. I mean the calculation cases when we try to calculate the possible radiological consequences coming from the repository to the environment, either the geosphere or the (indistinct) organic environment. So – so the – when we have – when we have established the (indistinct) basis with the requirements and conducted the performance assessment and we have received information from the – from the performance assessment, we can start to establish the scenario. And on the slide number five, there are the types of scenarios which have been developed and used in the latest safety case. So what we call the base scenario is the – is the most likely case which – which we think will happen in the future, so it's the expected evolution and – and it – in the best case, when we can calculate and look in to the (indistinct) case. Then we also taking the considerations on the incidental deviations from the – from the reference case - - -

MR JACOBI: I might just get you to - - -

MR AIKAS: (indistinct)

MR JACOBI: I might just get you to unpack that a little. You talk about the expected evolution, could you explain the expected evolution of what?

MR AIKAS: The expected evolution of – of conditions in the bedrock. So we have to look in all processes which may influence the properties at great depth which again could influence the disposal system at great depth. Let's take for instance that here in the north; we have seen similar glacial cycles, even the last several hundreds of thousands of years. When the glacial sheer has started to (indistinct) in the Swiss and (indistinct) mountains and started to crack and has reached the Rhine river in Europe and then retreated again. So we have to look and study what kind of effects this kind of evolution like a glacial cycle would cause at the great depth and would impact our disposal system. This means that we have to consider the effects of glacial – of the climate change towards the glacial environment with the permafrost – with the permafrost penetrating to the bedrock several hundreds of metres of depth. How that would affect the infiltration of the precipitation groundwater, how this would affect the chemistry of the infiltrating water and the chemical conditions in the groundwater and also the flow. And – and so that – so that this is part of the expected evolution. The question is the uncertainty is only tiny, when does it actually start and when does it end? And in this tiny question, the knowledge of the previous glacial cycles of course is of help, so that they can – expected evolution will be pretty much (indistinct) and everything would happen as it has happened before.

MR JACOBI: Yes. And you've referred to, I think it describes incidental deviations. Does that reflect that some parameters will be within a range and so you need to work from the top and the bottom of some of the – of those inputs?

MR AIKAS: Yes, a good example of this (indistinct) the deviation is that we – we assume that there would be one or two original defect (indistinct) canisters going to the repository, due to the – due to the undetected defects in the welding seam of the canister.

MR JACOBI: Now that's an assumption.

MR AIKAS: So that – that's an incidental deviation because that has been something which was ever – was not able to rule out entirely when this safety case was made.

MR JACOBI: Can I just - - -

MR AIKAS: After – yes.

COMMISSIONER: Sorry, Timo, while we're on the canister, can I just interrupt. I read some reports about questions in terms of corrosion of the canister and since that's the principal means of constraining the radionuclides that process has completed. So Posiva has convinced the independent regulator that those canisters are capable of containing the radionuclides for thousands of years?

MR AIKAS: Yes, at the moment there is I guess a very good concern on the corrosion properties of (indistinct) copper in the repository conditions so that the assumptions which have been presented during the last 10, 15 years on the possible other forms of corrosion than sulphide-driven corrosion. So they are not really a serious danger to the performance of the canister but they are some surface phenomena which you'd expect. Indeed, the knowledge based on the corrosion - that the regulatory conditions which are reducing corrosion, reducing conditions, and we have a 50-millimetre thick overpack so it will withstand very well the steady corrosion in those conditions. The disposal system is of course - it's very safe but at some point with the time the corrosion will proceed and we can see within a million years' time that some of the characteristics will lose integrity due to the corrosion but this happens probably with a few canisters, most likely.

MR JACOBI: I think we're at the point of dealing with what you described as an incidental deviation, which was that for the purposes of your base scenario - am I right in understanding that you've assumed in your base scenario that a canister might not be integral?

MR AIKAS: Yes, because at the time when this safety case was done the reference method for sealing the copper lid was electron-beam welding. The inspection of electron-beam welding seam is a bit tricky, especially with thick copper. Because electron-beam welding is a real fusion where you melt the copper and the seam properties, they are not similar as the overpack copper is. So the grain size is much thicker in depth. So in spite of using ultrasound and x-ray and other methods so we could (indistinct) entirely out and there could be one or two canisters which could have the original defect in the weldings.

I can tell you that after submitting the application today Posiva has made an agreement with SKB on using friction-stir welding method for lid sealing and this method is much more easily inspected. So it's grain size is almost similar unless it's in overpack. So SKB (indistinct) safety case, they don't assume there will be issue of defective canisters at all.

MR JACOBI: But that's an example of what I understand to be an incidental deviation. So that's something that's modelled for in the baseline case.

MR AIKAS: Yes.

MR JACOBI: Can we then deal with what you describe as a variance scenario. I think we've dealt with these in earlier sessions with respect to the range of future scenarios. What were the range of future scenarios that were modelled with respect to the Finnish safety analysis?

MR AIKAS: The reference case or variance scenario is that everything works as planned and we can fulfil all the requirements and this case is very safe. The variance scenarios, they are not as likely as base scenario but reasonably likely. So that in this variance scenario are assumed that some processes may be more quicker than anticipated in base scenario. The consequences of these will be the (indistinct)

On slide 5 the unlikely events, they are collected under disturbance scenarios. You can call a scenario like, "What if?" scenarios. That's what if something happens but it's not in the range of expected evolution but goes beyond? What would happen in that case? These disturbance scenarios, the mostly include some disruptive events of geosphere, like rock shear, but like a fault movement causing an earthquake and this earthquake seismic wave would then cause some rock shear in the repository, causing the impacts on the disposal system. These disturbance scenarios also include human intrusion. So what if we humans ourselves intrude in the repository and become exposed to radiation.

MR JACOBI: Before we come to the outputs of the safety assessments that were undertaken for the Finnish system, I'm interested in how you gather the data in order to form a view about the inputs with respect first to the geology and then to the engineer barriers. To what extent was there a scientific program to gather the information in order to form a view about the prospects of the geology to both contain and isolate?

MR AIKAS: That's a very good question: how to collect data? It's a long-term process, basically. Like I mentioned, we have conducted earlier similar safety assessments and these safety assessments actually give you clues what kind of data to collect and what information is needed. Of course by investigating sites, by drilling and other methods we collect lots of information of the geological properties, like the structure and the rock types and the groundwater chemistry and groundwater floor, which can be put into the models and then analysed. As well we are looking at the properties of the canisters and the other barriers, like buffer and backfill, because the containment and isolation of the engineered system is very much based on the proven technical quality of these barrier components, like the proven technical quality of the copper canister and inserts and the proven technical quality of the bentonite buffer and the backfill and closure materials. So we have to characterise the materials extremely well so that we know how they behave.

MR JACOBI: I'm interested in picking up on the geology. Reading the safety case synthesis, there's reference to there being rock suitability classification criteria that are set in advance.

MR AIKAS: Yes.

MR JACOBI: And I'm interested in the nature of the science that was then undertaken in order to establish whether the rocks that were you studying in fact met the criteria that you'd set in advance.

MR AIKAS: The rock suitability criteria or rock classification, it works in scales. In the current papers, and if you read Posiva's current reports, the emphasis is very much in the small scale, in the tunnel scale and in the deposition hole scale. But if we look at the big picture, we are looking at the site scale and what are the size of a proper site, which are the bounding features and geological features which actually bound a proper site. That's the first step. The second step, once we have located a site, what are the layered determining features, which is an important step, to define that this is actually part of classification. Like in our bedrock we have lots of (indistinct) claims where we have fracture zones and crushed rock which actually defines the repository area and repository panels, as we call them.

Then once we go inside these repository panels we come into the tunnel scale and the deposition hole scale. This is now very closely tied with the functional requirements of engineered barriers and the target properties of the rock because the target properties are such that they define how much groundwater flow will be allowed to a single deposition hole, for instance. Because this flow has to be constrained because if it's too high it may have an impact on bentonite buffer, like causing erosion, for instance. If there's flowing water and salt, clay material will be easily eroded away, and this cannot happen.

Also, if we are looking into the fracture system we try to locate locations where there would be no fractures or just very small fractures in size because the rock mechanical analysis shows that if there are large fractures they can be connected to each other and if there would be a large seismic event, these fractures would be able to transmit movement and cause a rock shear which might then impact again the buffer and canister and cause some undesired events in the deposition hole.

So the purpose of the rock classification system and the suitability criteria is to locate suitable positions for canister holes where the canisters will be put. In the long-run the canister holes would see as little water as possible and the buffer and canister systems would become as little as possible prone to corrosion and turnover of the groundwater. It's a very complex issue because it's trying to classify a natural system which is very difficult.

MR JACOBI: I think perhaps moving away from the natural and going to the man-made, with respect to the engineered barriers, again as I understand it, there's a performance assessment undertaken where the particular barriers are scientifically assessed as an input. I'm just interested with respect to the Finnish multi-barrier system what was the extent of the testing and analysis that was undertaken in order to be input into your safety case.

MR AIKAS: There was a slight disturbance in the - could you repeat the actual question.

MR JACOBI: Yes, sorry. Coming to engineered barriers, I'm just interested to understand the extent to which there was scientific analysis that was undertaken to provide the relevant inputs or parameters that went into the safety case with respect to the particular multi-barrier systems.

MR AIKAS: This is a very difficult question, actually. If we're looking to the behaviour of the disposal system, which is the canister, buffer, backfill and then the rock around it, the difficulty is that these barriers, they are not redundant. If you look at the nuclear power station, you have safety systems that are redundant from each other so that if one system fails, the others continue. But in the natural system like at deep bedrock there are interfaces between the barriers. Like the canister has to interface with the buffer and the buffer has to - with the backfill, and then the buffer and backfill has with the bedrock.

So the most effort scientifically and in testing the behaviour of the system is with these interfaces. Like the canister produces heat, for instance. So the impact of heat is very important to consider on the buffer; how the buffer will be influenced by this heat. This heat impact has to be limited so that the excess heat will not cause undesirable changes in the inserts of the buffer. Then again, this leads to the fact that what would be the optimum density and swelling pressure of the buffer in terms of the protection of the canister. This again sets some interface to backfill because the buffer starts to intrude towards the backfill so the backfill has to be able to keep the buffer down.

So there are also the scientific issues which have to be resolved first by laboratory tests and then by modelling. Then if there are some essential uncertainties or some process parts which are poorly understood, we have to go into large scale testing and long-term testing so that we can see and understand better how the system behaves. I don't know if I can answer your questions precisely but - - -

MR JACOBI: You have. I'm just interested to perhaps pick up that last aspect of practical demonstration and moving beyond the laboratory scale. To what extent is that going to be necessary on an ongoing basis from - you've talked about needing to conduct a safety assessment from an operational point of view. Is that where that sort of assessment is going to become more necessary?

MR AIKAS: I think yes and no. First of all, each repository is kind of first of the kind because it's implemented at the site in a certain geological environment which is unique. So whether you have let's say a KBS-3 type concept and you have to adapt it to a certain site which has different properties than Olkiluoto in Finland or Forsmark in Sweden. To some extent there has to be some testing made to assess that this really works also at this site. The more similar the sites are, of course less tests are required; or the better understanding we have, the less testing is required.

Another issue why testing is needed - and I think that it's a kind of full-scale test without real spent fuel - this kind of test is required in each case to see that we really can construct the tunnel and deposition hole as required with all the constraints as regards to using construction materials and making the excavation, and also managing the stray materials, and then of course installing the system just precisely as planned so that we can see that the system can be installed and we can fulfil the requirements. So for me today it's difficult to imagine how this could be done without the full-scale test.

But it's of course a good question that how fast you can go from a very early phase, from recognising suitable sites and characters, and get to the full-scale test. I think that today there's lots of understanding and this is much, much easier.

MR JACOBI: I just want to come now to the outputs of the safety analysis that were undertaken. I think we might have a graph that picks this up but I might need you to walk us through. But I'm just interested to understand in terms of Posiva's satisfaction, what was its conclusion with respect to the system that it had developed on the site that it had developed?

MR AIKAS: I think that there is still pretty much to be done in terms of developing all the details for manufacturing and installation of these components. So we think that the system is very safe. When we look at the outcome presented in slide number 6 we can see that the margins are large and the system is potentially very safe. But every detail requires lots of work. In safety engineering one says that the devil lives in details, but that's very often true. So that before we can manufacture canisters in a serial fashion and combine the inserts and overpacks, there's still a long way to go before all of this is quantified and accepted to be done in a nuclear facility. But still, I think that today the situation is pretty good.

MR JACOBI: Perhaps if we can come to slide number 6 and perhaps if you could assist us in terms of its interpretation. I think it's another one of these fabulous log-log charts both with respect to time and risk, but could you offer some interpretation in terms of what we're seeing on the X and Y axis.

MR AIKAS: First of all, the X axis is time. So you can see that it extends to million years. The Y axis is peak, normal, activity release, which is an in vectors. So what this graph actually does, it summarises the results of the four scenarios calculated in the safety case. This is a bit cryptic but there are three types of scenarios: those which are marked base scale, BS, in the - this group is what is called reference case or the base scenario. Then we have variance scenarios, the VS scenarios. That's the group of the variance scenarios in which the base case scenario phenomenon has been exaggerated. Then we have disturbance case group, which is this AIC, accelerated insert corrosion case. Then we have this RS, rock shear, and RSDIL - dilution - case.

The BS is indeed the expected evolution and then around it you see some slight calculation cases in which the calculation is a bit different. You can see that the base case is four or five orders of magnitude below the regulatory limit which is marked by the dashed line - - -

MR JACOBI: Am I right, though I think we're looking becquerel as opposed to in millisieverts, is that the equivalent of the .1 millisieverts per year Finnish constraint?

MR AIKAS: Yes, that's right. The green area of this picture is Posiva's interpretation of the time period for which the 0.1 millisievert per year criteria shall be applied. So it's the 10,000 years, when we think that we can assume that the current conditions will prevail. After 10,000 years the uncertainty increases we'd most likely start - the climate starts to move towards the ice age climate.

MR JACOBI: Am I right in understanding you talked about a large margin but what we're looking at with respect to the BS scenario is we're looking at something that is one-ten thousandth of the regulatory limit.

MR AIKAS: Yes. You have to remember that this case now includes the original defective studies, which means that the main dose comes from the carbon-14 and then from iodine-129 and chlorine-36, which are in gaseous form. So if there is a hole in the canister the gas will be released immediately. They are not absorbed in the geosphere. So this is a kind of release mechanism if we assume that there is a hole in the welding seal.

MR JACOBI: Just so we can pick up one of the others, one of the AIC scenarios, I think they were the disturbance scenarios. Is that right?

MR AIKAS: The AIC scenario, that's a kind of scenario in which the hole in the canister grows larger and causes the rapid or more rapid corrosion of the iron insert so this corrosion can (indistinct) that the release from the spent fuel inside the canister would be bigger than in the base scenario. You can really see that it's only, let's say, two orders of magnitude below the regulatory limits.

MR JACOBI: So one-one hundredth.

MR AIKAS: If such thing would happen, the release would be bigger than in the base case scenario.

MR JACOBI: We've heard a bit about human intrusion and other sorts of scenarios. Does that feature on this graph?

MR AIKAS: No, this is not feature on this graph because it's a disruptive scenario and dealt with elsewhere in the safety assessment. The assumption is that a drilling crew would be at the site and would drill through one canister so that they would be so lucky that by drilling a core drilling they would take a sample of a canister where there would be pieces of spent fuel and the drilling technician and the people who are doing the actual handling of a core sample would be exposed to radiation of the spent fuel. In this case there would be no release to the organic environment like in these release cases, but it would be a direct exposure of radiation due to the handling of the core sample. Even in this case, the exposure risk is quite limited.

MR JACOBI: Can I just pick up on what's shown on the far right-hand side as two ranges in yellow and blue. Could you just explain what they are. They're beyond the 10 to the power of six.

MR AIKAS: Yes, because these cases which are presented in the graph mostly deal with the one canister or a few canisters, but then the sensitivity of the results and uncertainties of the results have been dealt with on a kind of Monte Carlo simulation and a PSA, probabilistic safety assessment, methods to look at the impacts of what would happen if there would be more canisters corroding or defective with the time. Like in this rock shear dilution, RSDIL, they represent the case where the rock shear would take place and cause some damage on canister. At the same time there would be no ionic water intruding the great depth which actually would then erode the bentonite buffer, because bentonite buffer is vulnerable in that way; that if there would be no ionic water present then it would kind of get the bentonite to a colloidal form and it would be transported away from the canister hole.

So the assumption is that there would be rock shear and this ice age washing machine, as we call it. What if there would be several canisters affected by this process than just one? These columns on the right in that graph presents that the impact would be a little bit higher than in the case of a few canisters but still it would be less than the regulatory limit.

MR JACOBI: Can I just come to - - -

MR AIKAS: We have - - -

MR JACOBI: Sorry, continue on.

MR AIKAS: What we have to think is that a few thousand canisters are placed around a large area in the bedrock where they come into contact with water flowing and fractures. Not all canister holes see water at all but some do. But they see water at different points of time. The water which comes into contact with the canister holes has a different sulphide (indistinct) which is able to corrode the copper. This means that this system is, in the base case, not at all easily vulnerable. Not at all easily vulnerable even if there would be cases like rock shear or low ionic water introducing at a great depth - which is very unlikely, by the way. We don't have any evidence at the Olkiluoto site in the groundwater chemistry that diluted waters would ever have penetrated to the repository horizon in that depth. Still we do the analysis for it.

MR JACOBI: Can I just come to two final topics, and the first is the extent to which monitoring into the future is to represent a component or an aspect of the disposal concept.

MR AIKAS: What I have to say in the first place is that the safety cannot be based on monitoring. That's the first thing. So the monitoring has been already done at the Olkiluoto site for a very long time to establish the baseline. Monitoring is important during the construction and operation phase to see what kind of impacts the construction and operation will cause in the geological environment. During the operation time, before the closure of the repository, it's also important to monitor the system by the evolution of temperature, the groundwater - I mean how the hydraulic head will be restored at the site. Perhaps we can monitor the wetting or the saturation of the system of the backfill and buffer, but then (indistinct) monitoring is of course a tricky issue because what can be - no regard to monitoring information but that we can only see how the system behaves but the safety cannot based on the continuous monitoring, it has to be based on the fulfilment of the requirements.

MR JACOBI: I'm just interested also to the extent to which if something is observed to go wrong - and in this I include during the operational life of the facility as canisters are deposited - to what extent is retrievability built into the concept in Finland?

MR AIKAS: The system is fully equipped. They are retrievable during the operation period of course. If for some reason there would be information from the follow-up and monitoring that some requirements will not be fulfilled, then of course some corrective measures have to be made, so the system has to be opened and retrieved. This is controversial and expensive but fully possible. Of course it's also possible in that sense that there are facilities above ground where the canisters can be taken in cases where the canisters can be opened and the spent fuel can be removed and put into a storage facility. With the long-term, after the repository has been backfilled, closed and sealed, so retrievable - yes, but it's not designed to be retrievable.

The requirements in Finland deem safe disposal and permanent disposal so that the retrieval shall be extremely difficult. But if in the future technical evolution and development makes it meaningful, it's of course possible, but nobody of course wants to do that.

COMMISSIONER: Timo, one last question: in terms of the facility itself, how long would it be open whilst disposal takes place?

MR AIKAS: With the current inventory in Finland, the disposal period would be a bit more than a hundred years. So if the disposal would start around 2020-25, it would take some hundred years to dispose of the spent fuel from the currently operating reactors and from those which are under construction. So the facility would be sealed sometime in 2110.

COMMISSIONER: In that period of a hundred years, is it envisaged that there would be a pilot operation so that you would monitor performance of the canisters and the bentonite?

MR AIKAS: Most likely. Like, I mentioned that it would be worthwhile to establish a kind of mock-up disposal without real fuel. There could be perhaps heaters simulating the heat generation but which would be monitored continuously not only to increase the understanding of the system behaviour but it's of course important that the system will be technically developed all the time so that it will be optimised and the - I mean that the machines for installation and excavation today, they are the first generation machines. But automation of the machines will evolve and in the future it's important to know what are the issues we can improve and affect. This mock-up of a full-scale kind of exercise will contribute also to this.

Somewhere in the repository there is a need to calibrate, automate machines and do some further developments so that the research and development will actually continue in parallel with the safe operation.

COMMISSIONER: Mr Aikas, thank you very much for your time this morning and thank you for the time you've devoted in preparing this presentation. We very much appreciate your work both now and in the past. We will now adjourn until 7.30 tomorrow morning when we'll have Prof Rodney Ewing from Stanford University.

MR AIKAS: Thank you.

MATTER ADJOURNED AT 6.48 PM UNTIL WEDNESDAY, 6 APRIL 2016