Safe Final Disposal of Spent Nuclear Fuel in Finland
Mr. Mika Pohjonen, Posiva Solutions Oy, and Ms. Mari Lahti, Posiva Oy, Finland

Berta
Welcome everyone to the next GEN IV International Forum webinar presentation. Today's topic is on safe and final disposal of spent nuclear fuel in Finland. Our presenters are Mr. Mika Pohjonen and Ms. Sanna Mustonen. Doing the introduction today is Dr. Patricia Paviet. Patricia is the Group Leader of the Radiological Materials Group at Pacific Northwest National Laboratory. She's the National Technical Director of the Molten Salt Reactor Program for the US Department of Energy. She's also the Chair of the GEN IV International Forum Education and Training Working Group. Patricia?

Dr. Patricia Paviet
Good morning, good afternoon, good evening, everyone. Hope you don't have so much snow like we have right now. Unbelievable. It's my pleasure to have today Mr. Mika Pohjonen and Ms. Sanna Mustonen who are going to present this webinar. Mr. Mika Pohjonen is the Managing Director of Posiva Solutions. He has over 30 years of international experience in the energy sector. He has previously held various sales and management positions in the engineering and management consulting business. Mr. Pohjonen has a broad experience in the nuclear energy business acquired in numerous projects in Finland and most European countries that utilize nuclear energy, as well as in the Middle east and China. He has also worked as an invited expert for the International Atomic Energy Agency in environmental and social impact assessment.

Ms. Sanna Mustonen, Safeguards Officer of Posiva, has 20 years of experience in Posiva and Posiva Solutions. During her career in the program for geological disposal of spent nuclear fuel in Finland, Ms. Mustonen has worked in versatile projects concerning safeguards, data management, excavation works, and machine development among other things. She has been acting in Posiva's safeguards tasks since 2018. Prior to working in Posiva, Ms. Mustonen has worked in mining and in exploration companies.

Without any further delay, I give you the floor, Mika. Thank you very much both of you for volunteering to give this webinar. Thank you.

Mika Pohjonen
Thank you, Patricia. I hope somebody lets me know if my presentation doesn't show. If it shows, I start. My name is Mika

Pohjonen from Posiva Solutions, and I'm very pleased to have this opportunity to tell you a few words about our spent fuel geological disposal project in Finland.

A few words about Posiva, the utility which is responsible or company which is responsible for safe and cost-efficient final disposal of spent nuclear fuel of its owners. Posiva is a private company which is owned by two Finnish nuclear utilities. Teollisuuden Voima is purely privately owned, and then Fortum is stock listed company.

We have approximately 90 employees at the moment, and we hire something like 100 expert person years per year. And as we are now in the middle of intensive construction period, we have 150 construction workers on site.

Our turnover, which is a nice name for cost, was 127 million, because we are cost to our owners, and the subsidiary Posiva Solutions has been established in 2016 and that sells our accumulated expertise and has had projects in approximately 15 countries during this time.

I show you a photo of our home island, which is in southwestern Finland, approximately 300 kilometers from Helsinki. It's five times 1 kilometer [ph] island called Olkiluoto. In the middle in the top, you see three nuclear units. In the middle, Olkiluoto 1, then the second box like one is Olkiluoto 2, and then Olkiluoto 3 which is now in commissioning phase.

And then left of those power plants, you see our wet storage for spent fuel. All the spent fuel produced on the island since 1979, when the first unit was commissioned, has been so far stored in this wet storage.

In the upper right corner, you see a site of place for our final repository for operational waste. It's low and intermediate active waste, and the repository has been in operation since 1992.

We also have test-based [ph] reservation for decommissioning waste, but even the two older units have now 20 years more operating time. So, they will operate until 2044 at least, and the new unit will operate from 60 to 80 years.

In the forefront, you see the topic of today, our construction site of final disposal facility called ONKALO. The construction is ongoing. It was started in 2016, and the application for operating license was submitted at the end of 2021.

This is our project in copper shell, not in a nutshell, because we use copper canister. From the left, first 20 years approximately was spent for site investigation, site selection, and concept development. We applied for our first and most important license, which is the only one which needs to have a political approval or decision in principle. We applied for that in 1999 and got it in 2001.

After that, we had secured the site. We could start constructing ONKALO, which has a dual role. It has been serving and it serves as a research facility, but it also will be a part of the final disposal facility. So it's not a separate laboratory.

In 2012, after approximately 10 years further development, we were ready to apply for a construction license, and we were granted that in 2015. And then we started constructing the final disposal facility itself.

The intensive construction started in 2019 when our owners decided that we go forward and we built really the encapsulation plant, etcetera. So since 2019, our building construction activity has been quite intense. And I already mentioned that a little bit more than one year ago, we submitted the operating license application. Based on our experience, we estimate that the handling of it will take approximately three years. Of course, it's not in our hand. It's in the authorities' hands. But if we get the permit or the license in 2025, we are ready to start operations then, and we will continue approximately 100 years. This is not because we would be especially slow, but this is because Olkiluoto 3 will produce electricity at least 60, if not 80 years from now.

Our concept, in short, is that we pack the fuel assemblies, the cast iron insert, which is then placed in copper overpack. And then that canister is lowered to a depth of 420 meters, put in the final disposal holes in the tunnels and surround it with bentonite [ph]. The tunnels will be backfilled with bentonite and closed with concrete plug. And the bedrock there, 420 meters above us, is 1900 million years old. So it's very stable. We are in the middle of a tectonic plate, so we don't have especially strong earthquakes, only magnitudes one to two as a result of glacial rebounds. So it's a very, very stable rock environment.

As I mentioned, we have used ONKALO, which can be seen here as a graph on the right side. We have been using that for hundreds and hundreds of different studies, investigations of bedrock, of rock construction, and different tests and demonstrations. And we do have dozens of test holes from the surface and underground, 58 deep holes from the surface in the area.

ONKALO has been designed to be part of the final disposal facility. As I mentioned, the benefit from this is, of course, saving cost, not having an extra laboratory, but also getting the information of the environment from the real site from the very beginning.

This is how our facility will look after 100 years. It's quite small, 2 square kilometer footprint only. And this is, of course, due that we have a relatively small inventory in Finland, five reactors only, and we need to dispose of 6500 tons of uranium, which is 3250 canisters.

I show you a few photos of the project status above ground. So here is a picture of the encapsulation plant construction site almost two years ago. I show you this picture because we can see inside the plant. Here is the reception hall where the transfer cask is coming. And then it will be lifted in the vertical position and lowered into a corridor, which is under this whole building. Along the corridor, it will be transported under the hot cell, which we see here, the place where all the magic happens, where the fuel will be taken out of the transport cask. It will be dried, and it will be placed into the copper or the other cast iron insert, which is already in the copper canister in this phase.

Then, the canister will continue its travel. This we don't see anymore, but there's a welding station, there's a machining station, and then there is a cleaning and inspection station. And this area here is the place for the shaft where the elevator will be lowering the cask or the canister down to the depth of 420 meters. That was from left to right. This is from right to left. In fact, the same processes. And here you see the shaft, that’s the last phase of this process.

Just today, we have launched on YouTube a very, very nice animation of this process. You can see that by searching for Posiva encapsulation plan in YouTube. That is in detail describing the process which happens here.

This is the encapsulation plant. Approximately eight months ago, the building was completed, and the installations of equipment and machinery were performed.

These are a few pictures of photos from inside. The message of this slide is mainly that if you follow us in Posiva Solutions and Posiva on YouTube and LinkedIn, you find a lot of information. And as I mentioned, there is this animation released today. And then there is quite recent animation of the whole process as well on YouTube.

If we then dive underground, here, we do see the first final disposal tunnels in the graph. They are these which have been marked with green and still yellow. This is an old picture. These were all now green, meaning completed in last summer. And then you can see the driving ramp down where we have different research and development niches [ph]. And then you can see four shafts. And here are the technical facilities where the next picture or next picture is probably of the shafts. And then there are these technical facilities. And then in the light color, there are future tunnels. We will only excavate five tunnels at a time. And then we will fill them with canisters and then bentonite and then during that, we will excavate the next five, etcetera.

Here, we have some photos of the shafts in the different construction phases. We have personnel shaft, canister shaft, and then two shafts for ventilation. All the operations will happen via the shafts. The ramp will be used only if we need to bring some bigger machine or something up from the repository.

But to avoid that, we do have good technical facilities for maintenance, repair, parking. We have covered area there and facilities for employees, etcetera. This is just the development in the upper left corner. It's from September 20, and here it's December 21. So everything there, including the ventilation, electricity, etcetera, everything has been finalized.

The spent fuel transport is relatively simple in our case, because most of the fuel we have is in Olkiluoto. We have three reactors there. And the other power company, Fortum, has two reactors in Loviisa in southern coast of Finland. It's approximately 300 kilometers away. And this fuel will be transported either by road or by sea. It has not been decided yet but in the standard transport casks.

As I mentioned, we submitted world's first operating license application in end of 2021. It is a 17,000 pages e-document. So it's a series of documents which are cross referenced to make the studying of those easier for the authorities and stakeholders. It also contains, of course, first safety case in the world for operating [Unclear] safety, which has been submitted to authorities.

We kept our schedule again, which was loosely defined or defined 40 years ago. We expect that the H2, half two of 2024 would be the earliest time we could get the permit but might be 2024 or 2025. As I said, it is not in our hands.

I want to mention that in the beginning of next year, we will start a trial run of final disposal. And that is, in short, full final disposal operation. The only difference being that we use mock fuel. But mock fuel elements are like real fuel elements by dimensions, by weight, etcetera. So, they are not only radiating, that's the only thing that is missing. Otherwise, we will implement fuel transport, the whole encapsulation process for four canisters, final disposal to the special tunnel which has been excavated for this purpose. It's here, trial run tunnel. And then we also will try to reverse action of the process, because we will retrieve a damaged canister along the canister leaf or hoist the canister up to the encapsulation plant and cut it open, take care of the waste, and return the waste or the nuclear fuel to such a state that it can be packed in the new undamaged canister.

This is open against a fee for other waste management organizations if they want to participate and learn how we ended up in this result and what we would have done differently, really, to learn what is behind this 40-year project.

This is not only technical test. All the equipment and machinery have been tested and approved before this. And of course, here they function together as a process. But in addition to technology, we also test all the methods and procedures and organization, which then will take care of the final disposal starting next year. So we do have a production or operation organization already in place since 2020, and they are acquiring the operation of the plant in the start of this trial run. And that will be, of course, also very interesting to see how well the plants are functioning in real life.

Now, a few words of the public acceptance of our project is that from the very beginning of our company's owners operations in 1978, 1979, we have been very open and transparent, and the number one rule has been that everyone is an important stakeholder. We have identified the stakeholders, and we are very proactively and very fact-based way are communicating with them. And it's to be noted that it's our responsibility to be understandable. So this is the second cornerstone of this communication strategy that we need to be understandable. We cannot send scientific reports to school children or media is not interested in them, etcetera. So we have to design our message in such a form that the stakeholder in question gets the information he or she wants and understands it.

More than 20 years ago, in the decision-in-principle process, our home municipality called Eurajoki had the opportunity stipulated in the Finnish law where every municipality where a nuclear facility is proposed has a veto right in the decision-in-principle process. And the veto right is permanent. So if one council says no, then it is binding to the next municipality councils as well. And yes is permanent as well, so it cannot be overruled by the later councils. And the vote was 20 yes, 7 no.

And as I mentioned, the next step of this decision, or the last step of this phase, is that the decision goes for ratification in the Parliament and in the Parliament, it was ratified by votes 159 yes and 3 no and 37 members of Parliament were absent. So, it was quite [Unclear] process. The main arguments behind the decision of the Parliament were that aiming at final disposal is a better solution than just resorting to interim storing. If you look at what happens in Europe now or what has happened during the last 400 years, you see that it's not very stable in the long term or in the short term. In the long term, meaning tens of thousands of years, we will have ice ages, we will have hundreds of meters of water on top of the repository areas. Also, interim storing does not come into question.

An option for retrievability of waste canisters must be maintained, and this is what we do. And also, the moral justification is the present generation or that generation, previous generation which built nuclear power plants has to accept the responsibility for nuclear waste as well.

I would say that we have had three shafts to success if public acceptability is concerned. I say shafts because we go downwards, not pillars. So the first is trust and transparency. As we all know, it takes years to earn the trust or a long time and only minutes to lose it. And the trust we have earned from our stakeholders is our most valuable asset. We do not risk it under any circumstances. We can risk money, but we don't risk the trust we have earned.

Then, in Finland, it's the authority. It's not only nuclear regulatory authority, but also the other authorities involved are independent and they are trusted by people. They are also quite active in their communications. They are interactive. So if people ask something or stakeholders ask something, they get the answer. Then the processes, various permit processes, clear responsibilities and roles as well. So stakeholders know when they can affect a certain process.

And then as the third shaft, I would say that we have a very small community around us, 50,000 people only. And that's so small that during 40 years plus, everybody knows somebody who has worked in our power plant or our repository project or they have worked there themselves. And these people who have worked for us, who are working for us, are our most important ambassadors. So if they go home and say that they don't trust or things are not taken care of well, then our trust would be ruined. Our communications could not save our trust. But they obviously have gone home for 40 years and to their friends, telling that things are taking care of responsibly and well on the island. And of course, we are also not only employing and transparent, but also we of course pay taxes locally. In the Finnish system, we pay taxes to the municipality. No, I cannot say a lot. And as I mentioned, we have been transparent but also very reliable. So our reactors is a result of intensive maintenance and very well planned operations and maintenance. We have raised their output electricity effect from 660 to 900 megawatts. We have been always in the top four or top five of world's reactors in terms of availability.

So what we would like to say is that we are proud that we do have a solution for the final disposal of spent fuel. And doing that, we have a significant role in climate protection as we have solved the last big issue in producing carbon free nuclear energy.

Those were the thoughts also of Mr. Grossi, who visited us in November 2020, I think, in every case in the middle of Corona time, as you see, and we were happily adopting his term that Posiva's ONKALO is a game-changer.

Posiva Solutions, which I mentioned in the beginning, is providing its clients a holistic approach to final disposal project. We are working in 15 countries at the moment. If you start from the right, the high level, strategy level, and then everything's related to site selection and monitoring, characterization, then design and engineering of the EBS, barrier system, repository, machinery, above ground facilities like encapsulation plant and, of course, safety case and safety assessments are an overarching topic. And as we have already all contracts in place and construction finished for the time being, we really know what this costs. So we are assisting other organizations in their cost estimation, methodologies, etcetera. And the uppermost part is, the most difficult part is the stakeholder engagement and public acceptance. We are aware that we cannot copy paste anything that was done in different countries in different time. We cannot copy paste to anywhere but some fundaments we have obviously been doing right. And this is also an area where we are consulting our clients.

This was my part from the presentation. Thank you for your attention, and I give the floor to Sanna now.

Sanna Mustonen

Thank you. Good morning also from Rauma region. My name is Sanna Mustonen, and I act as a Safeguards Officer of Posiva as was here said earlier on.

My presentation goes a little bit more further or just in these safeguards topics. And here is the slide having the content of my presentation. First there are some introduction slides, few things about transfers of the material, although they already gained something already in Mika's presentation. And lastly, there will be some slides about specific requirements related to our disposal.

First some definitions from the safeguards and non-proliferation. Safeguarding nuclear materials, there are, you could say, three aims in that. And first is to prevent the proliferation of nuclear weapons and then the others are to ensure that nuclear, both material and other nuclear products remain in peaceful use, and these facilities and technologies are used only for peaceful purposes. For that, there is a nuclear material regulation. Nuclear material regulation is based on the international treaty called Non-Proliferation of Nuclear Weapons, NPT. Finland was one of the first countries to sign the safeguards agreement with IAEA already in 1971. Then when we joined the European Union in 1995, there was a need to have an agreement between European Union's non-nuclear weapon member states. And so, we have also a contract with that.

We don't operate direct with IAEA. There is our Finnish Radiation and Nuclear Safety Authority, STUK, between there because the IAEA's agreement is between the States. With STUK, we then develop our national nuclear material regulation systems.

And here in the corner of the slide, you can see the world map showing the countries that have now signed the NPT treaty.

The development of the nuclear material safeguards in Finland has been ongoing already for a long time. Since the starting of the construction of the ONKALO facility what Mika already told you as that started already in 2003. So Posiva and Finland as a nation has already national and international reporting and noticing obligations.

Both STUK, IAEA, and Euratom do carry their design information, so called DIV, work in Posiva site already even though that we don't have any nuclear material yet in our site.

During these almost 20 years now, we have developed this disposal safeguards concept for the underground facilities because as we are the first ones in the world, this has been new for IAEA as well and European Commission and STUK how to do the safeguarding.

There have been a few points noticed like transfer routes and storage locations of the transport casks that are important to surveil. Fuel assemblies and disposal canisters are then continuously monitored when they are put underground. And also, there are now plans that new kinds of safeguards, equipment that have not been used in Finland or elsewhere before are going to be used in our repository.

We have, at this point, a very strong and lively discussion ongoing about the operator declarations during the disposal operations. And actually, at this point in this week, IAEA is installing the first equipment to the encapsulation plant. So, these plants are turning into reality.

In this slide, there is this whole process of final disposal. In the upper corner, you can see these different kinds of methods are described in this one box and numbers from 1 to 3 are the different process steps. The process of final disposal starts from the spent fuel storage at the nuclear power plant. That means that the spent nuclear fuel is owned by the reactor operators until they go outside this building. After that, they are Posiva's responsibility.

And here in the corner, you can see that there are these possible ways of safeguards methodology that is designed to be used in the spent fuel storages.

Fuel is transported, as shown also in the earlier presentation, inside the transportation casks, and these are normal casks which are used elsewhere as well. Nothing special in those. When the transportation enters the encapsulation plant, the fuel is taken from the transport casks, and it is put into the final disposal canisters.

And now, as Mika has already explained, the encapsulation facility is ready as a building, and these works are ongoing now inside to install all the machinery and also the surveillance cameras and so on what will be there. This part is quite easy in the sense that IAEA has done surveillance in the reactors already for many decades. So that is very easy to design how to put there, the cameras and seals and possible laser curtains and so on, because that's quite similar as the other facilities around the world.

But when we go down to this spent fuel repository, this number 4, the situation is different, and there are some new methods. For example, this seismic monitoring system designed to be used to fulfill all the surveillance needs.

Here is a picture showing the transport casks. As you see, it's going to be and it is already what we have here in our island, so normal transport casks where the fuel assemblies are put in.

Here in this right corner, you can see three different disposal canisters. And these are different. We are going to use these three different designs, because we have three different sizes of fuel assemblies. The outer diameter of these canisters is the same. But the cast iron insert is different, and that's made for each fuel assembly.

There are some special requirements related to the disposal. And here is the text, this Guide D.1. And it just means, the name there, that it's our national guide. This Finnish national guide is built so that all the IAEA's requirements are already written there in our national nuclear guides. So, when we follow these guides in our design and in our operation, we know that we will follow the IAEA's regulations as well.

Here I pointed out some of the special requirements, and the lifecycle, for example, in our facility is going to be over 100 years. That has some special requirements for the design. And the other thing is that when the nuclear material is put into the canister and its disposal in the facility, you cannot go and verify it anymore, because it's put in the capsule, it has overburden of the bentonite material, and even the tunnel is then sealed with the block. So, in the reactor sites, if you have uncertainties, you can go and check are there those fuel assemblies or not what you are requiring, but that cannot be done anymore once the final disposal is done.

The operator shall give consideration to ensure efficient coordination of the safety, nuclear security arrangement and nuclear safeguard measures. And there is a need, already in the design phase in construction and, of course, in the operating phase that all this knowledge of the facility is stored properly.

After that, spent nuclear fuel is traveling inside this Olkiluoto island, even from Fortum facility into Olkiluoto facility. The very important thing is the continuity of technology that is assured in every stage also after the disposal. And it's not just we have to inform our regulatory body not only from the nuclear material movements, but we also need to inform them, for example, our final disposal construction, normal tunnel construction work so that the regulatory body can be sure that no, for example, extra cavities or extra tunnels are made into the facility.

Also, we need to show our designs in advance so that the regulatory body can come and check against our designs that we are really constructing those tunnels, what we are supposed to do. And for the continuity of technology, every fuel item and disposal canister need to be uniquely identified. And that's as not only the nuclear fuel is something that you need to know where it is, but the data with the fuel has to be known that it's there where it should be available when needed.

And last, here it is said that the operator shall design the nuclear waste facility and its operation in such a way that the continuity of control data after the verification of the fuel items can be assured at every step of the way. So, the continuity of the knowledge is very important.

How do we then answer into these requirements? First, there is this handbook. So all necessary provisions for nuclear safeguards when designing, constructing, and operating a nuclear waste facility should be somehow identified in our handbook. We have different kinds of handbooks starting from the design and construction. And also, we have a safeguards handbook.

Then about the no undeclared activities, how we say to the authorities that the excavation is ongoing only in those places, what is what there should be. For example, microseismic monitoring is used for that purpose. So, we have microseismic stations, the same kind of stations that are used for monitoring the earthquakes. We have the same things. But our so-called earthquake excavation is, of course, very small, much smaller in magnitude. And here, you can see a picture about our final disposal facility looking sideways from it to the underground. These balls represent a blasting round underground. So when we send this map to our authorities, they can see that, okay, there are, for example, done excavations in the connection tunnels to the canister shafts and for example, down there is the technical area that has been excavated. And then they can look that against the plans that we have provided them if they match.

The second one that how the authorities are going to check that on the design or the reconstructed tunnels, what there should be is the laser scanning. And this is the laser scanning that is done by the authorities.

And here is the picture. The first picture shows there in the corner, it's a almost handheld machine device that is brought into the underground facilities. There is a parking tunnel where this measurement is now taking part in. And in the lower picture, there is then a picture about how the laser scanning looks like after it has been done. Third one here is about the ID markings. So the fuel assemblies and the disposal canisters, they have to have a visual readable ID marking.

And the fuel assemblies, as normal, they have their own numbers in their handles. That's very common as usual. And also, the disposal canisters will have an identification marking. The marking will be engraved to the lid of the canister. And here are the possible places where the engraved ID will be then.

The last one is to verify the nuclear material. So that is for that reason also that when the material is given from the reactor owners to Posiva's [Unclear], then it needs to be verified that it's exactly the same material that, for example, TVO gives to us, that we receive it. And that is planned to do with so-called passive gamma emission tomography measurement. And that's the measurement, so called PGET that has been developed during these more than 10 years of final disposal with the authorities. And the detection level is so as you can see from this picture. These are the cross-sections from the fuel assemblies that you can even see in the pin level what there is inside of this [Unclear]. So if there are missing pins or something, that will be visible with these measurements.

Thank you. That was my presentation about the safeguards of our final disposal facility.

Berta
Thank you. Thank you, Mika. Thank you, Sanna. If you have questions, go ahead and type those in now.

And while questions are coming in, we'll take a quick look at the upcoming webinars that we have on schedule. In March, Advanced Reactors Safeguards, Materials Accountancy Challenges. April, Overview of Nuclear Graphite R&D in Support of Advanced Reactors. And in May, Graphite-Molten Salt Interactions.

I see several questions that have come in. You should have the ability to Sanna and Mika to follow along if you undock the questions pane. I'm just going to start at the top. I do apologize about the sound. It is very difficult if you can imagine for technology to coordinate everything internationally. I'm located in Utah, Patricia's in the state of Washington, our presenters are in Finland. We have time zone challenges, so bear with us. I apologize.

What is the reason for the staged approach for the excavation of the tunnels?

Mika Pohjonen
Maybe I can take that. It's two main reasons. One reason is, of course, related to safety, that if you create, or we try to keep the hollow space underground or in the rock, minimized all the time. The greater the space, which is hollow, etcetera, at the same time, greater the chance that it changes the rock environment.

And the second reason is cask flow reason. If we are operating for 100 years, so there is no point of digging 50-60 kilometers of tunnel, which part of it we need after 100 years.

Berta
Thank you. Did you have anything to add, Sanna, or does that cover that?

Sanna Mustonen
No, that is a perfect answer, I think.

Berta
Great. It’s not a question but a comment. I'm glad to see that maintaining retrievability of spent fuel placed in disposal is a priority. What drove the decision to use iron or copper encasements rather than steel alloy encasements in the canisters?

Mika Pohjonen
I can maybe general level answer to that, although I'm not an expert. Our concept is a result of decades of development and study, much of it done together with SKB from Sweden, who have a similar concept. All the scientific facts, I don't know behind that. But one main thing for using copper is that crystalline rock contains water, and that's a corrosive environment. We surround the canisters by bentonite, and that prevents the water from being in contact with the canister. And if, because we have gone through all the ifs, if the water gets in contact with some of the canisters to 5 centimeters if copper, securing the content from corrosion and the cast iron insert is bringing the mechanical strength. But I would like to refer to Posiva's website where we have over 2200 reports published, and there are several of this canister development for more information.

Berta
Thank you. When can you finish the safeguards management report to IAEA at the time of disposal facility closure?

Sanna Mustonen

I may answer that. We don't do, in that sense, kind of a one report, but we are reporting all over the way when we are in our process. So we have certain things that we have to report to authorities yearly, and some things even monthly, and some things that when in our process there are certain process steps, then we have to inform that, okay, we are now in this step and can we continue, and are these all the paperwork, so to speak, clear that we have informed all the possible things? So if that answers the question.

Berta
Thank you. There's a question about the retrievability requirement. How do you intend to fulfill the requirement in real time during operation, as well as the post operational stages? You want to talk a little bit more about that?

Mika Pohjonen
Yeah. I can shortly comment that retrievability is reached by – it has few things which it has to fulfill. First of all, it must not be easy or cheap for obvious reasons. And the second is that if there would be retrieving, it must not affect the overall safety or it must not affect the safety negatively. And these are the bases for designing the canister and tunnels and the whole system so that the canisters can be mined back safely. This has been tested in full scale with our sister organization in Sweden. That's a design question. Not easy, not cheap, but possible without affecting the overall safety negatively.

Berta
Thank you. Are the canisters for encapsulation designed locally from original defined specifications, or is it adopted technology from an existing design?

Mika Pohjonen
That is a Posiva and SKB design. The design, the manufacturing methodology, the material, the welding, everything is our own design and a result of own research and development.

Berta
Thank you. Has the IAEA published its requirements for safeguards verification for SF repositories? Or is Posiva being used as a test case for IAEA to learn about what is possible for the safeguards and repositories?

Sanna Mustonen
Yes, we are a little bit like laboratory rats in this case because being the first ones in the world. So, there are not general or specific requirements for verification states. And this is ongoing discussion now what is enough and what should be now used in ONKALO facility.

Berta
Thank you. I'm reminded of the slide in Mika's presentation about stakeholders and the great number of them, and I think that would put IAEA and Posiva on that same relationship.

Sanna Mustonen
That is true. So as well that the world is looking for us, it is looking for the regulators as well.

Berta
Yes. What dose rates are associated with the disposal canisters in the underground transport? And then once they're in place, is there an underground transport cask that is used until the waste is finally in place?

Mika Pohjonen
Sorry, I just got this now. I just have to read it. Dose rates for people are zero because everything is automatic and remote controlled. That is the short question. There are no manual work, no men, no staff so that they could get the dose. And then second one, we don't use any underground transport cask, but the canisters, when they are packed, they are ready for final disposal. So they are lowered via the shaft as such, and they are transported underground as such, as they are.

Sanna Mustonen
And in underground facility where there is the machine who moves them, they have a shield in it, in the machine, but that's not a whole cask.

Berta
Thank you. What is the groundwater table at the site?

Mika Pohjonen
Again, I can maybe answer to that but it's…

Sanna Mustonen
We are diving in our groundwater. We are in the island, and we are very low island, so we are more to speak covered with the groundwater, but just now, technically, we keep the groundwater out from our tunnels.

Berta
And then the next question, I believe, is in relation to that. It asks what is the barrier used in the repository?

Mika Pohjonen
Multiple barriers and the first is the cast iron insert, or in fact, the fuel pellet cover, and then the cast iron insert, then the copper canister, and then the bentonite around that, and then the bentonite backfilling of the tunnel. And then, of course, natural barriers. These are engineered barriers, but natural barrier is then 420 meters of very stable bedrock.

Berta
Thank you. I think that addresses the next question as well, the backfilling materials, you've indicated the bentonite.

Mika Pohjonen
The sea area is in no contact of the final disposal. So this is very good to think about this. The canisters are isolated from biosphere, so they will not be in contact with the water contained in the rock and the seawater. In no case, sea is in the area 10 meters deep and we are in the depth of 420 meters and totally isolated from biosphere. We have evaluated migration of nuclides in the worst, worst, worst cases. And all those results are reported in our reports. And they do not go even in the worst imaginable or in an unimaginable case, they don't go even close to any borders set for impacts or limits set for impacts.

Berta
Thank you. I think that addressed that and touched on the next question, too. You've talked about remote work. Can you talk about expected radiation exposure to any workers?

Sanna Mustonen
Maybe I can answer. Like I said, work is done so much remotely as possible. Of course, when the canister is exposed and on the surface, you don't go near it. Then there is radiation for sure, of course, and in some cases where you might need to be perhaps near the canister, might be some cleaning works or some malfunction of some machines, but they are thought to be so unlikely that the real doses are very, very low.

Mika Pohjonen
I could fulfill here that of course, like every country, we do have radiation limits in the legislation for nuclear workers and for radiation workers in hospitals or x-ray workers, etcetera. So these doses caused by any of our activities or our nuclear power plant activities, they are very, very far from those limits always.

Berta

Thank you. Can you talk a little bit more about the gamma emission tomography examples that were shown? Only possible while fuel is outside of the geological repository or is there a means of performing this tomography after the fuel capsule has been placed in its stellar resting place?

Sanna Mustonen
Yes, it is so that it's only possible to do these measurements when it's outside the geological repository, for example, in a pool area, because that's the device that it goes, or which way you say it, the fuel assembly goes inside to this measuring device. So after the fuel rods or fuel assemblies are put into the canister, then it's not able to measure those with this emission tomography measurement device.

Berta
Thank you. Do you consider humidity and salinity of the repository? Are there any plans to prevent potential corrosion?

Mika Pohjonen
I think there was one question missed about optimization. I can tell about the optimization, because now I will be trying to roll these questions on screen. Sorry. Has the underground footprint of the repository been ever subject to optimization? Yes, everything has been subject to continuous and iterative optimization, for example, the volume and the footprint, because every cubic meter of excavation and every cubic meter of backfilling costs money. So everything is, I would dare to say, quite often optimized iteratively.

Sorry, Berta, what was the another question?

Berta
Do you consider humidity and salinity of the repository? And can you talk about the plans to prevent potential corrosion?

Mika Pohjonen
Yes, these are the central factors in our surroundings, in our environment, inside the rock. And potential corrosion is not taking place after the canisters have been surrounded by bentonite because they are not in touch with water. But if and if there would be contact with water, then 5 centimeters of copper is enough for hundreds of thousands. No, it's million years at least enough for corrosion impact. Does Sanna want to complement?

Berta
Thank you.

Sanna Mustonen

The design basis is that we need to take this in account.

Berta
Thank you. How long does safeguards duty continue? Forever?

Sanna Mustonen
Well, a little bit less than forever, but long, I would say. It's as long that we have to do the operation, then we have need to do our safeguards duties. And I suppose that when we do the closure, then we have to finalize what are then required for the closer phase. But then after that, we don't have to do any safeguard measures, as is thought now at this point.

Berta
Thank you. I don't see more questions. There are people offering thanks and accolades. I appreciate that. Again, I do appreciate you sharing your expertise, both Mika and Sanna. And Sanna, for you jumping in at the last minute, we had a change in presenter very shortly before this date or the live webinar. So thank you for picking up that mantle in such short time period.

Sanna Mustonen
Thank you. It has been a pleasure being able to participate.

Mika Pohjonen
Thank you everybody. Thank you for your attention and please visit Posiva website, Posiva YouTube, and Posiva LinkedIn so you will find a lot more information.

Berta
Great. Thank you. Patricia, do you…

Dr. Patricia Paviet
Thank you very much Mika and Sanna. As always, the Q&A is so interesting. Thank you again.

Berta
Thank you. Bye-bye.

Dr. Patricia Paviet
Bye everyone.

Sanna Mustonen

Bye.

Mika Pohjonen
Bye.

END