RESUMED **[11.59 am]**

COMMISSIONER: We will reconvene topic 14, the transportation of nuclear materials. We very warmly welcome from ARPANSA Mr Jack Dillich and Dr Samir Sarkar. Counsel.

MR JACOBI: ARPANSA is the Commonwealth government's authority on radiation protection and nuclear safety. Its functions are multifaceted and include the promotion of radiation protection standards that are consistent across Australian jurisdictions and in line with international best practice, including those applicable to the transportation of nuclear and radioactive materials. Mr Jack Dillich has been the chief inspector and head of regulatory branches 2014 and is responsible for licensing, compliance and inspection of all Commonwealth entities using radioactive sources and operation nuclear or radiation facilities. Mr Dillich is a nuclear engineer and has worked for decades in the commercial nuclear power, nuclear propulsion and research sectors.

Having joined ARPANSA in 1999, Dr Samir Sarkar is currently a principal inspector in the regularly services branch. He holds a PHD in nuclear science from Kanazawa University in Japan, and his areas of expertise include nuclear fuel management, radioactive waste management, and the transportation of radioactive materials. Dr Sarkar is the Australian representative of the IAEA's transport safety standard committee. The Commission calls Dr Samir Sarkar and Mr Dillich.

COMMISSIONER: Gentlemen, thank you for joining us. Can I start with a description of the various packages, and perhaps starting with excepted packages, so I want to try and get an understanding of the contents, the form of packaging, the design characteristics, and the expected radiation levels from each of the packages. We might just move through them one by one if that's okay. So start with excepted.

MR DILLICH: Slide 3, please. Very good. Now, in order to set the table, I'm going to have to back up just a little bit, but give me a couple of minutes to do that. First of all, radioactive material is shipped around the world. Millions of consignments happen every year around the world. It's been going on for decades and the track record of the industry is quite safe. Before we delve into the package types - and this slide shows all five types that I'd like to talk about - I need to talk a little bit about radiation and radiation dose, because we're talking about radioactive material, which is a dangerous good class 7. There are many types of dangerous goods which are shipped around the world. Class 7 is one small fraction of those.

The radioactive material that's being shipped does present a radiation hazard to people in the environment. The packages are meant to allow the shipment of these, either by sea, by air, by rail or by truck, safely. All living organisms are exposed to ionising radiation every day. You and I are. This is natural, it comes from food, air, and cosmic rays. Typically an individual will be exposed and receive anywhere from two to three thousand microsieverts per year in radiation. That's year after year. This is natural and it's what we are.

A return flight - I want to put this into context, because we're going to talk about radiation dose, I want to put it in context. The radiation dose you would receive just by a flight, let's say from Australia to Europe, or to the United States and back, a return flight, would be on the order of 100 microsieverts. So you would receive an additional 100 microsieverts for that holiday that you take, as a result of just being up at 30,000 feet for 10, 15 hours, something like that. That's ballpark. Now, science tells us, we've studied this quite a bit, that the effect on the human body at this additional 100 microsieverts is insignificant. It's negligible. It's not even measurable. That's true by probably three orders of magnitude. So it's very, very insignificant, that 100 microsieverts. So I'll try to put that in the context when I talk about each one of these packages.

The excepted packages are packages which are used to transport radioactive material that is of such a low level that the potential hazard is insignificant. Generally for excepted packages, although they are labelled appropriately, there is no testing that's involved, and you can see it's basically the box with the "fragile" on it, there will be something that is just very, very slightly radioactive. There's no shielding involved, there's no cooling involved, and if you were to hold that package for hour upon hour, the total dose would be less than the insignificant amount that I talked about of 100 microsieverts.

Mr JACOBI: Is there in fact a limit at the surface for an excepted package?

MR DILLICH: Yes, there is.

MR JACOBI: What's that?

DR SARKAR: Five microsieverts per hour.

MR DILLICH: So if you were to stand there and hold it for 20 hours, and it was at the limit, which is highly unlikely, you would receive that insignificant dose that we would all accept. By the way, a chest x-ray is about the same, 100 microsieverts. I give that as an example because it's something we accept in society. Excepted packages may be used for limited quantities of radioactive material and the potential hazard is just not there.

Let's get into industrial packages. They're typically used for two types of material. One type of material is a material that has a very low specific activity. What that means is the radioactivity per unit mass is low. The other type of material that it's used for is material that would have surface contamination. A good example of that would be tools that are used at power stations. Instead of generating a lot of low-level waste trying to decontaminate these tools when they're just going to be contaminated again at the next point of use, they would be transported, for instance, as an industrial package.

Industrial packages are subdivided into IP1 through 3, which differ regarding the degree to which they're required to withstand routine and normal conditions of transport. They're used for low-activity materials such as uranium oxide concentrate. I'm pretty sure you've had experts in here talking about uranium oxide and the transport of that. That would not be unreasonable, to have a container like that full of 200-litre drums of that kind of material. Low specific activity.

MR JACOBI: Again, to pick up the question from before, is there a limit that's specified with respect to exposure - - -

MR DILLICH: It's the same one.

MR JACOBI: It's the same. It's fine.

MR DILLICH: Typically that's a limit and it's not approached in any fashion.

MR JACOBI: Actually, could I pick up on that. In terms of measurements, to what extent are measurements made with respect to such packages? You're saying that you're not going to receive a rate of - - -

MR DILLICH: The point of origin has the responsibility for measuring, and typically when it's done, it's done with a radiation instrument, a handheld radiation instrument, and it will be measured on contact, which is typically a couple of centimetres up - the probe will be a couple of centimetres away from that, at various locations, a full survey. The external part of that particular container would also be smear-surveyed to make sure there's no loose surface contamination as well. Then at one metre is the typical location. So at various locations a metre away from the outside of that, it will be taken.

MR JACOBI: So is the five microsieverts as at the surface, or is the five microsieverts per hour, is that the - - -

DR SARKAR: From the industrial packages, you can go up to even 500 microsieverts. However, in practice it is not the case, because what they consider is, if you work in that industry, so package handler, whatever it is, considering that you may want eight hours a day, the total effective dose throughout the year that a human within the public limit - that is one millisievert per year, even if you are - throughout your lives. So that's the limit there. Also there is (indistinct) transport index. So you have to comply with that one, which is a requirement, that you have to record that for this shipment, transport index, based on your particular measurement (indistinct) the surface of the package.

MR DILLICH: Okay. In general, low-level waste - and by the way, I digress again, but I have to set the table. We talk about low-level waste, intermediate-level waste and high-level waste, and those waste categorisations are not based on transport. Those are for storage of wastes, okay? We talk about them in the terms of transport just because they're classified that way ultimately one way or another. For transport it's all about the radioactivity, and to some extent the form, and almost all of this is in solid form. Okay? For excepted and industrial package types, shielding is not a particular issue. However, you can see that the metal associated with that container right there will provide a certain amount of shielding. Distance is also important. So you mention on surface, and the further away, of course, from the point source, the dose rate will drop off exponentially, so quite a bit.

Type A packages are used for the transport of relatively small but significant quantities of radioactive material. Now, because it's assumed that this package could be damaged in an accident, a severe accident in particular, and that the portion of the contents may be released, the amount of radioactivity in a Type A package is limited. It's a very complicated formula because it depends on the radionuclides involved. So you look at all the radionuclides after it's been characterised and you kind of sum those up into a total. In the event of a release of a Type A package, these limits ensure that the risk from external radiation or contamination are very low.

MR JACOBI: I think that slide might pick up some examples of those.

MR DILLICH: Here's a very commonly used Type A package, in Australia as well it's being used, and this is a technetium generator. Maybe you can't see it. The cutaway is meant to show how the source, the generator itself, is inside this rather large, well packaged unit. It's my understanding that the packages are reused so the customers - there's probably a hundred customers Australia wide - in this particular case, if it's Gentech generator like the bottom picture shows, ANSTO would be sending these out routinely every week of the year and the packages would come back and be reused.

The packages also have a certain amount of shielding, so one of the points I wanted to make with a Type A package is there is shielding. It depends on the source, but typically if it's a gamma source, which is the predominant source of concern for external radiation dose, there would be either metal or lead. Those are extremely effective shielding materials. This is a Type A packages. Now, Type A packages, unlike the other two we discussed, are in packages designed for certain expected kind of accidents.

In this particular case, it could be used on an aeroplane or it could be use on a truck. Well, it's probably used on both. This particular material, the generator itself, it's very perishable, it has a very short half-life, so it has to be transported rather quickly to the point of use.

MR JACOBI: As I've understood the evidence so far, there's an adjustment of the material that's included and the shielding. As against what standard is that adjustment made in terms of, again, the expected radiation dose on the outside of the package?

DR SAKAR: Yes, it is a requirement of the Type A package that you have to amend within a certain limit, the transport index is, again, control factor.

MR JACOBI: I understand the transport index is the control factor, but, again, perhaps to bring it back to very practical terms, we've talked about a limit of 5 microsieverts per hour. Is that the same limit that is again applied?

DR SAKAR: No, for this one you can expect normally 14, 15 microsieverts per hour from one of the generator. This is the extreme case, big case, as you can see.

MR DILLICH: The way it practically works, if you have radioactive material that you have to get from point A to point B, you're not going to create and certify a package of that, there are going to be packages available that are certified for use, so you have to make - typically, it's a commercial decision, "How do I get it there?" If you can, you split it up into small pieces and you ship it a number of times, you make a number of shipments to get it where you want to go. We haven't got into Type B packages yet. Type B packages can be extremely expenses, so you don't want to use a Type B package for something that could be done much cheaper.

MR JACOBI: One of the methodologies might be to simply divide so as to reduce the amount of activity you get from that source, and that then meets your controlled external limit. Is that right?

M DILLICH: Correct.

MR JACOBI: Right.

MR DILLICH: In this particular case, staying with this example, I think the biggest generator that ANSTO puts out is 370 gigabecqurels, which is about 10 curies, and so that's as strong as the source is going to be, and their packages are designed such that the radiation doses that somebody might receive under normal transit conditions or whatever would be insignificant. We can do the same thing after a couple minutes here, we can go to slide B. Type B packages are required for transport of highly radioactive material, and typically when we hear about highly radioactive material we might think of spent nuclear fuel from a commercial reactor.

That would be the prototypical classic Type B package that's used. These packages are tested, they must withstand the same normal transport conditions as Type A, but because their contents are much more than the Type A it's necessary to specify additional resistance to release radiation or radioactivity. The concept is that this type of package must be capable of withstanding expected accidents, and expected means reasonable accidents that could occur. Type B packages are used to transport material that's different, as spent nuclear fuel to vitrified high level waste.

They're used for shipping larger quantities, as I mentioned before. There are many, many kinds, probably 150 certified designs around the world, and some of the more expensive ones cost over a million dollars. Before we leave today, we will talk about one that we have experience in licensing. Type B packages use shielding to limit the dose rate, they have to, and so you can see the Type B package at the bottom there. That is probably four metres, five metres high, it's extremely large. There's another picture with an individual standing and you can see how small he is next to it.

There you go, in the lower right-hand corner. That is just the outside of the package, there's quite a bit of steel. Something like that might weight 100 tonnes empty, and then another six or eight tons with, let's say, spent fuel inside. These things are massive, they're not going anywhere. The amount of steel, there's lead lining as well, so the shielding is quite significant. Type B packages, I'll get into this in just a second, but when we're talking about irradiated spent fuel, because the radiation, the decay heat, the residual heat from the fuel is still such that it puts off heat, there's a cooling period and the fuel is typically either in water or stored onsite for months, if not, years, before it's actually shipped, so by the time it's shipped not only the radiation but the heat that's being generated has decayed away quite a bit.

Let's go to slide 4, if we can. Type C, I don't really have a lot to say about Type C because I have no practical experience with Type C. Type C packages came about around the time of the 1996 addition of the International Atomic Energy Agency transport regulations. They introduced this Type C for a very, very robust design for air transport. Smaller quantities of high activity material can be transported in Type C packages, these packages are most robust, they're designed to survive sort of like a black box, if you will, being dropped from an aircraft. It's pretty robust.

It's my understanding, and this is not first-hand experience, that the Russians have some experience with Type C packages. They have transported spent fuel and new fuel by air. Can we go to, maybe, slide 6? There you go. Very, very quickly. I talked about radioactive material, but 95 per cent of what is shipped as radioactive material has nothing to do with the nuclear fuel cycle, you didn't invite me here to talk about the 95 per cent, so let me focus just for a little bit on the front end and the back end of the nuclear fuel cycle and kind of focus on maybe the 5 per cent of radioactive material shipments that would be of interest there.

In terms of yellow cake, uranium oxide concentrate, that's transported from the mines to conversion facilities, they're typically in 55 gallon, 200 litre drums, if you will, into shipping containers. There's no special radiation shielding required, the yellow cake is only slightly radioactive, but typically it's alpha, an alpha emitter, and it can be stopped very easily with any type of substance whatsoever. UF6, uranium hexafluoride, nuclear fuel is transported to and from enrichment facilities in the form of this uranium hexafluoride.

It's chemically toxic, but it's still only slightly radioactive. It's typically shipped in cylinders such as the one on the upper right-hand corner, and these cylinders are rather large, they're a little over a metre in diameter typically, depending on the enrichment. For commercial nuclear fuel, the uranium is enriched maybe 4 per cent, typically.

MR JACOBI: Can I just interrupt you just at the level of the hexafluoride, the gas canisters there. What category are we dealing with there? Are we still at the stage of industrial packages as we were with respect to uranium ore concentrate?

MR DILLICH: I've moved beyond the industrial packages. No, it wouldn't be industrial in this particular case.

MR JACOBI: Right.

MR DILLICH: It becomes a little bit more complicated. Once you're dealing with fissile material, there are additional requirements associated with fissile material above and beyond just normal radioactive material.

MR JACOBI: No, I'm just dealing with the issue of the material at the point of conversion, and so what I'm interested in is to understand at that point - - -

MR DILLICH: Okay, yes, the front end with the conversion for - - -

MR JACOBI: Before we get to enrichment.

MR DILLICH: UF6, in that particular case, that might be industrial.

DR SAKAR: Similar to industrial, similar to it, it does not need any approval.

MR DILLICH: I got ahead of myself. Thanks for that. Yes, I don't need to talk about that. In this particular case, yes, and there are a number of different cylinder designs that can be used for that kind of transportation, so no cooling required, no shielding required there. New fuel: if you have new fuel which has been fabricated for use in a nuclear reactor somewhere, it's going to look like this whether it's been irradiated or not. But here, again there's no shielding required. New fuel is not particularly radioactive. You can handle it. So new fuel is fairly easy to transport as well. The most common means of transporting new fuel is by truck, rail, but it could be also by sea or by air. The biggest thing with new fuel is it's expensive and the tolerances are extremely important. So it's handled very gently and it has to be packaged so that it's not damaged during transport.

MR JACOBI: Can I just pick up the point of new fuel and then to the point of the converted materials. If you were to approach it from the perspective of what the radiation exposure you might reasonably be expected to be, again is there a design limit in terms of the way that the casks or the containers are designed in order to provide a particular outcome in terms of radiation exposure at the surface?

DR SARKAR: Exposure is not the main issue here. The main issue here is more of protecting the fuel plus the criticality. So these are the key aspects. In terms of (indistinct) it will be background level.

MR DILLICH: So the uranium is like hexafluoride, from a chemical point of view it is toxic so you need to be concerned about that. But from a radioactive point of view, none of this would be of any concern. If we go then to the back end, the next slide we see, now it gets a little bit more interesting. So on the back end, when fuel is unloaded from a reactor core typically instead of having a hundred per cent uranium in some kind of form or whatever, it's been in a reactor core for, let's say, five years - three cycles or something like that. It's highly radioactive. It's typically contained still predominantly 96 per cent uranium. You now have about 1 per cent plutonium which has been transmuted as a result of being in the reactor for so long. Then these nasty 3 per cent fission products which are highly radioactive. So that's good.

Now, what you see here in these pictures - and I just wanted to give you a flavour for it - in the United States where most of my commercial experience is, because there's not a solution to what to do with the spent fuel, all hundred reactors at the many different sites still have the spent fuel from the original core load. So what they do is, they typically will put it in spent storage pools under water and they'll keep it there for a couple of years. But more and more what they're doing is, they're using these dual-purpose casks. These are Type B packages. You're looking at the outside, which is concrete, but there's a lot of metal inside those things. What they do is, they simply store - and these are licensed facilities, spent fuel storage facilities - these are licensed facilities where spent fuel is passively stored, shielded and, through natural convection, cooled.

The fuel, for instance, inside of these - you can see the worker standing right next to it - there's enough shielding there that there is no significant dose one way or the other. They're typically inside protected areas, just like the reactors themselves. They're typically adjacent to the reactors. That is just a practical solution because there's still no political solution in the United States for what to do with this.

I bring this up just because it's a pretty good case in point: there's a number of ways to safely store high-level waste, and this is an example of that right there. The cask in transport on the upper right is another example of a Type B container. This would be highly radioactive, but you don't know exactly what's in it and I don't have it in my notes right here but you can see it's being transported on a railcar from one point to another.

The drums down below, again when I talk about transport packages, it doesn't matter what the material is going to be used for or what it was used for. It all has to do with radioactivity and the form it takes. So in this particular case it's possible that you could have waste where the total amount of radioactivity in the radionuclides would require it to be transported in a Class A or a Class B container. This is a typical drum of radioactive material that would have to be done in that fashion.

MR JACOBI: Can I pick up there. The Commission is interested to understand the record associated with - we understand the spent fuel has been moved and we're interested to understand the record in terms of the movement of spent fuel and whether there's been any manifestation of risk associated with this movement.

MR DILLICH: I do have some statistics here. I'll go through them rather quickly. Since 1971 there have been 7000 shipments of used or spent fuel over many millions of kilometres with no property damage or personal injury, no breach of containment and very low dose rate to the personnel involved. This includes 40,000 of used fuel shipped to AREVA's La Hague reprocessing plant. At least 30,000 tonnes of mostly UK-used fuel shipped to the Sellafield reprocessing plant and 7000 tonnes used fuel in over 160 shipments from Japan to Europe by sea. To some extent I think 4500 tonnes of used fuel around the Swedish coast. Some 300 sea voyages have been made carrying used nuclear fuel or separated high-level waste over a distance of more than 8 million kilometres. We're talking about 4000 casks, each of about a thousand tonnes.

So this has been going on for decades. There have been incidents involving radioactive material shipments but you can see - I can tell you first-hand that these packages are extremely robust when we're talking about Type B packages, which is why they cost so much. Dr Sarkar will get into some of the testing requirements; they're also extremely expensive and in-depth.

MR JACOBI: You referred to incidents. Are they incidents were there's been a breach or a failure of the containment and the cask?

MR DILLICH: No.

COMMISSIONER: So they've been transport incidents.

MR DILLICH: Right. The nuclear industry is fairly transparent and the safety culture is such that incidents, no matter how small, are looked into quite extensively and you try to extract lessons learnt from them and it's shared among the industry. Because what we've found out world-wide over the past decades is, when there is something that happens in one country it's the fallout from that - and the fallout is a bad pun. But there are ramifications to the industry world-wide. It's a community that shares its lessons learned and it's very transparent. So you can go online and find out a lot about these incidents. You can read in-depth about what happened at them. The idea is it will prevent possibly something similar happening elsewhere.

MR JACOBI: Can I just pick up the issue of - we've dealt with spent fuel and the Commission is also concerned because of its terms of reference in considering issues of waste. We're also interested in I guess the packages that are typically associated with the movement of waste and waste products, given the particular form that that waste takes. So if you could take us through that.

MR DILLICH: Low level and intermediate level waste - and as I mentioned before, those are terms that only mean something in terms of ultimate storage or disposal, not transport. They're generated through the nuclear fuel cycle, and other places, but nuclear fuel cycle from the production of radioisotopes for industry and also for nuclear power. There's all kinds of things. Radioactive waste: when we're talking about low-level radioactive waste, typically what we're talking about are rags and gloves - trash - that's contaminated; ordinary items that in the course of doing whatever you're doing with the radioactive material becomes contaminated. Low-level waste is typically low specific activity waste. So typically it can be shipped in something other than a Type A or a Type B or a Type C package. It can be shipped rather easily. It's typically shipped in drums like the picture below.

There's a lot of different materials and so all these materials would be emitting a certain amount of low-level radiation. The composition of intermediate-level waste is much broader but it requires some amount of shielding. So the experience that Dr Sarkar and I might be able to expand upon in a bit has to do with intermediate-level waste from research reactor use in Australia. That is intermediate-level waste, not high-level waste.

MR JACOBI: Can I just come back to the low-level waste. In terms of what you've referred to as a broad medley of scrap and trash products, is there an evaluation that's made of that, given that it doesn't have a homogeneous quality? Is there an evaluation of the nature of the waste before a decision is made about packaging? How is that decision made?

MR DILLICH: Typically what's required is that the custodian, if you will, of this waste will characterise the waste. Now, what that means is it's a laborious pain-staking process. What the person has to do is go through that waste using the proper PPE and protection and whatever and measure what kind of radionuclides are involved and how strong they are. Now, that's important to know, because if you know the radionuclides involved you can project up to 20 years what's going to be left, if anything, if it's short-lived or is it long-life radioactive isotopes.

A good example, and if you have a representative from ANSTO here, I know that, for instance, at ANSTO, which is one of our licence holders, they have characterised all of their low level waste and have it drummed up in one particular licensed facility. You may even have a picture in there, don't you? This is all the low level waste that's been generated for some 50 years at the Lucas Heights facility. It's not a large volume, but they've done all that painstaking work, so they know each one of those drums, what's in it, it's all in a computer database and that's what that is.

MR JACOBI: In terms of then making a decision with respect to the transportation of that sort of material, again, is there a characterisation that's conducted or is there an assessment made?

DR SAKAR: Yes, in that case, when you want to transport (indistinct) and in that case that would be waste acceptance criteria, if you have a facility, and then the operator will propose that criteria to the regulator and that will dictate the type of packaging, and, again, depending on the type of facility, so the waste acceptance criteria would be the key factor there, and that will determine the (indistinct) you must not exceed that sort of level, and you must not use this kind of waste, the chemicals, something like this you must not use in this package, you must transport it separately, so that sort of condition will come later on.

MR JACOBI: Again, the choice of package would depend upon the limit that's fixed as at the service of the package itself?

MR DILLICH: No, we have no experience because ANSTO has no place to send it, so it's not going anywhere and we have no application for anything. Then just closing up with transport, in the United States, for example, there have been about 9,000 road shipments of defence related transuranic waste for permanent disposal in a deep geological repository in New Mexico, and almost half of the shipments were from Idaho, some distance away, using public roads and that sort of thing, or rails in some cases.

The experience of commercial nuclear fuel, as I said before, that fuel is being stored at a number of sites throughout the United States, and ultimately it will be transported safely somewhere, wherever that is.

MR JACOBI: I think we've dipped into the discussion at the level of the categories of packages. I would just like to take a step back, and I was hoping you might explain how those particular packages are essentially applied as legal requirements under law, and perhaps we can then move back from their earlier source at the international level.

MR DILLICH: Sure.

MR JACOBI: A similar slide might pick up the international regulatory aspect.

DR SAKAR: Okay, thank you. Considering that transport is an integral part of the nuclear industry, or nuclear fuel cycle, or radiation business, so in order to assure the community there is some safety requirements in terms of transporting radioactive materials, in 1961 I came up with the requirements to be followed for transport of class 7 material, and that's, you know, all the safety requirements. Then these safety requirements are, again, you know, moved to the next level like (indistinct) transport requirement. In the global requirement, for example, the (indistinct) model regulation, which you call it (indistinct) and it deals with all classes of radioactive material.

In the next slide, I will explain that a little bit more. Then you come to the type of transport. Depending on the (indistinct) of the transport, whether it is road, rail or air or sea transport then you, you know, impose the requirement, and then finally it comes to your national regulatory process there, what you want to do and how you are going to adopt all these international requirements. We have to also acknowledge that in order to maintain our harmonisation in the global regulatory process we all need to follow the almost identical requirements so that there is no disharmony in the requirements.

If you go to the next slide. As you can see, it starts from (indistinct) what you call the regulation for safe transport of radioactive material. Now, we call it a specific safety requirement. It goes to the UN orange book, which is for all classes of radioactive material (indistinct) dangerous goods, and then it has one chapter which directly incorporates the requirement of (indistinct) then depending on the type of the mode then your model regulation comes into practice, like (indistinct) for air transport (indistinct) for sea transport.

In Australian cases, what we do is use the declared option of the (indistinct) in the road, rail and (indistinct) again, in Europe they have ADR, AND, and all are based on (indistinct) and then if you go to the next test slide in - - -

MR JACOBI: Sorry, can I just pick up, because I notice that's the 2012 edition of the safety standards. To what extent is there a progressive review or updating of those standards?

DR SAKAR: Usually, the United Nations has a review cycle of two years, i.e. it tries to catch up with that, but in practice it does not happen. For example, from the 2005 edition we have 2009, 2012, and now in the last meeting we've decided that we'll have another revision, so we can expect maybe three years' time there may be another revision, but UN orange book they usually do the review every two years.

MR JACOBI: Am I right in understanding that the Australian Code will then be rewritten in accordance with it?

DR SAKAR: To update it accordingly, yes.

MR JACOBI: Does that apply by force by the ARPANSA Act? Is that Code enforceable?

DR SAKAR: It is through ARPANSA Act, plus, you know, in the next slide I will explain over in Australia we want to maintain the national uniformity so that all the states and territories follow the same code. We call it the National Radiation Protection (indistinct) so all the states and territories are signatories of that, so they gave a commitment that they will follow this.

MR DILLICH: So our Act requires us to consider international best practice.

DR SAKAR: As you can see, Australia's regulatory framework, because Commonwealth regulator, ARPANSA, mainly regulate road, rail and inland waterways for Commonwealth entities through this code, and civil aviation is for air transport (indistinct) is applied by AMSA, that is, the Australian Maritime Safety Authority, and six states and two territories they have (indistinct) and on the top of that, as you can see at the corner we have a group we call the Transport Competent Authority Forum, which is a national working group.

Through this group, with the regulator, we exchange information and share information. In Australia we maintain the national uniformity, and if there's any issue we try to resolve it through this working group.

MR JACOBI: I want to deal with the Australian regulatory arrangements as they govern transport. I want to separate out and deal with, first of all, the idea of the movement of radioactive materials and the process of actually transporting and separate that out from the (indistinct) validation packages. Perhaps you could explain just in broad terms what the requirements are in terms of a particular transport route or a particular transport pathway being approved.

DR SAKAR: The requirement is accordance with the ARPANSA Code or (indistinct) for example, in most cases because they do not need to consider the amount of activity involved in the transport. They do not need any regulatory approval for transport as such, however, in some states like Victoria they have a process like the licence, the carrier, the company that does it, to make sure that they are trained, they follow this and that, so every state has an additional requirement for the transport. As I said, as long as they comply the (indistinct) and even numbering, all these requirements and all the declarations, in most cases they're okay.

If there is anything that needs approval, for example, in some cases you will find that the (indistinct) hospitals, they're an out of state design. For example, they're designed in the 1970s, which are obsolete, so once they want to transport they have to go through the provision of the code, we call it the special arrangement, and in that case they have to demonstrate the safety case that the safety is at least equivalent to the current standard. So in that case it needs to go through the regulatory approval process and in that case ARPANSA maintains that central database for approving some particular type of (indistinct) and they issue that, "Look, you use this number but let us now make that nationally we know what is happening."

MR JACOBI: If I can come to fuel cycle activities. We've heard this morning about the transportation of uranium concentrate. I'd be interested in the extent to which that requires approval from a regulator and then what's examined from the regulator's point of view with respect to such an activity.

DR SARKAR: Because these are done with a private industry it is mainly regulated by the state authorities. So what they do is, the owners attempt to make sure that they are in compliance with the requirement of the transport code. It's the standard practice for a regulator time to time go and check the complaints monitoring, checking, "What did you do? Did you follow this and this?" and check the records, and sometimes they can do some reactor inspection also - unannounced inspection - as a part of the regulatory process.

MR JACOBI: But shifting to the sort of activities that ARPANSA regulates and thinking about a Commonwealth activity but if one was to theoretically talk about the movement of low-level waste, what would ARPANSA need to do in terms of examining an application to transport such waste?

DR SARKAR: Look, depending on, as I say, the size of the shipment, if the activity is low, in that case you do not need any regulatory approval for shipment. But if there is a case that there is a point B has a facility and you need to transport that low-level waste from point A to point B, in that case, looking at what will be the consignment, then ARPANSA may decide, "Okay, look, you need approval because of this and this," then looking at all the safety aspect, "What is the transport plan, safety plan? What do you usually do for other - - -"

MR JACOBI: Does that require an examination of the - perhaps again to come back to the potential for exposure to radiation from the public.

DR SARKAR: Exactly, and including, "All the accident conditions, what do you have? What do you have if there is like - what contingency do you have in place?" I mean again you have to again communicate in terms of the emergency plan with emergency service and all this stuff needs to be there.

MR JACOBI: To what extent do you analyse the - I'm not suggesting you should go back and redo it - but examine the analysis of the characterisation of the way that you described before that a calculation was made of the characteristics of the type of waste? Would you examine that sort of information?

DR SARKAR: Yes. What happens through our inspection - for example, I will give you an example, they have a considerable amount of radioactive low-level waste. How do they do the characterisation? Of course we need to look at the system itself there, the technical aspect also. Is the system calibrated? Do they have a quality management system in place? Like is it calibrated at a certain frequency to make sure it gives confidence in the measurement? What sort of standard deviation? Is it one standard deviation or two standard deviations taken into account in the measurement - of course we do.

MR JACOBI: I think again picking up the need to transport spent fuel, as I understand Australian spent fuel is being sent overseas to be reprocessed, is that an activity that you regulate?

DR SARKAR: Yes.

MR JACOBI: Can you just walk us through in broad terms from the regulator, your perspective, what the analysis is that you make of such transportation and - - -

DR SARKAR: I will do it in the following way: for example, this is the flow chart and as you can see the orange box there is for ARPANSA. Once we receive the transportation application for approval - and before approval we have to make sure the package that will be used - usually this is a licensed package because it's very expensive, so is it certified, properly certified. Then we do another assessment based on the original assessment. We use the safety case and we look at all the critical factors like if there's an accident, will it withstand? Did the previous level take into account all of these factors? Then we validate the package; that is this package is authorised to use in Australia to undertake particular activity.

Then they submit the safety plan. That is how the shipment will be undertaken safely and then we look at what are the operational controls in place: the back-up vehicle, communication system, exposure control, and the convoy will be supervised by health (indistinct) are the drivers trained. All these factors are taken into account and then we have another control in place to assure the public that it is done safely. We do the pre and post monitoring of the route. Once we know the route, we do the pre-shipment monitoring, as you can see, and then we keep the record and then we do the post-monitoring to make sure that there is no contamination; it is identical what we did pre-shipment monitoring. Also, after this - - -

MR DILLICH: So that's actual radiological assessment, sir.

DR SARKAR: Actual physical measurement of entire route. We have a vehicle monitor in system so we monitor the entire route. Then we look at that loading operation. We physically go there. We make sure they follow all the right procedure. We look at the exposure to the operator during the operation, plus we also - so before that we have an all emergency meeting. All emergency meeting means you know that the regular, police, emergency - how it will be done and how it will be done if there is an emergency. Then we also did the debriefing also, and also we get the records from the licence holder that what is the exposure record.

So far as I will explain it in the next slide if we turn - this is the thing that we consider in that - these are from the research reactor fuel. Please go to the next one. As you can see, in that case we have a coordination with MSA because Maritime Safety is the authority for sea transport. So once we approve the safety plan, it also needs to be approved by the Maritime Safety Authority. They physically inspect the vessel because this is their area of expertise. Then we did so far all the HIFAR as well as the MOATA reactor fuel in nine shipment without any incident. We did not have any incident and all were transported safely.

COMMISSIONER: It goes to France, does it?

DR SARKAR: France and some of them were sent to USA because US origin fuel, under the bilateral agreement, they take back and they will take care of the - - -

MR DILLICH: So MOATA was a small reactor at the Lucas Heights site. It's not in use any more. HIFAR was a reactor that operated about 50 years and it's no longer in use any more. Some of the fuel was shipped overseas to the UK, most of it to France, much to the US, but the US, with an agreement, takes it back, never to come back to Australia again. That's a one-way shipment.

MR JACOBI: I will try to come to the question of package design. I think we've already picked it up in terms of - and perhaps you can explain in terms of an answer you gave before. Is most of the package analysis that you do in Australia validation of casks and designs that have already been done overseas?

MR DILLICH: Exactly. There aren't that many vendors who make Type B packages. In the United States there's three big companies that do that. The Europeans have a couple. So what we would do here in Australia is we verify the certification that's already been done.

DR SARKAR: We do one package, the new package. There is an Australian package by a private company. We did it because that package will be used in overseas and I think that package was validated in Russia, in China and some other countries and it will also be used in the States. So we did one package a Type BU, a BU package, which will be used mainly for (indistinct) sources or transporting caesium and cobalt sources.

MR DILLICH: So you can see why it's important for all member states to adopt the same standards from the IAEA.

MR JACOBI: Can I just pick up in terms of the regulatory oversight and perhaps a new package design because I suspect that's going to pick up much of what you might do in a recertification or a validation about what the regulatory process is that's associated with - - -

DR SARKAR: When we did the Type BU, just before that we are using what Mr Dillich has already mentioned, the Type B package, and this is the TN81 what we are going to use for (indistinct) return and if this can be used for spent fuel, the same package, and it's - - -

MR JACOBI: Sorry, just to take a step back, a TN81 is just a particular model of cask.

DR SARKAR: It's a model, yes. AREVA they call it now. There is like TN24, there is TN7. This is just the model. As you can see, when you design a package you have to have multiple layer of defence. We call it defence in there - for protection. As you can see, I mean it contains a number of safety features like from shielding to like the cooling fans and also for shock absorption. You have the cover during transport and your primary/secondary leads. Again, inside this you can see that the waste itself will be contained in a stainless steel canister and which will be again in a copper basket. So you can see that the number of layers of protection are there and that's why they are pretty robust and withstand any anticipated accident condition.

So, for example, when we assess the Australian package we call it model 1860. It's a Type B package. What we did is, we looked at all aspect of the requirement of SSR-6 - that is, from testing regime to the quality system of that institution - and they had to provide all the test results plus sometime if something is not possible to do, they have to demonstrate. For example, if you are not authorised to use the maximum amount of the radioactivity which will be transported, it will be huge, so you may not use it for normal testing but you can extrapolate and nowadays there's a very powerful computer called to assess the radiation level.

So we did take into account all this requirement, test results and we verified those. In some cases we recalculated. We also ran the computer independently, then we accept it and then we issued the design approval certificate.

MR JACOBI: The Commission understands that there are some testing requirements against which Type B packages - what they're required to withstand. I think we've got some slides that might pick some of the tests up.

DR SARKAR: These are the general tests that you don't need to visit - like spray testing the packet is working in any condition, then you do the stacking test. If you go to the next - 22 - as you can see, the nine-metre drop test is the standard requirement. However, see, in our case it was done 10 metres to give a little bit of penalty to make sure that it would meet standard and take a more conservative approach. Then in the testing there is also sequence and you have to take into account the cumulative effect of all these tests. Like once you do the drop test, then you subject it to the penetration test.

MR JACOBI: Same cask?

DR SARKAR: Same cask. Then you go to the next one, thermal test. Then they do have to withstand the 800 degrees Centigrade for 30 minutes. Then you go to the immersion test. You have to be present at an example of the emersion test. Then you take the cumulative effect of all these tests, that is there any breach of the package containment. Once you are convinced that, no, results are okay, acceptable, no breach, then you are in a position to make your decision whether to certify this package.

MR JACOBI: Just so that it's clear, what you're talking about it being cumulative is that you're not taking four different casks and testing them separately.

DR SARKAR: No, it's the same cask.

MR JACOBI: It's the same cask that goes through the exercise.

DR SARKAR: Yes. Otherwise you know that in realistic scenario it don't make sense because the cumulative effect needs to be on the same cask rather than the individual one. These are the practical example of a full-scale crash test for that Type B package. It is a bit of - you know, from the old days but, as you can see, the train and the truck collision and the train is hitting a very strong concrete barrier.

MR JACOBI: You mentioned realism and this is something that's come up in the evidence this morning; that is, we heard a view expressed this morning that the Type B standards that I think we've just been discussing and the testing requirements and the suggestion was that they weren't adequate because they don't protect a range of realistic scenarios and I'm just interested in your view as to whether the scenarios that are addressed are realistic.

DR SARKAR: In short answer, the answer is yes, because what you do - in the old days because at that time we did not have the power computer program and now what you do is, you do probably one-third of the scale, then you extrapolate, then you consider how it is almost identical because you can use the old results, which are full-scale test, like this is a full-scale test, and you can see that even after this crash the package integrity was intact and there was no breach. If you go to - - -

MR JACOBI: Just picking up on that because cask design changes, is there a requirement for a full-scale test for the new casks or do you do that by scale models?

DR SARKAR: The general practice is scale model because based on the historical results, the full-scale result. Now you can do the - so like I'll give you an example: of the TN81, which we are going to use, the impact test was done using F18 air crash model. It used the impact result of the missile to, say, one-third of the scale. So that used the computer modelling which almost give you the very accurate and precise representation of that crash test. So in most cases it is the scale - you use a scale.

MR JACOBI: Given the testing that I think you've just conducted, is there evidence from testing that the packages are capable of withstanding pressures or impacts that are beyond the requirements of Type B?

DR SARKAR: For impact analysis, I would say that considering the conservatism used in the analysis - for example, I mean as Mr Dillich said, for Type C package it's the recent one and you can't expect any higher because you are doing air transport. I think its requirement is like 94 metres per second impact. When they did analysis for the TN81, they used the F18 air crash impact. In that case it is 214 metres per second. As you can see, the conservatism is much more higher. So it is a model for beyond design parameter was used. Even in that case, it was shown that the package integrity will be retained.

MR JACOBI: Is that also the case beyond questions of impact and thinking about things like emersion or fire?

DR SARKAR: The fire/immersion - I mean 30 minutes they considered that you'll have a recovering operation during that time, considering the realistic scenario. Because all the controls they go hand in hand. If you have this kind of transport, your emergency people are there. All the recovery operation will be there. Considering that track record so far, that all the international organisations they did not feel that you need to increase the requirement because when this requirements are revised, all the international organisations are involved, like ISO standard organisation, and there is a German company which are very good at testing. It's a government - the acronym is BAM. There is also a AREVA representative, industry representative. So they all have their say and if they feel that whatever we have meets the requirement and it will ensure the safety of transport, so - - -

COMMISSIONER: Can we move then into actual accidents. What's actually happened with spent fuel? What have been the accidents and what have been the results in terms of integrity of the cask?

DR SARKAR: As with the road transport, road and rail transport, that competent authorities, we mainly concentrate on the realistic accident scenarios of a road accident. So in that case we also used the results done by the other representatives like NRC. So last year NRC published a risk assessment and also like if there is a tunnel fire, although it is not the case in our Australian case. So we take all this into account, whatever is the international best practice or international available information, then we things we could look - in that case it is this sort of risk is incredible. Plus what you do is, we have the safeguards - ASNO - office. They're the security one. We also take their advice. What is the risk assessment in terms of getting the spent fuel cask hit by a sort of like missile or any other - so some sort of explosive attack on this kind of thing. Then they give us their assessment considering the security control in place. So we take all this into account and then we say, "Look, it looks like it is - - -"

MR DILLICH: I'm not aware of any incidents or accidents that have breached the container for a spent fuel. But Fukushima, we could talk a little bit about that.

DR SARKAR: Yes, in the incident - like I said, that during the Fukushima event there are eight dual-purpose casks which is used for storage as well as for transport. These casks, as you can see on the left and side, I believe if I can recall that just close to the shore you can see there is a small - the building is - I mean from the left, it's the third one, smaller one, it might be (indistinct) and it was directly hit by the tsunami.

COMMISSIONER: Yes, we saw it.

DR SARKAR: And there is no release and the integrity was intact. This presentation I took it from the Japanese representative at the trans meeting IAEA Trans meeting. So far the record shows that there has not been any breach of containment for any sort of spent fuel accident or incident.

COMMISSIONER: There was a shipwreck (indistinct) in 1997.

DR SARKAR: Yes. That was not spent fuel. That is a (indistinct) irradiator. So that is not a spent fuel. But nowadays, as you know, in 2001 the irradiated nuclear fuel code - I mean the INFS classification came into practice so you have to double-hull and then all these things need to be there so that it had more safety features.

MR JACOBI: Can I just pick up those changes. You've talked about there being a change in shipping requirement. Could you talk the Commission through that. What was the regulatory change at that period?

DR SARKAR: Regulatory change is when the - I mean the Maritime Safety Authority approves their transport plan. In that, they take into account what type of vessel will be used and then the vessel's safety features they assess and then say, "Look, you have to comply with IMFT for spent fuel."

MR JACOBI: So these are additional operational controls within the package?

DR SARKAR: Yes, these are the additional operational control.

MR DILLICH: It specifies where in the ships cargo. It's below decks and there's certain features that have to be met. Double-hull obviously is a big deal.

MR JACOBI: So is that now an international requirement?

DR SARKAR: It is.

MR JACOBI: And from what point?

DR SARKAR: It is part of - it's in addition to IMDG Accord, "Enters maritime dangerous" is the code.

MR JACOBI: So one of the codes that I think branched off from the orange book. Is that right?

DR SARKAR: Yes, you're right.

COMMISSIONER: Though it wasn't spent fuel, I understand there was an aircraft crash too with Type A and Type B.

DR SARKAR: Type B, yes, and there was no breach of containment, even from Type A in that incident, so it remained intact. That means that whatever we know is in place in times of the regulation so far, there has been no complaint with all the requirement. There has been no notable incident in transport of radioactive material.

COMMISSIONER: How do you keep your organisation up to date with developments, international developments? How does ARPANSA do that?

DR SARKAR: For example, I sit in the IAEA Transport Safety Standards Committee which main task is to update the SSR-6, the transport regulation in coordination with other relevant bodies. So this is the main source that we get. Also, this is for other dangerous goods because this is not Class 7. There are Department of Transport, they go to other even subcommittee for other transport code. At the same time, the CASA - Civil Aviation Safety Authority - representative, they attend the IKR meeting and ANSTO people, they met in the IMO meeting so that in this way their interface is properly maintained but the main driving force is the IAEA Trans for this safety requirement.

MR DILLICH: So ARPANSA staff, they spend quite a bit of time participating in the committees that generate revisions to this.

DR SARKAR: Also, if there is any issue to Australian interests, for example, from the mining point of view (indistinct) level all these things; that there is no regulatory bar into the industry. At the same time, maintaining the safety of the community.

COMMISSIONER: Gentlemen, I think that exhausts us. Thank you very much for your evidence. It's been very useful. Thank you for all the proportion you put into assisting us understand the transportation issues.

MR DILLICH: Our pleasure, thank you.

MR JACOBI: Thank you very much.

COMMISSIONER: We'll adjourn now until 1430, when Hef Griffiths will join us from ANSTO.

ADJOURNED **[1.05 pm]**