Indian Institute of Technology Madras

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NATIONAL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING

NUCLEAR REACTOR AND SAFETY

AN INTRODUCTORY COURSE

Module 13 Lecture 03

Safety Regulation in India Cont...

Dr. G. Vaidyanathan

School of Mechanical Engineering

SRM University

Good afternoon everybody. These last two lectures I have been talking about the activities of the Atomic Energy Regulatory Board and how it carries out its regulation and we also saw how any upgradation to the existing plants of older designs are done. For example, we looked at some improvements after the Three Mile Island. We saw some improvements after the Chernobyl accident and in this lecture we shall see what happened after the Fukushima. Mind you these deliberations which are done in the AERB if you really look up it is like a court of law. The arguments has to be given based on actual, something that you have to prove beyond doubt that it is safe. The whole discussion is held in the most cordial atmosphere. All of us aim at delivering safety and it is not that few people agree, few people disagree. All need to agree that safety is assured, and in this process of safety discussions, we have found that our knowledge base has

been enhanced very much. Here we are able to bring in the inputs from experienced people in other fields also. So do not think that this regulatory excise is just a formality. No. it really go deep into that and no question is too small a question to be answered. We will now proceed ahead.

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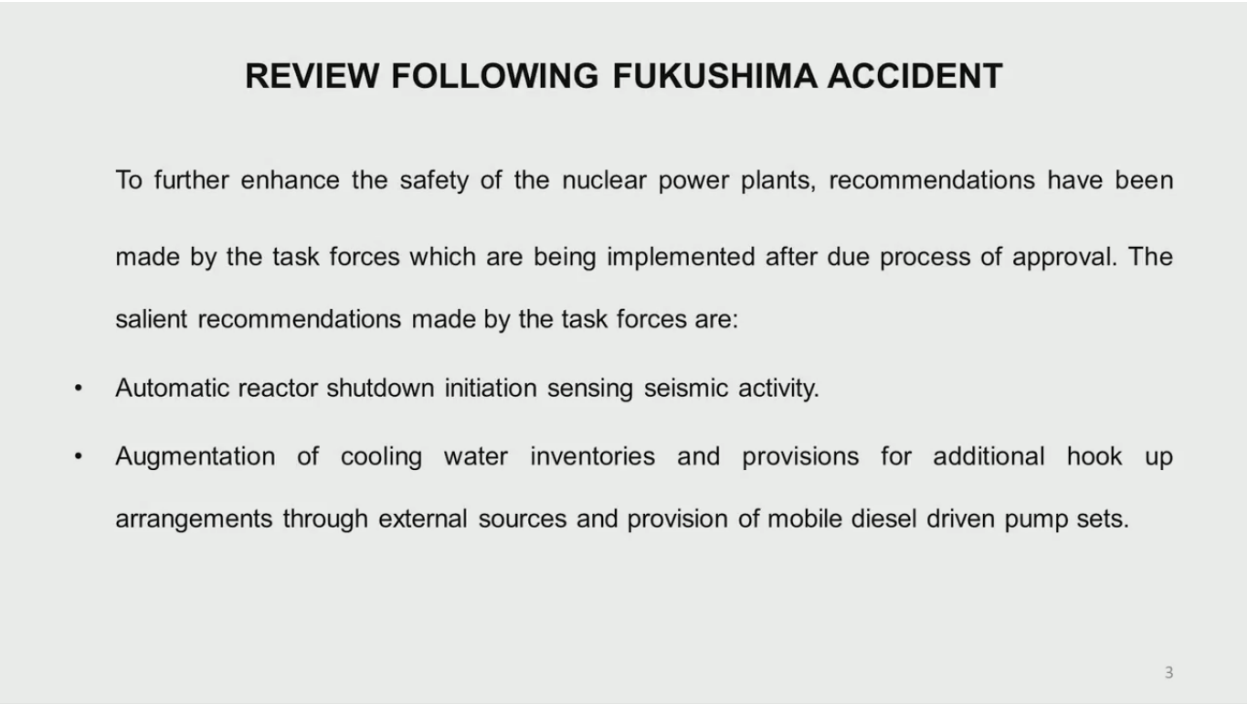

We will look at what sort of things we needed to do after the Fukushima accident. Now hear this Fukushima reactor is a boiling water reactor and these reactors are similar to the first two units at Tarapur. Based on the accident reports which have come some reviews have been undertaken and some recommendations important recommendations made. One important recommendation was automatic reactor shutdown in case of a any seismic activity. In the later reactors it has been mostly introduced but it is not common to have this seismic activity sort of monitor. They do monitor the activity but no automatics shutdown. But subsequent to this Fukushima the feeling was that it should be automatically shut down more as a safety measure. Here I can tell you one happening in the – there is a fast reactor plant Phénix in France and every day around eight to nine the record of the seismic detectors used to be higher than what is normally throughout the day. Similarly it used to be a bit higher during the evening. Initially people didn't understand what is this. When they analyzed it was found that is a time when most of the employees are entering the site in the morning eight to nine and four to five people are living. So the seismic

activity it's getting recorded. So such fine sensors they had. Then one more thing which improvement we felt was the cooling water inventory that is the amount of cooling water. That is you must be able to provide cooling for a longer amount of time and be able to hook up additional sources of power. In the case of Fukushima because the diesel generators themselves were flooded by water, they couldn't operate. So in that case their fire engines and all came. So here if you make provisions in the initial stages of the design itself to have some input by which you just can bring the fire engine and then link it it might be better so that time is not wasted. So no additional things need to be done. So this some provisions has been made along with you have mobile diesel driven pump sets were made available at the site so that that could take care. This again I repeat it is a again in defense in depth. It is only an additional sort of safety.

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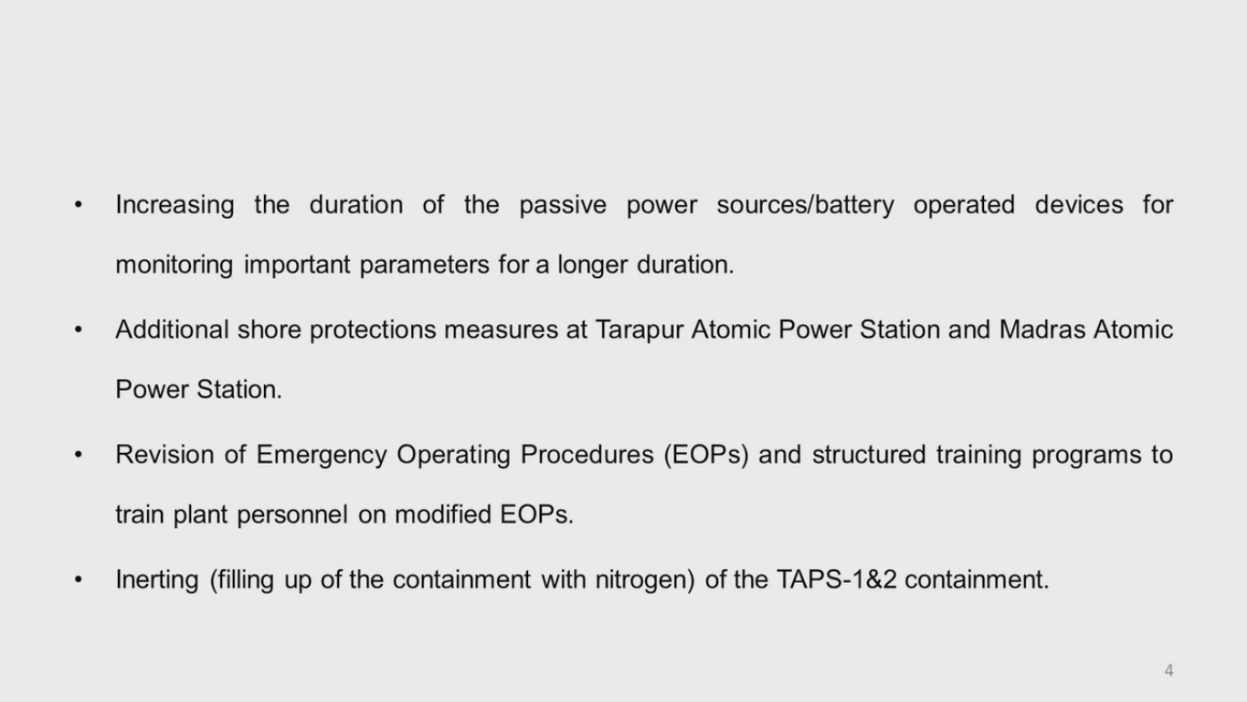

Then other thing was the increase in the duration of battery supplies. You know battery supplies are needed for the instrumentation to monitor the health of the plant and some valves may need battery power, some limit switches may need battery power and we normally have a uninterrupted power supply system which gives the AC power after taking from the batteries, converting into AC and that gives similarly the DC battery power. It was felt that if we can improve the duration of that it will be better. Why we say it is passive because it comes on, it is already online batteries are online, only thing no switches are needed to be open. So we call it the

passive power source. Then Tarapur even though it is not very close to the seacoast some shore protection was done but major at the Madras Atomic Power Station we did, you know, that atomic power station at Kalpakkam, Madras Atomic Power Station at Kalpakkam was affected by the tsunami in 2004. If you recall my lecture on the events in different nuclear plants but nothing happened to the plant. Nothing means no doubt the cooling water pump which takes suction from the seawater that room was flooded and once the room was flooded the pumps could not operate. The pump tripped but within minutes when the water receded it was just an hour or two of inspecting those room and then we could have started but we started a bit later so that we are sure that nothing has happened. But we did have some deaths in the township where maybe all the design basis things were not followed. So sometimes we felt we have made the nuclear reactors really considering all design basis events but not the township. Then that by constructing some walls on the shore. We also reviewed the emergency operating procedures. Then the training to the operators basically during earthquakes and tsunami what we should do. We took the feedback based on the tsunami experience of 2004 and improved this. Then in the case of Tarapur, we looked at inerting the containment in case of a accident with nitrogen. That was one additional thing so that oxygen is not available for any combustion. Here you may recall in Fukushima the hydrogen released by the reaction of zirconium clad with water within the core had produced hydrogen which the concentration of which grew up beyond 4% to 10% and available oxygen in there was sufficient to ignite it and that caused the explosion. It was a hydrogen explosion, not a nuclear explosion. Somehow people tend to say the reactor exploded. Reactor never exploded. It is only the hydrogen which exploded. So inerting with nitrogen is one. Again this is again like a what you call defense in depth approach. I can tell you in the case of Tarapur, we have a common building to which both the containments are linked something like a vacuum building which I mentioned in the case of heavy water reactors or CANDU reactors and those hydrogen all the -- it is linked except during accidents. So the normal hydrogen generation everything is continuously goes to the other building from where it is ignited. There are igniters and then ignition is done to burn the hydrogen. So hydrogen will never get concentrated and this of course subsequently this passive auto carrier recombiners of hydrogen we're in hydrogen oxygen or combined. This also we are now introducing in all the plants. Okay now we talked about the safety review after some incidents in different plants happening what we did. We looked at that.

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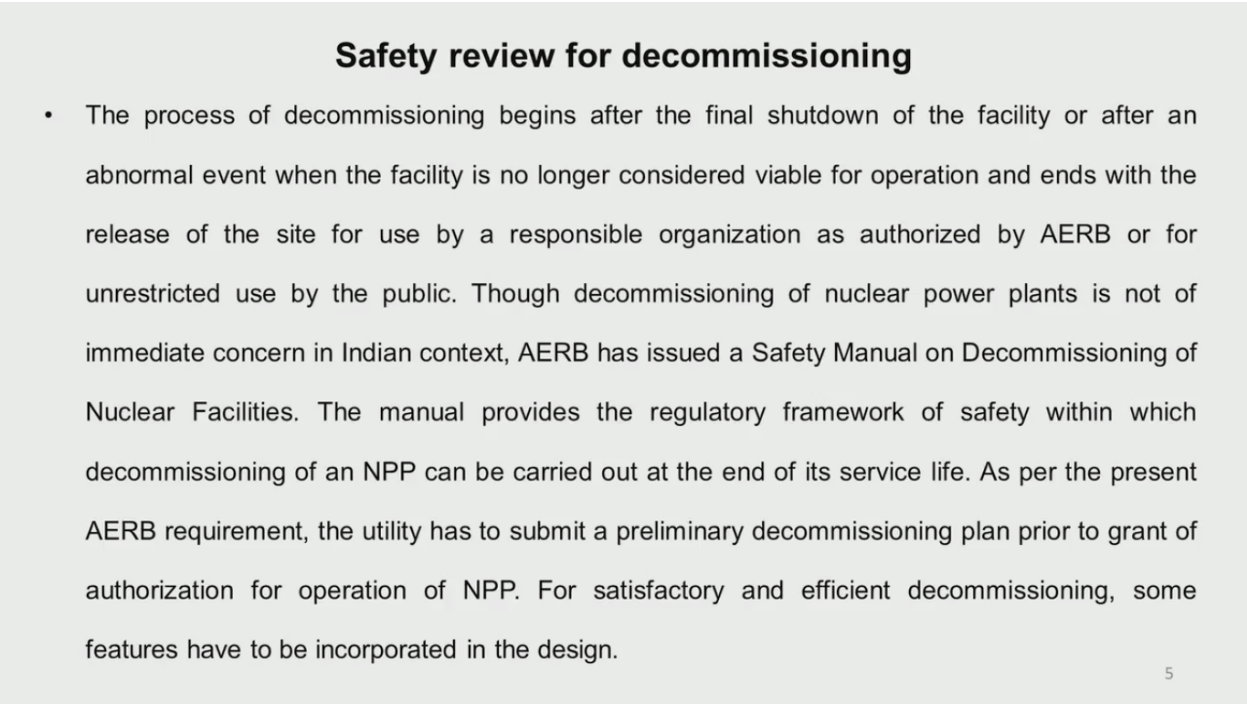

Then let us say the plant has lived its life or the plant has had a major accident. Now you are not going to operate it anymore. When you are not going to operate it anymore then the idea would be to decommission it. Remove the equipment and then maybe put another plant there but then this is not a easy thing to do. The whole reactor contains lot of radioactive material. The core material have got activated. So you just cannot go and work on them. The activity has to come down. Then the liquids which are radioactive liquids they are to be handled. Then they have to be safely disposed.

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- The responsibility of decommissioning the nuclear power plant lies with NPCIL. For the purpose of meeting the cost of decommissioning, a decommissioning levy is collected from the consumers of electricity from nuclear power station and kept in a separate decommissioning fund. The decommissioning fund is invested in long term investment so as to earn optimum returns on the fund while maintaining adequate safety and liquidity of the fund. This gives assurance to AERB that lack of fund will not come in the way of safe decommissioning. Before taking up the decommissioning of the facility, the utility will prepare a detailed decommissioning plan. Based on review of the plan, AERB will approve a set of technical specifications for the facility to be followed during decommissioning.

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So when all these steps which are required are put down by the utility which wants to decommission a facility and then these procedures are reviewed by the Atomic Energy Regulatory Board. As of now we already have a safety manual on decommissioning of nuclear facilities though till today there has not been need for decommissioning any plant but in the few years or decades from now we may have to look at that. So based on these procedures have to be laid up, put to the regulatory authority by the utility to get the grant of authorization. Till that the plant has to be maintained in a safe shutdown state. It is something like to start a company you need clearance licensing. To close a company also you require a license. It is something akin to that but here safety of the people is involved. So as such the responsibility of the decommissioning is with the utility that is the NPCIL. If you look at the cost structure of the electricity which is being supplied a small portion is levied for decommissioning also so that when the plant is decommissioned because as long as a plant is operating you are getting revenue but once the plant is stopped, you do not get revenue. You do not produce electricity. So you cannot go to the people at that time or go to the government at that time and ask for money to decommission the plant. So we have a fund which is already collected based on a levy for decommissioning which is also accounted for in the cost of the unit of electricity and this is kept in a long-term investment so that when it is needed for decommissioning financing is not a issue. Here also just like technical specifications of operation we need technical specifications of

decommissioning. And how does the utility draw up this? Of course one is we do have decommissioning experience of different countries. In the USA many reactors have been decommissioned. Also in UK. In fact the fast reactor decommissioning in UK is a very good experience for fast reactors in India, and all these experience is shared through the International Atomic Energy Agency. So knowledge is not secret and from our own side lot of R&D needed towards decommissioning is already underway so that when needed all these would be put together and if you take U.S. decommissioning after an accident was done for the Three Mile Island the major thing was the large amount of radioactive water which needed to be purified then only the water could be let out. So this led to a development of specific resins which would take up the activity and once this resins take up the activity, that resin could be treated as a radioactive waste while the water could be let out into the river or sea and this was a very big job. They had developed remote units which could do that and that gave us a very good experience of how things can be done.

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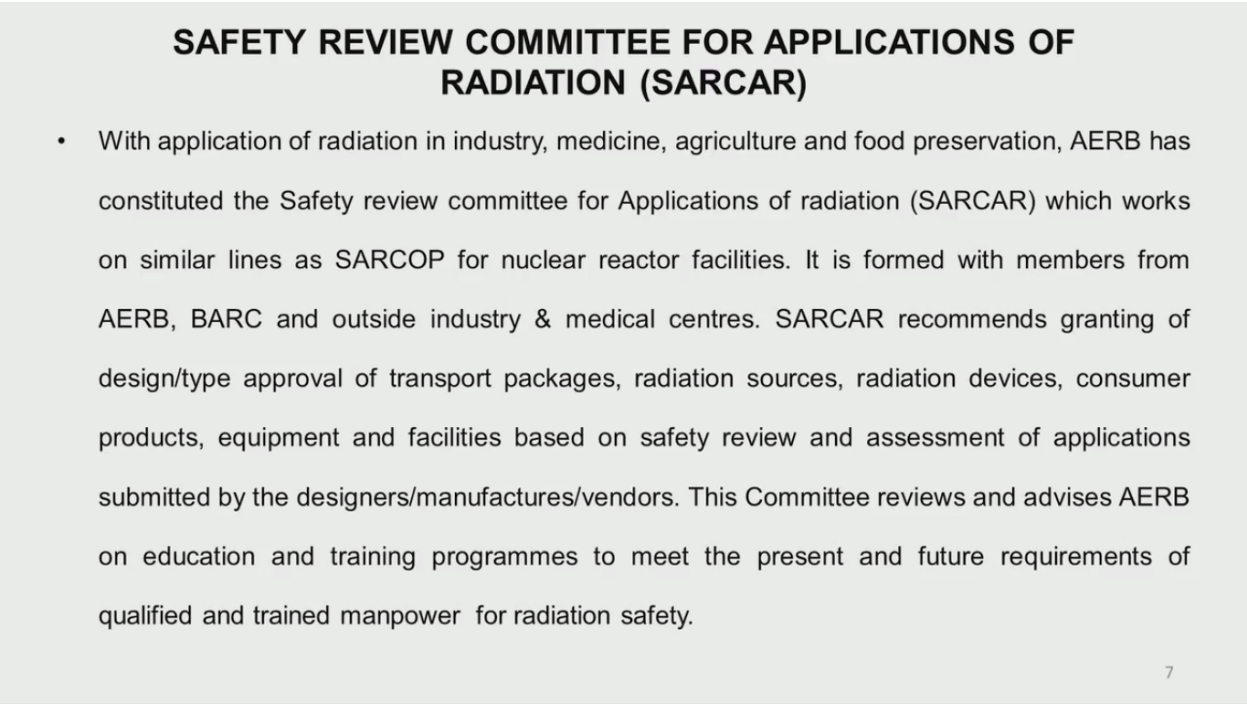

Having looked at the safety review of the nuclear power plants, we saw there is other thing is the nuclear and radiation facilities that is other than nuclear power plants rest of the nuclear radiation facilities comes under this. So similar lines as SARCOP it has members drawn from the regulatory board, BRC, the industry and the medical centers because medical facilities, industrial

facilities come under the jurisdiction of this committee. So what is the role of this committee? SARCAR it recommends granting of design type approval for packages, transportation of radioactive sources for different radiation devices. Then also the safety review and assessment of operation of these facilities. Now this which things are submitted by the designers, the manufacturers and vendors to the SARCAR which reveals them and once they give the approval they can be utilized in the actual medical or industry or elsewhere. Not only that the SARCAR also advises on conducting education and training programs to the people because we require lot of qualified and trained manpower for the different radiation facilities. So they must be properly trained. So SARCAR in fact tells what should be the curriculum of their training, what all things they should know. All these for radiation safety as an industry has grown with very good review by this SARCAR.

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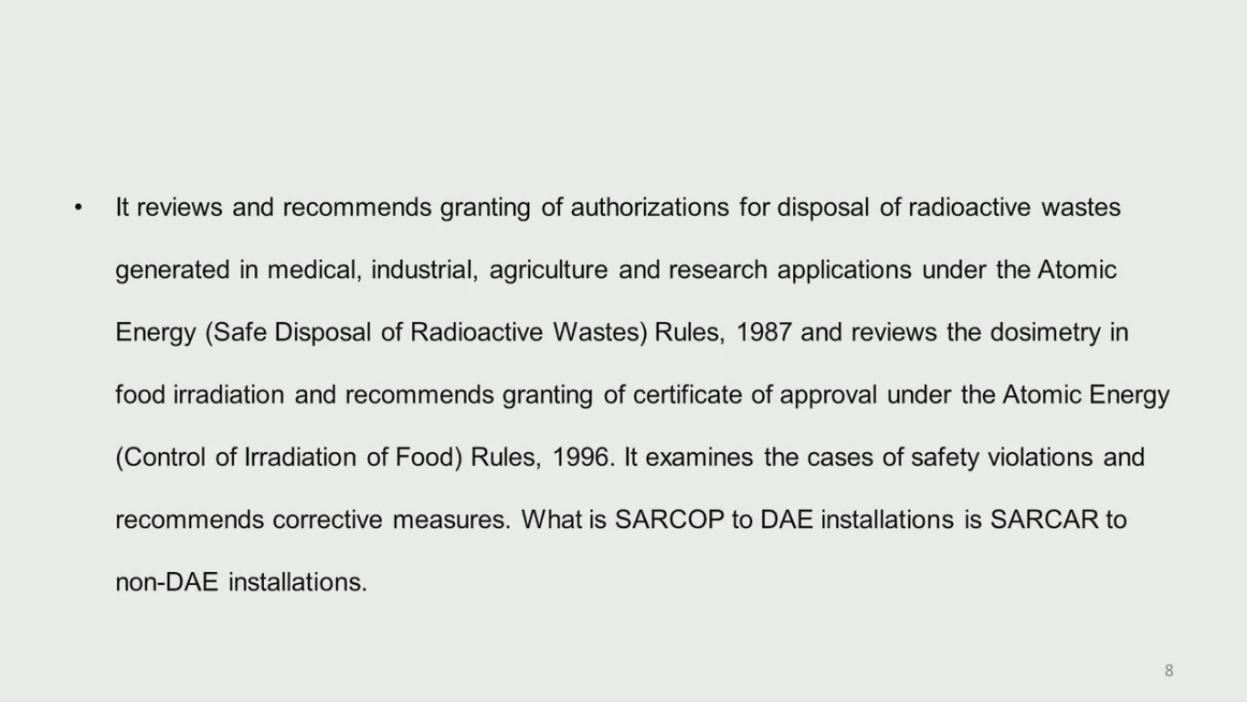

So then should we need to dispose radioactive waste then whether which are generated in the medical, industrial, agricultural, and other applications, if you see in my first two lectures I talked about a variety of areas where radiation is supplied and everywhere you could have waste and how to dispose them. Safe disposal rules which are been promulgated in 1987. Not only that irradiation of food. Today we have food irradiation as an accepted norm. irradiated food are being sold in Maharashtra. It is slowly gaining importance. So this SARCAR will certify this

establishments for irradiation of food. So whether they are following. So in short what is SARCOP to DAE is SARCAR to non-DAE. DAE means Department of Atomic Energy.

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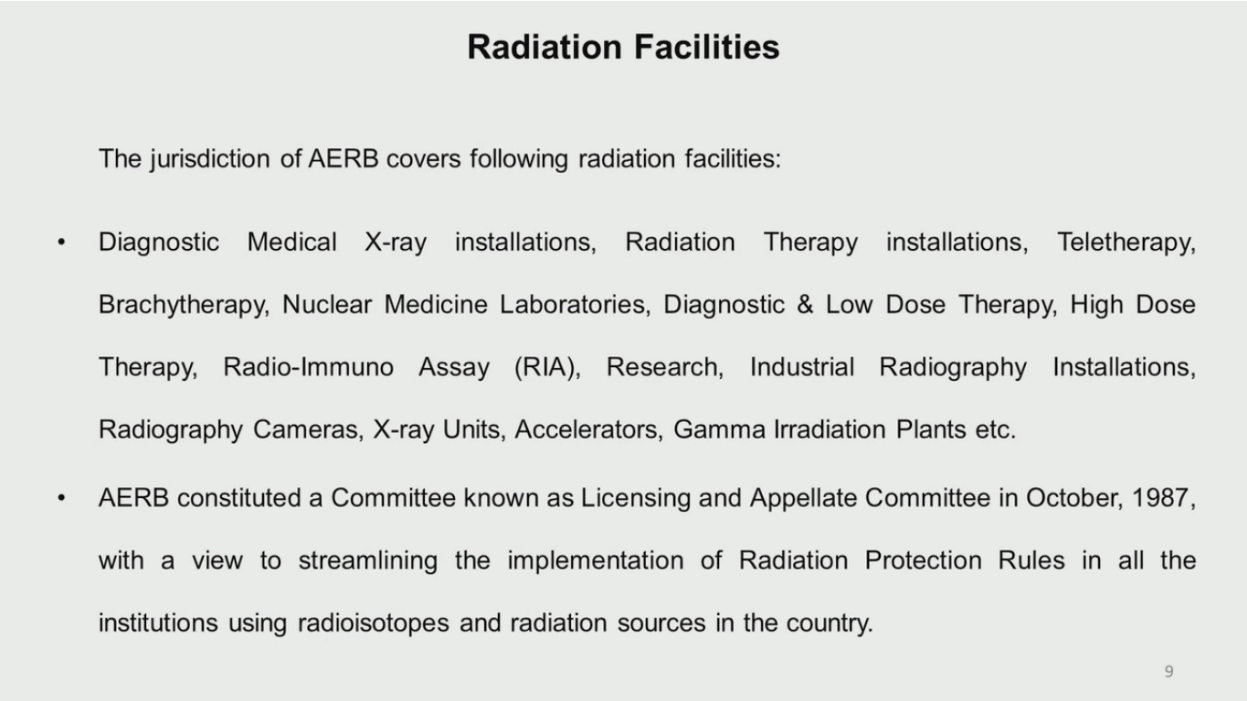

Now what are the radiation facilities that AERB covers? Is it long but nevertheless it is my duty to point out the different. One diagnostic medical X-ray installations, very clear. You have a huge number of extra installations in the country today. Radiation therapy where radiation medicine is given. Teletherapy, we saw Brachytherapy implanting the radiation source inside. Nuclear medicine laboratories. High-dose therapy Radio-Immuno Assay, industrial radiography, radiography cameras, X-ray units, Accelerators, Gamma Irradiation plants, and any more. So all these are come under the jurisdiction of SARCOP.

So AERB has constituted also a committee which will license these establishments in the country just like the licensing of the power plants in the nuclear power plants in the country. So this of course has started in 1987, this committee. So wherever radio isotopes are used or any radiation sources are used they are doing that.

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- The Committee recommended approval of Radiological Safety Officers, provided guidelines for education and training in radiation safety, reviewed and recommended "Type Approvals" of all radiation equipment as well recommended issuance of "No Objection Certificates" to such equipment imported from abroad. The committee reviewed and approved installation of plants for X-ray machines and Teletherapy units, evolved procedures for licensing of radioactive materials and registration of X-ray equipment. It reviewed and recommended applications for transport certificates for radioactive materials and reviewed the emergency preparedness plans for transport of radioactive materials. It provided norms for penal action and also to hear appeals from contending parties.

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And they give guidelines as I mentioned for education and training in the area of radiological safety, and they approve a certain equipment which is used in the radiation area for measurements or any other activity. So a type of equipment if they give an approval okay this type of equipment is approved by AERB. If it is not approved then it cannot be used by the facility. Similarly if you are importing it from abroad, sometimes you do not get the equipment of late – most of the equipments are getting developed or fabricated within the country but sometimes there has been need in the past to import it. In case you get an import the design of the equipment has to be submitted to the AERB and it would then issue a no-objection certificate for import. Not only that the committee has reviewed the installation of plants for X-ray machine which will produce X-ray machines, teletherapy units. It has also evolved licensing procedures for registration of X-ray equipment. In fact this committee also looks into the transport certificates for radioactive wastes or radioactive material and emergency preparedness plants in case let us say an activity source, radioactive source has been dropped or it has been lost, so under that condition what sort of action should be done and what sort of penalties have to be put on the utility in case there has been a negligence on their part. So all these things however, it is gaining more and more strength and these things require support from all governmental agencies in the implementation. AERB is only a small organization. It requires support of many state organizations also.

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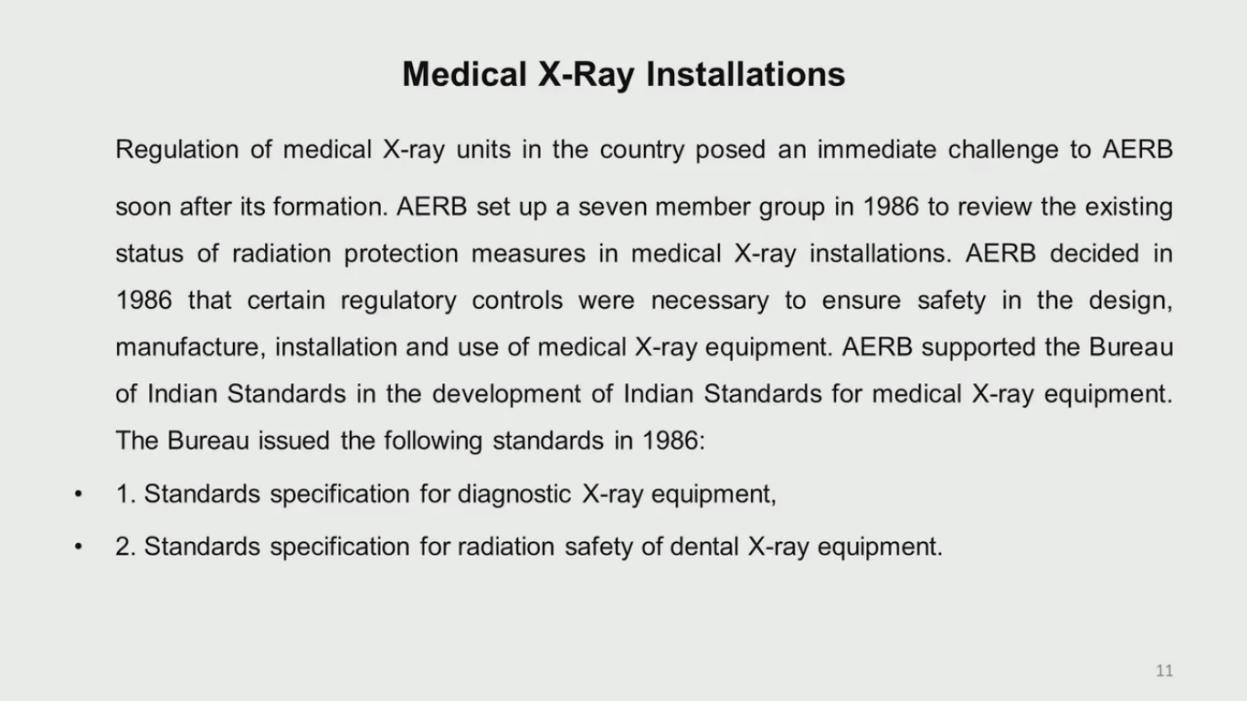

So one of the important things which reference to the medical X-ray installations was AERB set up a committee to link between all the medical X-ray installations and felt that things are not going on in a right fashion. The person who is taking the X-rays himself he is not aware of this radiation safety. Forget about the person whose X-ray is being taken that fellow should be he may be trained in taking an X-ray but is he trained in handling that equipment? Does he have a person who has enough knowledge about the radiation equipment? So these things were looked into and AERB brought out along with the Bureau of Indian Standards the standards for medical X-ray equipment that need to be used. One for general X-ray other for dental X-ray equipments.

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- The total number of X-ray installations in India was not known accurately. Then AERB sent the guidelines for medical X-ray installations to all district authorities in India. The district authorities sent addresses of medical X-ray installations located in their area. This provided the initial input to the X-ray registration programme. The inspectors from CSIR and DRDO collected data on 30,583 X-ray installations. The programme did have a tremendous impact. However the number of diagnostic X-ray units registered is only around 50,000, by 2008. The staff of AERB made a detailed analysis of the data collected and sent letters to all the above institutions and where deficiencies were observed, directions were given to remedy the deficiencies. In order to improve the status of radiological safety in medical X-ray installations, quality assurance test of each X-ray unit had to be carried out and the deficiencies found were to be remedied. A quality assured X-ray unit would result in optimizing the radiation dose to patients and minimizing radiation exposure to radiation workers.

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But now when this was started or this action was now the question how many X-ray installations are there? AERB cannot be going around scouting where the things are. So it required the support of district authorities. They in turn state, the district, and not only that in many industrial establishments where hospitals all everything finally it appeared that there are about 30,583 extra installations but nevertheless it was felt that there would be surely much more than that but many of them were not -- we are not knowing where they are. So that needed further enforcement by the local state governments. So in such cases all units, x-ray units or ask to be registered with the AERB and AERB personal would go. They would check their equipment weather equipment is in order and they would give a training course to the operators and every X-ray unit or hospital would have a radiation safety officer who is knowledgeable about the medical effects as well of the radioactive nature of the equipment which it's using. So that awareness.

So here the idea was the amount of dose which is being given to the X-ray needs to be controlled based on the requirement and this radiation safety officer with a background of a new field which is called as medical physics which has emerged after this. So today every big hospital has a radiation safety officer.

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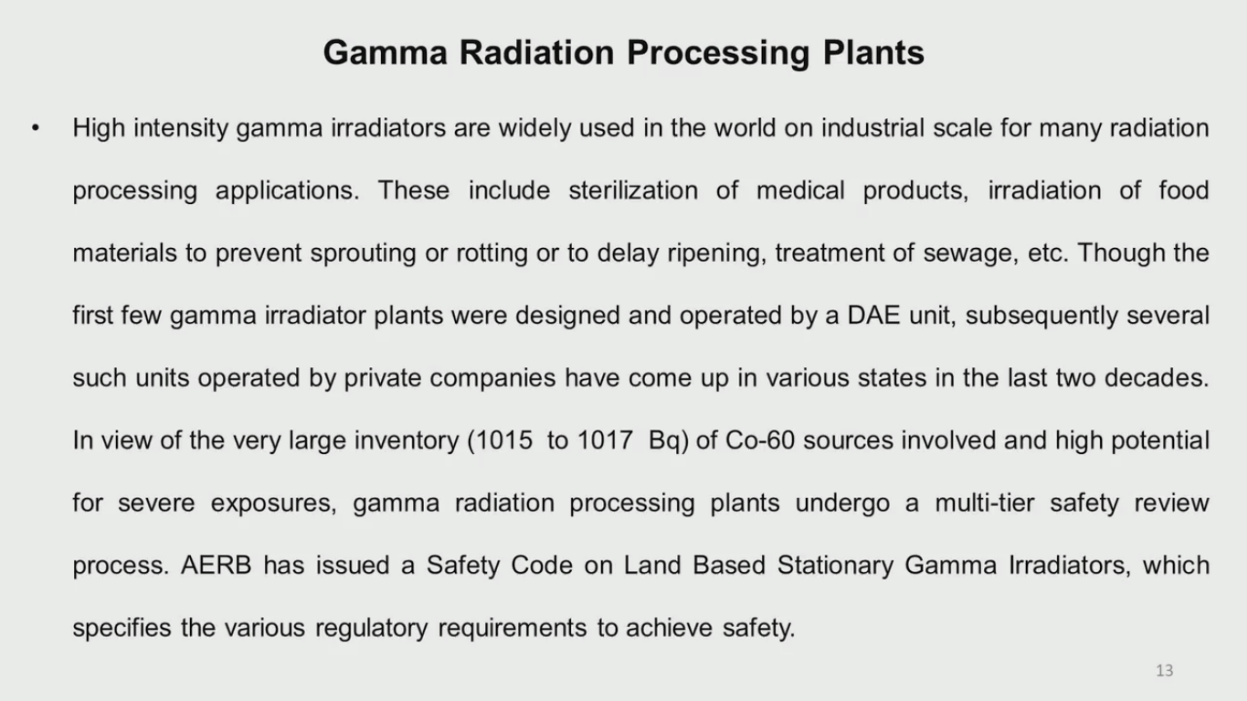

Then besides this, the Gamma radiation processing plants which are many in the world. Of course in India they are few. They do the sterilization of medical products as I mentioned the medical gauze, the syringe, or the irradiation of the food materials, or treatment of sewage. So lot of gamma-irradiators have been designed and built and many of them have been handed over to private companies. So this deal with large activity of cobalt-60 sources and they have a high potential in case these sources come out because they would give a large amount of Gamma radiation. So there was a need to really treat them with the highest priority and the safety review process was made. In fact AERB has issued a safety code on Gamma irradiators which specifies the various regulatory requirements for safety.

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- A large number of radioactive consignments, nearly 80,000 per year, containing radioactive materials in different forms, varying nature and quantities are being transported within the country for use in medicine, industry, agriculture and research, and also for nuclear fuel cycle activities. In addition, radioactive materials are also imported and exported or pass through the country in transit. Radiation Surveillance Procedures for the safe transport of radioactive materials were formulated in 1987, which stipulated the requirements for ensuring safety to persons, property and environment associated with such transportation. Ever since, the competent authority is approving every package deployed for shipment and only the packages of approved design are being used.

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Now we get many materials which are transported for use in the industry, agriculture like fertilizers or research, or many times for the nuclear fuel cycle activities. Also sometimes radioactive sources are procured. So in all such cases if you know that it is radioactive there is no doubt but nevertheless in order that radioactive things do not come in, at all ports, at all airports we have radioactive detectors which give signals in case any radioactive products are coming or in case there is a doubt whether they contain radioactivity, the personnel from the Atomic Energy are called and we check, do surveillance and find out whether there is any active product being transported. And if it is so whether it is being transported properly.

So practically all these packages of radioactive equipment for shipment and coming all need to use packages of approved design and this is being implemented by AERB. So who are the vendors the manufacturers. In fact before the input they need to get clearance from AERB anyway for import and at that time they also need to submit how the package is going to be done, how it is going to be airlifted, or it is going to be shipped, how it is – what are the test reports and what are the quality assurance that has been put into the whole design and transportation of the packaging until then these things are not cleared for transport. Now this has gone into a separate stream with lot of equipment coming on transport being transported. A committee on safe transport of radioactive materials acronym COSTRAM has been constituted in 2003.

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- Designers, manufacturers, consigners and users of such packages comply with the requirements including submission of safety report on the package design, test reports and quality assurance manual as applicable to specific packaging or shipment. Certain shipments such as those for Teletherapy sources, high activity radiation sources used for certain exposure devices, high intensity irradiators, etc., cannot be carried out without prior approval from AERB. A Committee on Safe Transport of Radioactive Material (COSTRAM) has been constituted in May 2003 by Chairman AERB to review various safety aspects of transport of radioactive material.

See once your requirement of a certain thing becomes more and more you need to have a specialized agency for that. So that is where our learning process we find okay more of such things are coming. No. Then this needs to be attended to by a separate committee. So like that we have set up the COSTRAM that is a Committee on Safe Transport of Radioactive Material.

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Regulatory Inspection of Radiation Facilities

- Inspection and enforcement activities are important components of regulatory functions of AERB. The objective of the inspection is to ensure that the stipulated regulatory requirements related to handling of radiation sources are fulfilled in practice. The Radiological Safety Division (RSD) is responsible for carrying regulatory inspections of all non-DAE radiation facilities. RSD prepares the schedule of inspections as per the category of radiation facility which depends on its potential hazard. Plants with high intensity sources like gamma radiation processing plants are inspected once a year while radiotherapy units are inspected once in three years.

Then just as we had regulatory inspection of the nuclear power plants by SARCOP, here we have the regulatory inspection of the radiation facilities. Of course, the major role of this inspection is to ensure that whatever regulatory requirements are being stipulated in the handling of these radioactive sources are fulfilled in actual practice. So also the documentation of the procedures and the authorizations whether at different stages or proper all these are given in the guides or the manuals and whether they are followed. So here the radiological safety division which consists of experts in health physics does this regulatory inspection. It has a schedule depending upon the type of the facility and its potential hazard. Now depending on the hazard your inspection interval varies from one to three years. Normally radiotherapy units are inspected once in three years whereas Gamma radiation processing are inspected every year because the turnover is very high.

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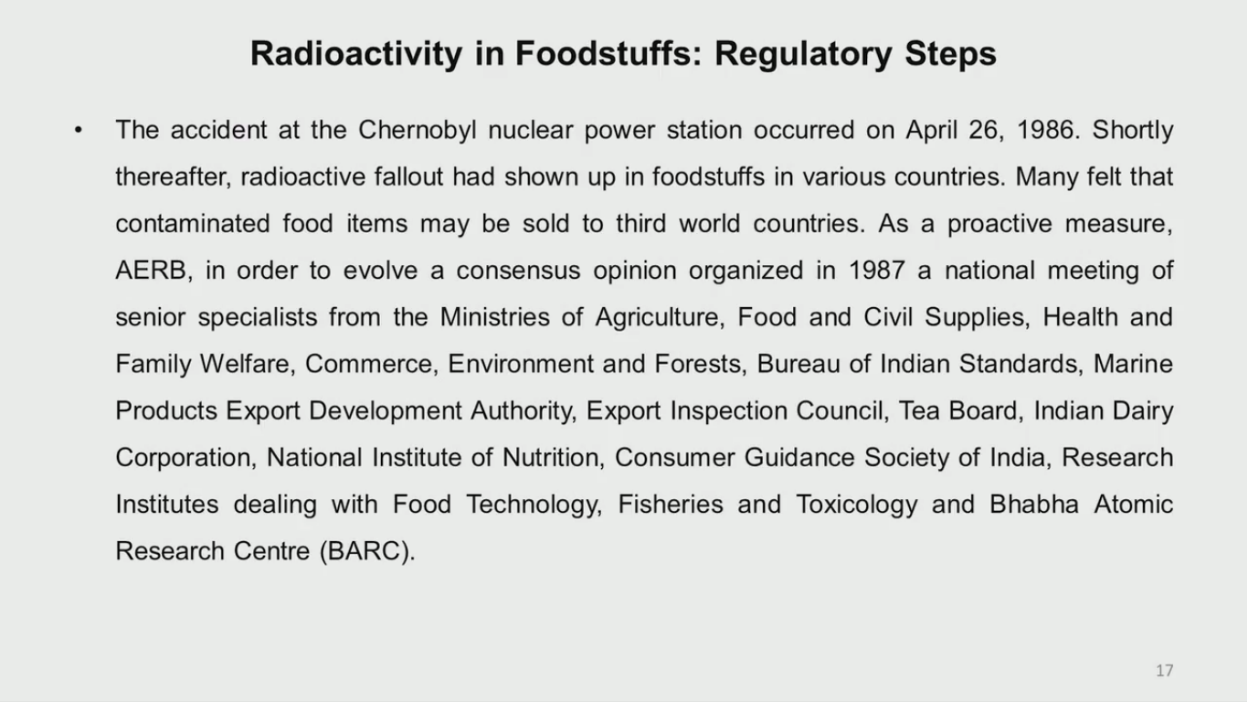

Then radioactivity in foodstuffs. You may be aware that the Chernobyl nuclear power station accident occurred in 1986 and afterwards people felt that the foodstuffs in the nearby countries people said do not consume. That food would have been contaminated by the radioactivity which has come out of the Chernobyl plant. So many of the things might be transported to India also. So whether the food whether it's really correct or not so luckily for India we did not have any

impact though we were able to measure that Chernobyl accident has actually happened after nearly a month or two after that we did our environment surveillance laboratories did detect there is a small peak which correspond to the Chernobyl. Maybe based on the direction of the wind and other things and no other fallout had taken place. So we could attribute it to the Chernobyl event. It was not very high but nevertheless as a extreme caution and proactive measure the government evolved wanted to evolve a consensus because lot of food means lot of other agencies are also involved. So it brought in people from the ministry of agriculture, food, and civil supplies, health and family welfare, then environment and forests, then marine products development authorities, export promotion; all these because tea board, dairy corporation, why you remember when we were talking about the source term of activity we found one is the air route, other is the through the animals eating the grass, radioactive grass that cows giving milk, the fishes taking the radioactive water; all sorts of things. So that different pathways are there. So for example after the Fukushima accident, many people are not taking fishes from Japan. So this required lot of these things and in this area we have a very well-developed laboratory at the Bhabha Atomic Research Center which has been doing research on these things for practically last three to four decades and this committee brought out a standard based on which we could follow to say whether it is contaminated or not contaminated.

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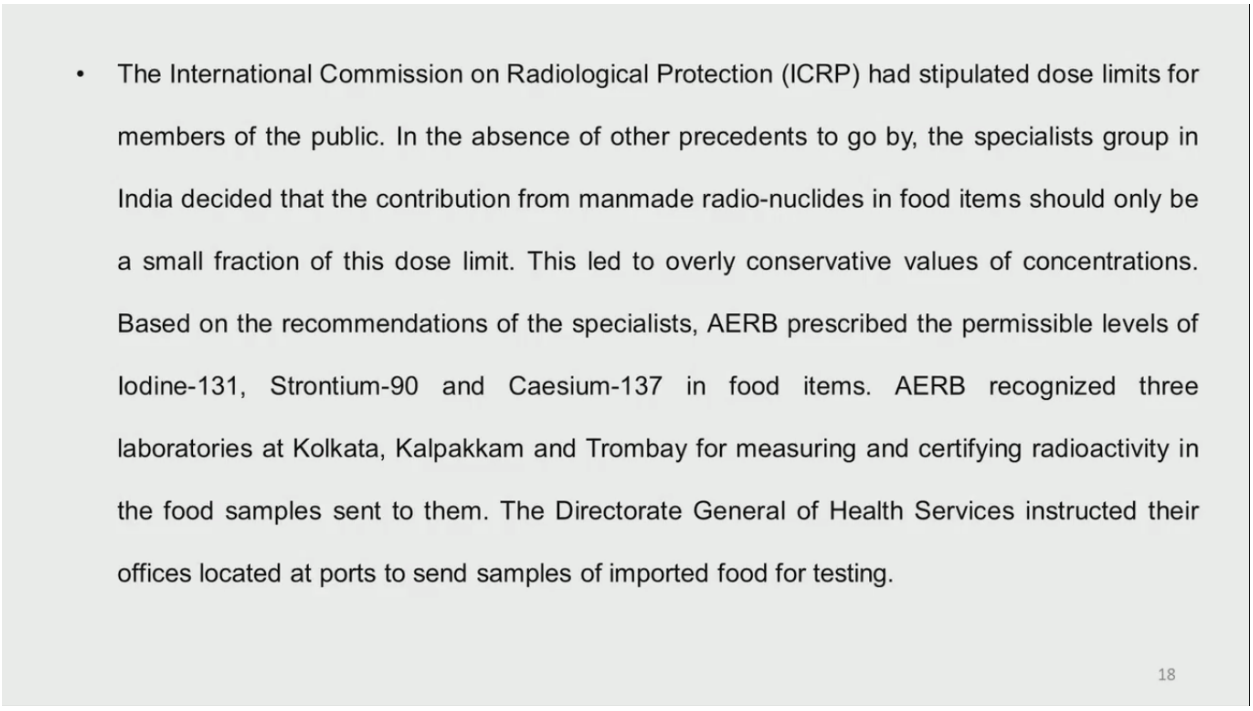

This commission of course or this committee had the background of data of dose limits from the International Commission of Radiological Protection we call the ICRP. Then this specialist group of people in India felt that in spite of that we will not take that full limit as a limit we will only a small fraction of that limit only will give for the foodstuffs. As I said again as a extreme caution. So based on this the permissible level of the three radioactive isotopes radioisotopes iodine-131, strontium-90, and cesium-137 in food items were drawn up. Then not only that AERB accredited three laboratories of the at Calcutta, Kalpakkam and Trombay for measuring and certifying this radioactivity in the food samples which was sent to them. They are basically the environmental survey labs of which are set up around these plants at Kalpakkam and Trombay and the directorate general of health services always at ports whenever there is imported food a sample is sent to these laboratories for testing.

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Now in short we see that we started as a small group of experts called as DAE Safety Review Committee. From that stage in the 60s slowly at that time the number of plants were not much. So a committee could do the job, but after the 80s when more and more plants, more and more nuclear and radiation facility is coming up there is need for separate entity which is called as the Atomic Energy Regulatory Board. Now it is more than three decades. Now this regulatory board has a very very comprehensive system for design review, operation review of all the nuclear

power plants, all the radiation facilities in the country and it has from time to time developed its own in-house capability to analyze and study. Not only that it has set up its own research institute which again collaborates with educational institutions inside the country and outside the country.

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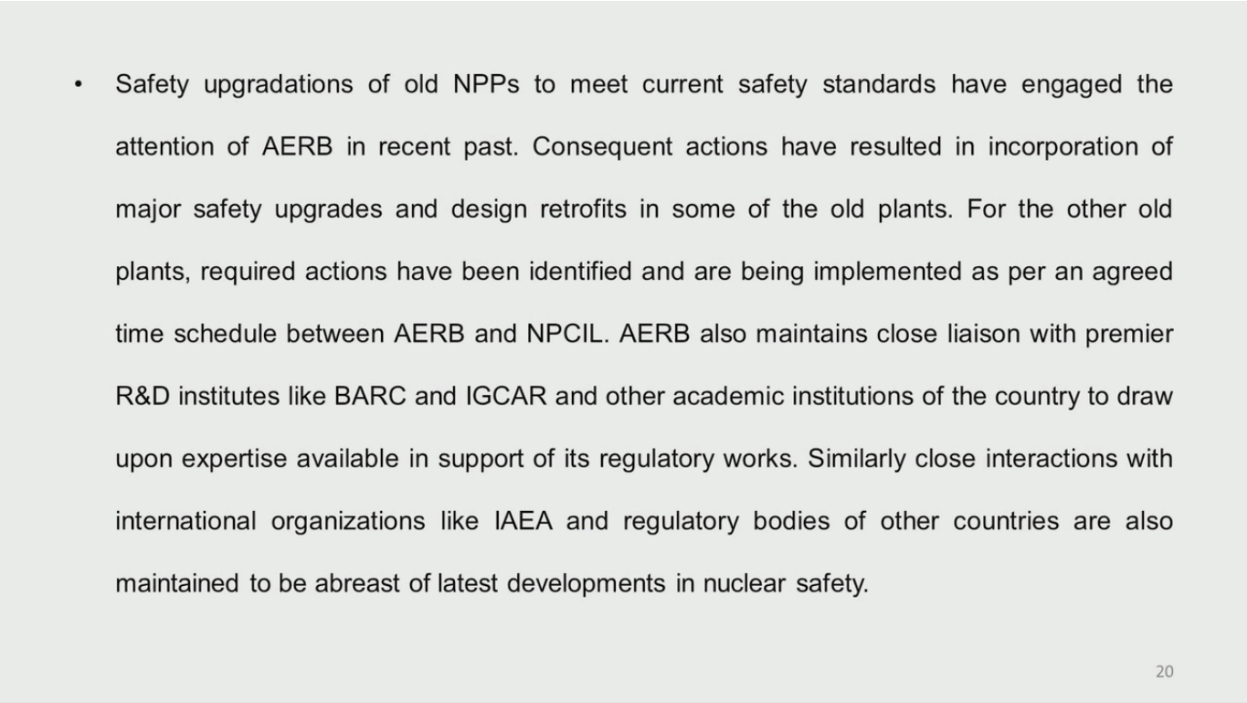

Not only that this AERB itself collaborates with other regulatory organizations of different countries. For example I mentioned to you that with the Russian regulatory authorities we had a memorandum of understanding for the Kudankulam reactors. Though we have not set up any reactors with the support of USA, no doubt already in the last four years lot of cooperation between the Atomic Energy Regulatory Board and the U.S. Nuclear Regulatory Commission has been there. The major effort has been to compare the standards, compare the guidelines and try to make them uniform so that in the event of we going into this import any nuclear reactor designs from U.S. how we need to accommodate the Indian viewpoint or the Indian standards into such designs. Not only that AERB has been proactive in many areas as I just mentioned about radiation in food and set up a committee on transportation of radioactive materials. So also we saw that whenever any incident happens in other countries or basically the major accidents we the AERB we sits on and then looks at the design and modifies as the utility to modify the designs or procedures. One thing I can tell you there has been a feeling created in the media that AERB is not independent. It is reporting to the Department of Atomic Energy. This is a wrong

notion. When this was stated I myself went through the complete AERB publications and I happen to come across one publication which I mentioned earlier also silver jubilee book of AERB wherein the first 25 years how it has grown and how it has implemented the regulation, safety regulation has been documented. You will see there in many cases AERB has put its foot down and not allowed the utility to operate until the its recommendations have been implemented. I myself have been a witness as to how the fast breeder test reactor was licensed. There used to be many arguments but in the end safety was our prime concern and we have succeeded in this venture only because of the independence which has been truly practiced by the Atomic Energy Regulatory Board.

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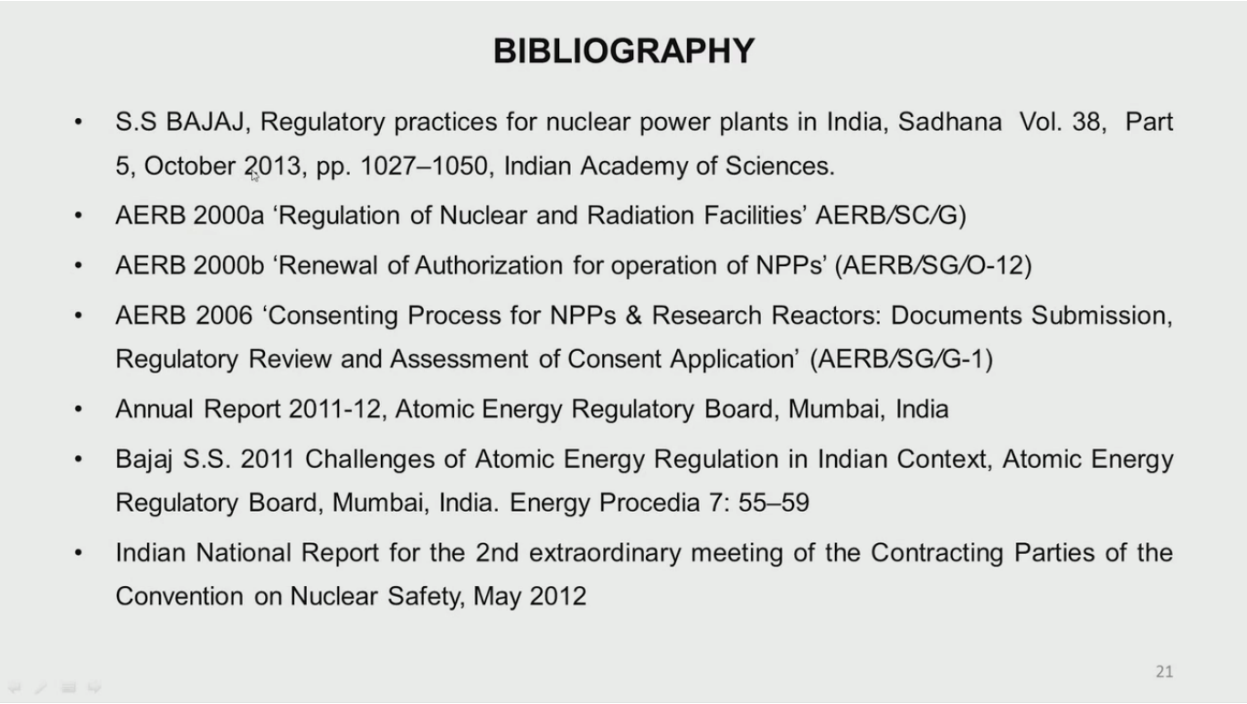

So now I just take you to the end of my talk. As I mentioned AERB has closed license with all R&D institutions and regulatory bodies IAEA, etc. and it has kept itself abreast of all the developments in nuclear safety.

To give you a bibliography the paper by Bajaj on the regulatory practices which was recently published in 2013 is very good. Then in the IAEA the regulatory board gives a report on the convention on the nuclear safety every year. This is every year there is a report. So you can look at these reports which are submitted.

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- Koley J *et al* 2006 Regulatory practices for nuclear power plants in India, Atomic Energy Regulatory Board, Mumbai, India. Nucl. Eng. Des. 236: 894–913.
- A.R.Sundarrajan, K.S.Parthasarathy,S.Sinha, Atomic Energy Regulatory Board 25 Years of Safety Regulation, AERB, Mumbai, 2008.
- S.C.Katiyar, S.S. Bajaj, Tarapur Atomic Power Station Units 1and 2 Design Features, operating Experience and License Renewal, Nuc.Engg. Des. 236 (2006), 881-893

Then this was the report-- book which I was mentioning by A.R. Sundarrajan, K.S. Parthasarathy, and S. Sinha Atomic Energy Regulatory Board, 25 years of safety regulation published in 2008. Of course, I had the – I had to read line by line two years back when I translated it into Hindi.

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ASSIGNMENTS

- What are the functions of AERB?
- How is AERB organised to execute its functions?
- Describe briefly, how the safety review of a new nuclear power plant is carried out by AERB?
- How does the AERB equip itself in reviewing new designs of nuclear power plants? Explain the basis of licensing the Koodankulam NPP.
- How does AERB conduct the regulation of operating NPPs?
- What were the implications of the FUKUSHIMA accident on the regulation by AERB?

So this is a very important document which I feel everybody must read. Last but not the least to see how much of you have grasped these are some questions regarding AERB, its functions, how does it equip itself with knowledge base, how does it regulate and what not and how the regulatory INC is successful in India. Thank you.

Online Video Editing /Post Production

R. Selvam

S Subash

F Soju

S Pradeepa

M Karthikeyan

T Ramkumar

R Sathiaraj

Video Producers

K R Ravindranath

Kannan Krishnamurty

IIT Madras Production

Funded By

Department of Higher Education

Ministry of Human Resource Development

Government of India

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