INDIAN INSTITUTE OF TECHNOLOGY MADRAS.

Indian Institute of Technology Madras
NPTEL
National Programme on Technology Enhanced Learning

NUCLEAR REACTOR AND SAFETY
AN INTRODUCTORY COURSE

Module 14 Lecture 01
Safety Practices in India NPPs

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Good morning everybody in the last few lectures. I explained to you the mission of the Atomic Energy Regulatory Board which is the organization which oversees the safety regulation of not only the nuclear power plants but also the various other establishments which deal with the use of ionizing radiation like medical in the industrial field in the field of geology and so many other areas now. I will take you in this next three lectures this and the two more lectures.

I will take you through what are the safety practices which are being actually done in the nuclear power plants so that with these examples you will really have an assurance that whatever has been spoken as safety regulation is really being carried out so the title of this lecture.

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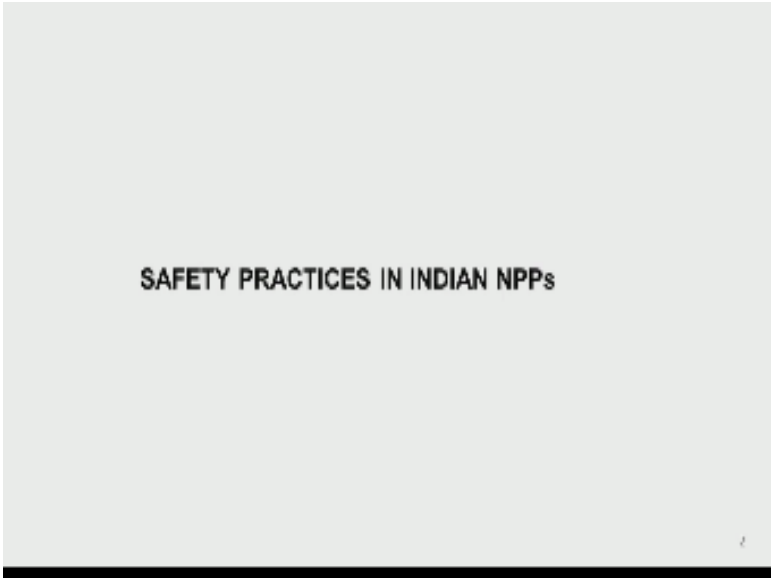

And the next two would be safety practices in the Indian nuclear power plants.

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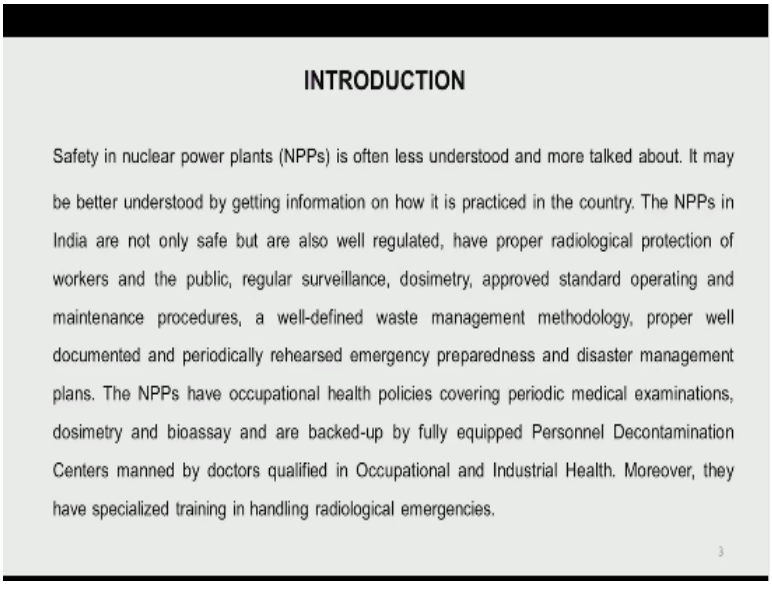

And safety is of course more talking about everybody talks about safety but the understanding of safety the depth of safety is often not understood fully in fact this series of lectures would have

taken you to great depths of safety sometimes it is better to talk how it is practiced rather than how it should be done first and foremost we have nearly25 nuclear power plants and many establishments like the reprocessing like the fuel nuclear fuel complex then we have the heavy water plants and all the overall regulation and safety has been of regulation of safety has been.

So good that we thank God we have not had any incidents of a magnitude which should really cause concern so as we say the taste of pudding lies in eating now we can say with enough confidence that the safety regulation in the country is in safe hands okay now what are the objectives of this regulation have the radiological impact that is the the protection of the workers occupational workers and the public they are well protected if productions are reduce assured from the radiological release.

If any so all this is because we follow approved operating procedures approved maintenance procedures approved surveillance and yeah very defined management methodology which is very documented and including not only the normal conditions of operation including emergency or what I call as disaster management so this is the uniqueness of the Indian nuclear power plants and facilities. So all the nuclear power plants have standardized occupational health policies wherein we carry out periodical medical examination.

We also look at the doses which the workers are receiving through the filling badges or the TLD badges and everywhere should there be any contamination we do have provisions to decontaminate for which people are trained and qualified in industrial health and safety so health safety becomes has become a very important constituent of our atomic energy establishments.

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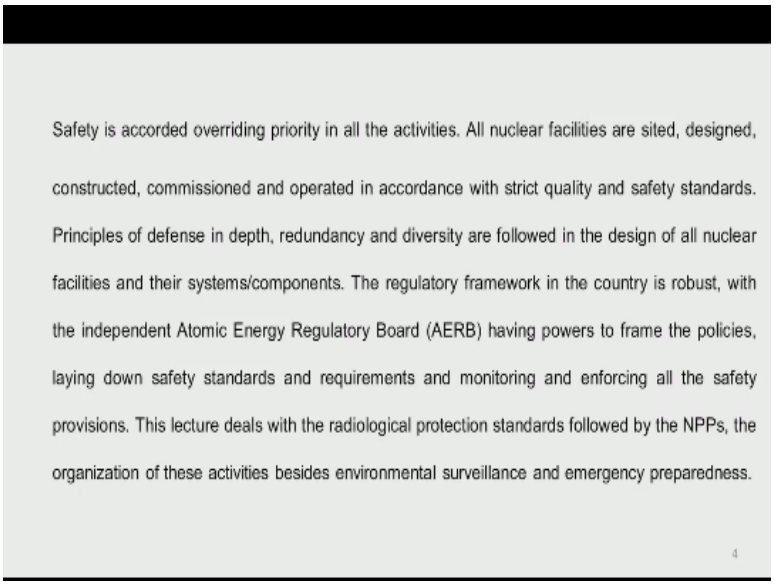

So we saw that all facilities are located in sighted design constructed commissioned and operation in accordance with the strict Quality Assurance standards and maybe repetition. We follow the principles of defense in depth wherein redundancy diversity and independence is followed in all the facets of the design and this lecture we will so focus on the net effect that is with the Radiological production standards which are being followed by the nuclear power plants and how the whole thing is organized besides talking something about environmental surveillance and emergency preparedness.

So when I talk about this radiological protection how is being done and how what is the really achievement so that indirectly tells you who the plants have operated well and safe now let us come to the radiological protection of the occupational workers.

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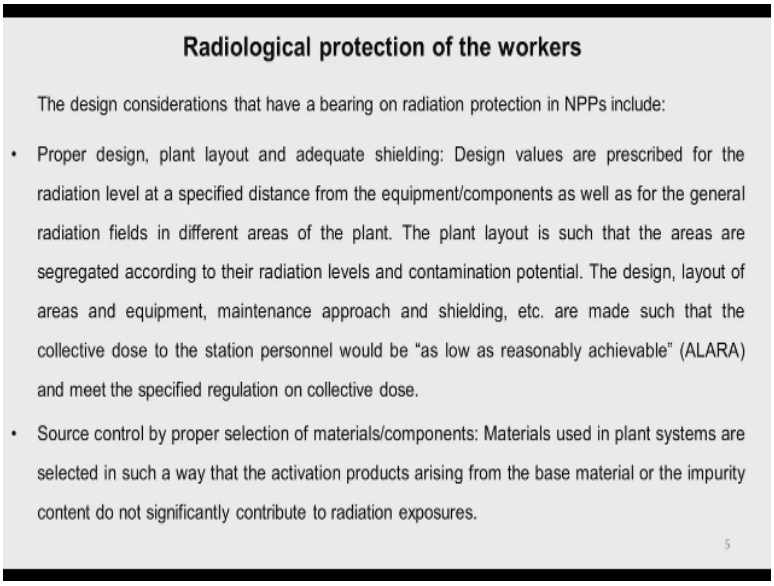

Occupational workers basically the people who work in the areas where you have radiation so first in the design of the plant. I must see to it that there is provision for adequate shielding suppose. I have a component which can emit radioactivity. I must see to it that it is encompassed by proper shielding radiation shielding of course if it is going to be a heat source also you also require a thermal shield also ,so that the thing is not felt outside so right from the design this starts and also different areas of the plant.

You have to see that from maintenance angle the person must be able to reach that place and do maintenance means that place must not be having a large amount of activity should there be a high radiation zone he may not be able to enter or he may require additional special shielding through which by along with which he can enter that place so segregation of the areas based on their radiation activity or contamination potential is there in the design itself so what is the end thing that all this is done in such a way that for the time the person is needed or planned to be needed in the place for any maintenance or any repair.

The collective dose to the station personnel or the occupational workers should be as specified in the regulations and preferably still lower as low as reasonably achievable so this concept of as low is reasonable you will see this has been the drive and how it has helped that effects you will see in the lecture then the other methodology or of the radiological protection is that materials which you use in the plant should be such that they do not get activated too much we are seen

some materials get activated more some metals give activate at the same time you need to use materials.

This should not get corroded in that environment so we look at things which satisfy both so that the amount of radioactive material or activated material I should say is less of course the when. I talked about corrosion you have impurities and they also get activated so this is something like compromise taking economics also into question.

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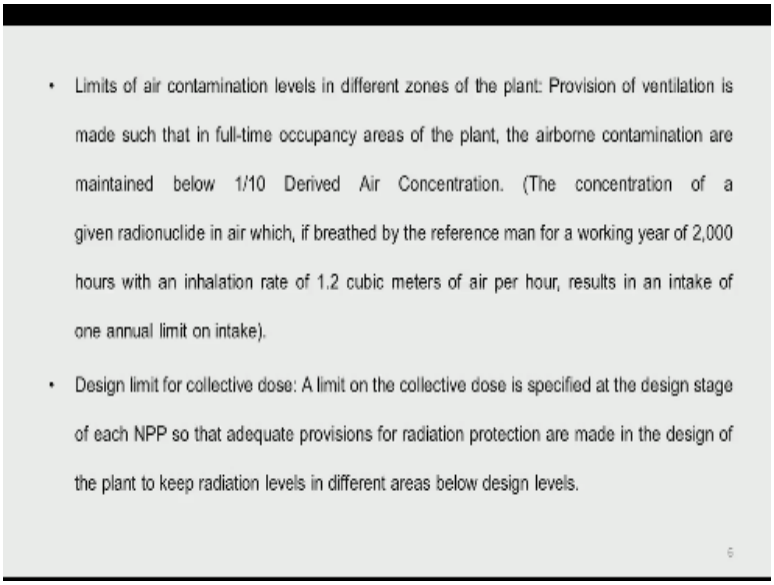

Then what we do in the different zones of the plant we have some limits of contamination and we provide ventilation mind you ventilation is a very important aspect of all nuclear establishment perfect ventilation control is essential how many are changes we have to plan such that our concentration or the contamination would come down is a very important aspect of the design of a facility in fact. I will say if the ventilation system fails maybe you may need to stop further operation of the plant.

It is not an emergency but unless if it rains you have to stop okay now what is the how do you do that there has to be some criteria the criteria is what we called as derived air concentration so how do we derive the definition of the derived our concentration is the concentration of a given radio nuclei in air which if breathed by a reference man for a working year of about 2000 hours with an inhalation rate of 1.2 cubic meters per hour of air results in an intake of1 annual limit on intake that means this will be the maximum.

Which can be taken which is if taken more than this may be harmful so this is the concentration now what we do we specify the different areas such that the total should not be equal to the or more than the annual limit so here we say 1/10 of a derived air concentration this is just an example then collective dose here it is not the contamination it is the collective dose so we have a limit on the collective dose specified at the design stage itself because only based on that you can take do the adequate protection by using proper radiation fields and enough of radiation shielding.

So that you achieve the minimum radiation level in that zone so this is from my design viewpoint itself there is a design limit okay, now coming to the actual operation the Atomic Energy Regulatory Board has prescribed.

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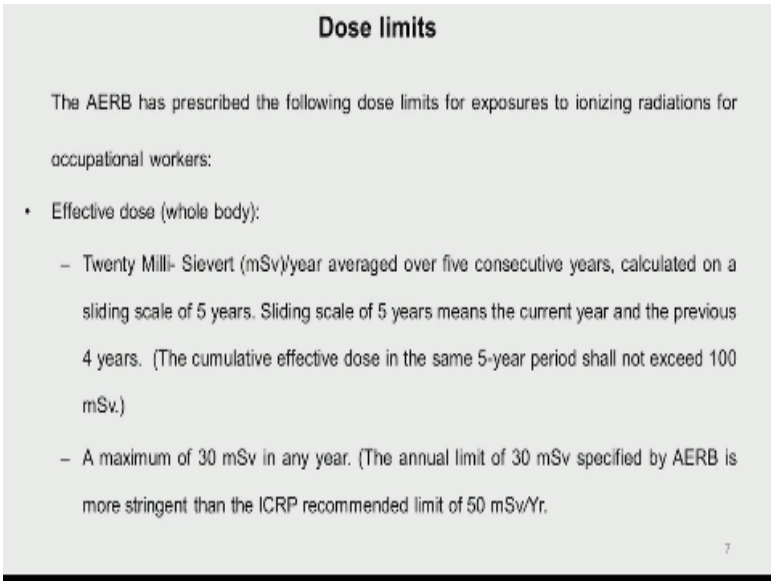

The following limits for exposures to ionizing radiations for occupational workers the effective whole body dose 20 Milli-Sievert per year averaged over five consecutive years and calculated on a sliding scale of five years this sentence needs some explanation which is follows the sliding scale of five years means the current year and the previous four years you take an average that is what is called as the cumulative five-year period and it under no case should exceed 100 Milli-Sievert means 20 Milli-Sievert per year for five years could be hundred year 100 or cumulative.

Let us say but in one year again there is a limitation a maximum of30 Milli-Sievert in any year not more than that so 20 can become 30 not more than that so you here you will be you know surprised to note that the ICRP even though it is recommended Milli-Sievert 50 Milli-Sievert per year we have specified 30 Milli-Sievert per year for our Indian plants so it does not mean that if 30 does cross 30 it is dangerous so even 50 is not dangerous ICRP itself has put a limit but nevertheless.

Our approach is to see that any person receives as low a dose as possible so here is where our safety approach is of highest standards then there is also a limit on the dose for the individual organs of the body.

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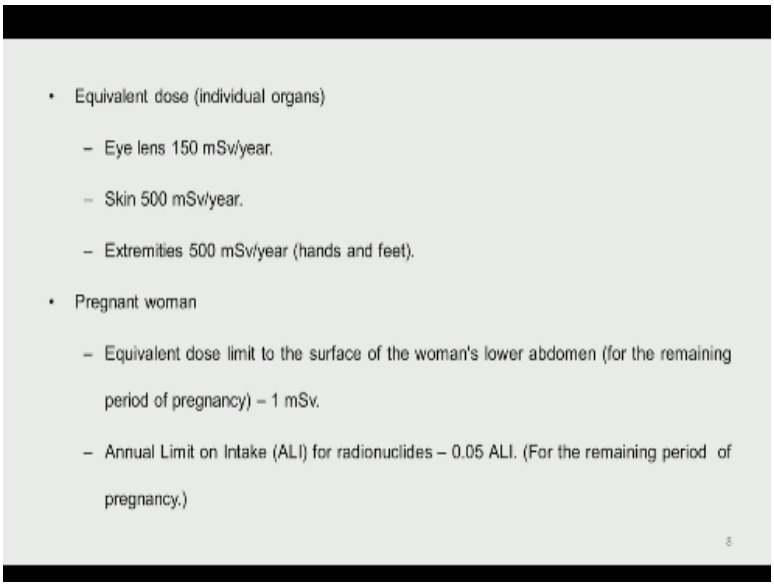

For example your eye lens can withstand your higher radiation so the limit is something like 150 Milli-Sievert per year skin the limit is still higher 500millisieverts per year same thing with your extremities like the hands and feet but when we come to women working in the nuclear plants or the basically pregnant women we again would like to take care of the fitness so we say the lower abdomen during the pregnancy period should not cross one Milli-Sievert and the annual limit of intake of the radionuclides due to contamination.

The limit will be .05 of the annual limit on intake so this way again we are trying to be give as low a dose as possible to the as reasonably achievable to the pregnant women.

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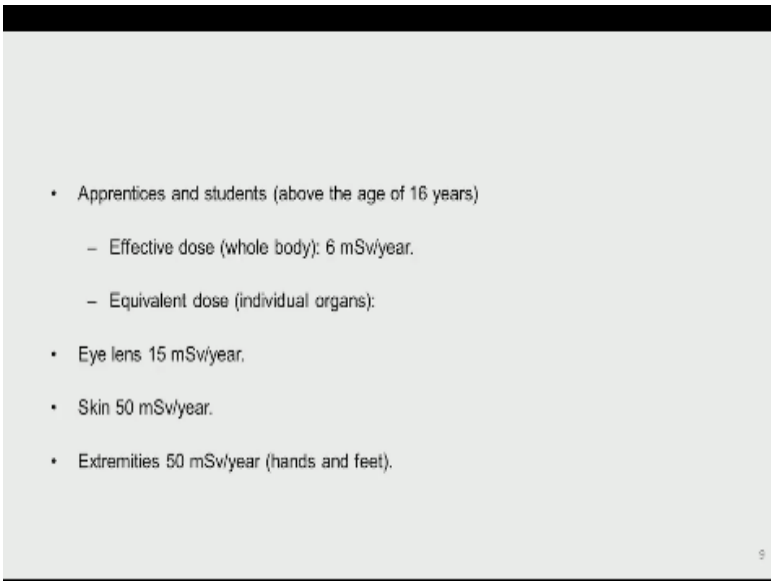

Now in many of the establishments internship is taken by students there are trainees or apprentices who would come and go so for them also there is a limit the limit is effective whole body dose should not cross six Milli-Sievert per year and of course coming to the individual organs islands15 Milli-Sievert per year skin 50millisieverts per year and extremity is50 so the idea is that we differentiate between an occupational workers and the two people who are just coming and going the reason is very simple.

The occupational worker is being monitored continuously whereas the trainer the apprentice is not being monitored so we are very well you know clear in this aspect there a person who just comes and goes for whom the medical test may not believe we should be more careful.

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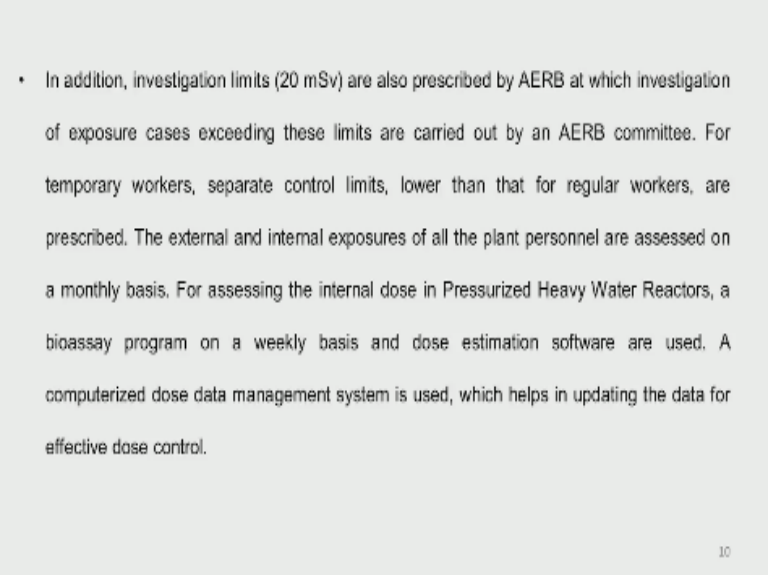

Now besides giving the limits the AERB also AERB also prescribes at which exposure level investigation should be done so here AERB says 20 Milli-Sievert if it is crossed then this needs to be investigated further so this is for the occupational workers for other workers that we lower limits which are prescribed then what is the frequency of assessment both internal and external exposures are assessed on a monthly basis now for the pressurized heavy water reactors and which is a major thing in our country we have the bioassay program on a weekly basis so basically the figures and the urine.

We samples we take and we analyze them is there any ingestion anything is there so that also we do and we estimate the dosage received by him and all this data is computerized it is stored we have enough backup information on that so at anytime. I can get the history of radiation doses received by a person should that be need for investigation now what is the Organization for radiation protection if you recall. I have been telling about the health physics division health.

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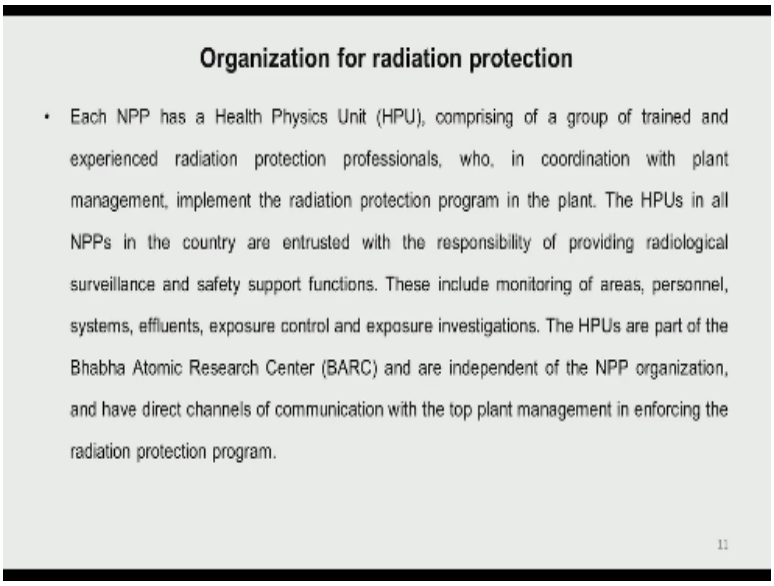

Physics deals with the health of the person and the radiological safety division. The major portion would consist of health physics people who are basically radiation protection personnel who have a knowledge of the radiation and their effects biological effects on the human beings and they are also aware of the plant and they are a part they support the plant but they are not a part of the plant it is very important they give support to the plant they have the responsibility of carrying out radiological surveillance and wherever there is activity help the organization or the plant people to take care and do decontamination

If necessary but their major thing is independence all the health physics units in the nuclear power plants do not report to the utility that is Nuclear Power Corporation of India no they report to the Directorate of Health and Safety in the Bhabha Atomic Research Center so it is an independent organization but everywhere the health physics is a part of the routine operation crew just as operation crews are there every three shifts the healthiest crew is also there for every three ships and they are the people who give the real radiation support function.

To the NPP management and they enforce the radiation protection program since this enforcement requires them to be independent of the utility they have been organized to the port to the BRC so what the Directorate of health physics or earlier it used to be called as a Directorate of radiation protection.

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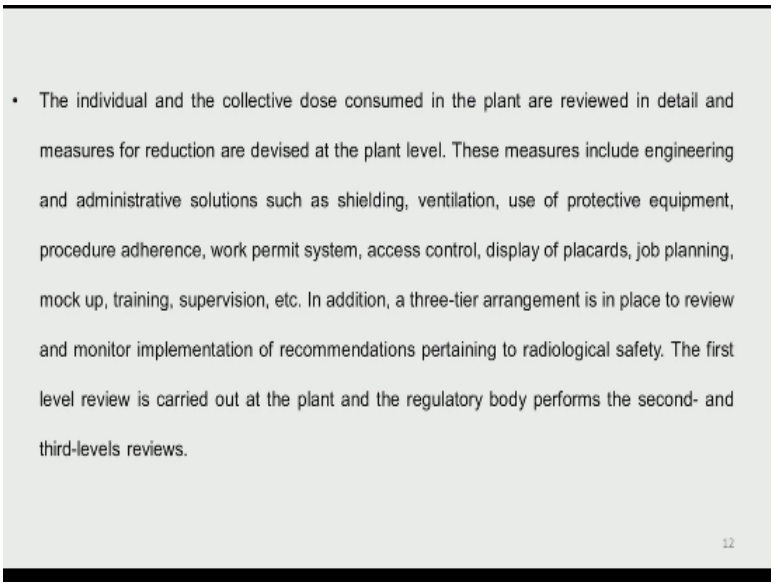

They get the data from the individual power plants the individual doses the collective doses and review and suppose they feel that in a particular power plant so it is on the higher side now you have got twenty what reactors about seven to eight places where it is located in some plants if you have higher that means somewhere the operation philosophy has not been properly followed or somewhere there is a issue real issue to be resolved so indirectly this data would tell us whether about the health of the plant also then in case they are more the they will sit.

In the plant people and give some engineering solutions like better shielding improved shielding or improved ventilation or use of better or extra protective equipment then in some cases if they find a lack annoy in the permit system if it is not adherence is not proper they may advise that then access control basically what do you access control should we find a place where activity is more than what is expected, we try to cordon off that area so that we restrict the access to that is why access control that word is there and we will have some play cards displayed so that you know the persons are aware and some of the means other means to improve.

The working would be a better job planning sometimes we could have some mock-ups so that people would be trained to do things better and of course last but not the least here good supervision of these people then in the review process again we have a free tire arrangement the first way view is carried out within the plant based on the data which they have collected then the regulatory body we have the radiation safety division which does the second one and if required they may go for another third level review also.

I was telling that the mission is to keep the collective annual dose to plant personnel below the limit below the dose budget approved by ARB.

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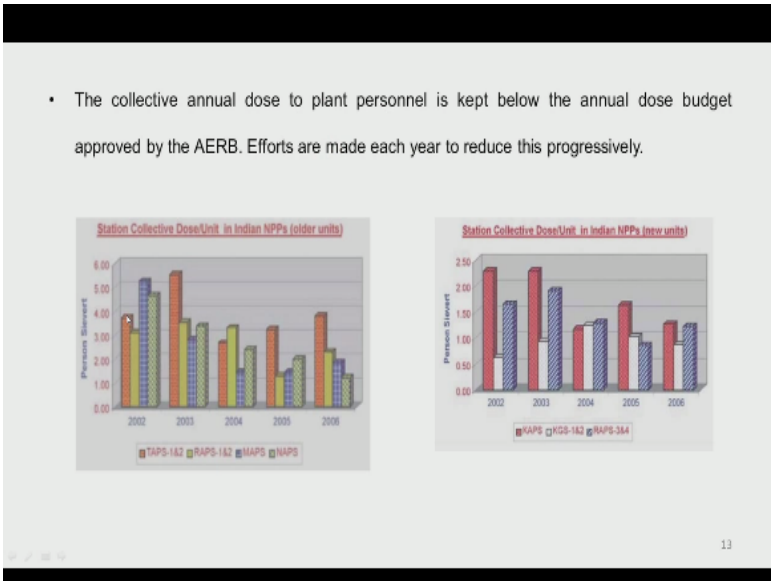

So you find the name budget that means based on the design and other experiences the plant says this is my annual dose which I am expecting and things so whether it is within that if it is not within that we do all the reviews and changes like that here .I just want to present you the collect those per unit of some of the older units and apparently it is also not that bright this is Tara pore the brown one is Tara pore one and two the boiling water reactors then the next one is yellow that is Rajasthan units one and two you know now there are more than seven units working.

There then the blue one is the madras atomic power station and the last the green one is the narrow atomic PowerStation so if you see for the period2002 to 2006 how the operation of these have been so apparently it has just crossed in case of Tara pore by man Seward's man or person seaward but then if you look to the later plants like the chakra Para in Gujarat taiga in Karnataka and Rajasthan unit three and four you see it has come down drastically even here also if you see after two thousand four more or less they have been at a very low level.

So the efforts always effort to reduce the radiation even though it is below the limits so this safety approach is unique to the nuclear industry now how do we achieve this as low as reasonably achievable exposures.

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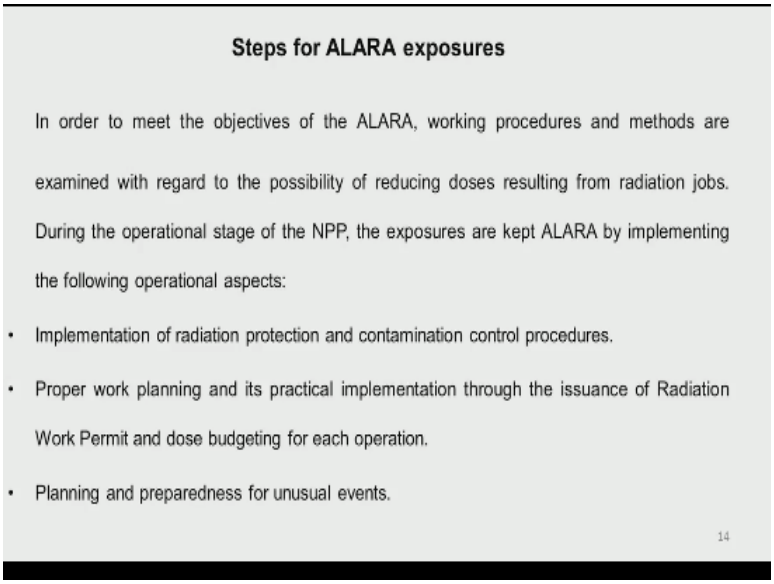

So we examine the working procedures we have lot of brainstorming discussions with the workers with their supporting staff with their supervisory staff and we tried to reduce the exposures you might recall in my last lecture. I told you about the calendar II tubing the calendar tubes are being replaced every 10 years when we are using the circle 2 and these tubes had to be cut removed and then the new tubes put so at that time any person who goes does the cutting job

or the handling job even though it is remote does receive a certain amount of dose so we keep allow the person to be there in the area for a time in which he will get the dose afterwards he will not go into the area again so we try to cycle the workers such that each person disease minimum dose so here so we when we do this reduction.

We have to look at how the any work is being carried out then whether we could minimize the exposure by better work practices better work trying and also try to imagine some unusual events and then plan for that also just as we talked about emergency preparedness so here this exercise has led us to prepare ourselves for making exposures as low as possible now the AERB reviews this collective dose budget of every unit then once they give this is what is the maximum exposure.

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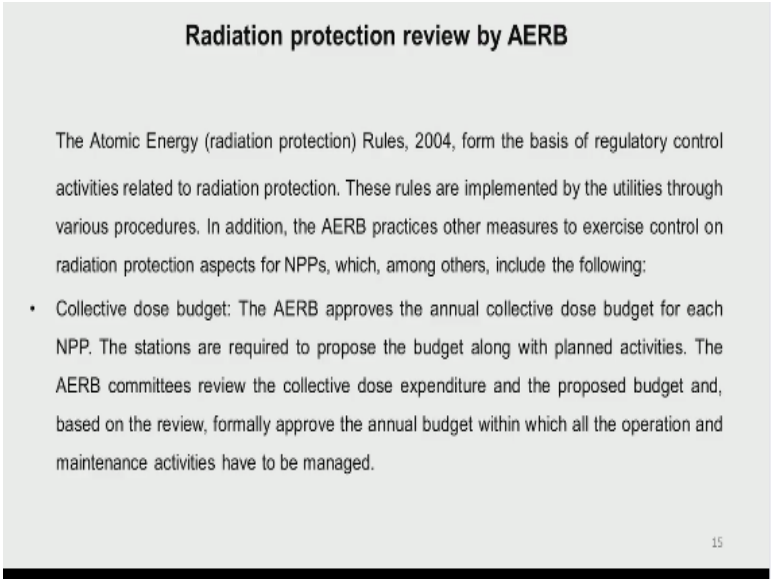

The moment that has been consumed ARB reviews and sees whether they can allow some additional or is there something to be drastically done to improve the design or improve the working conditions improve the work culture so once you propose a budget and we are not able to meet then all these reviews are taken undertaken.

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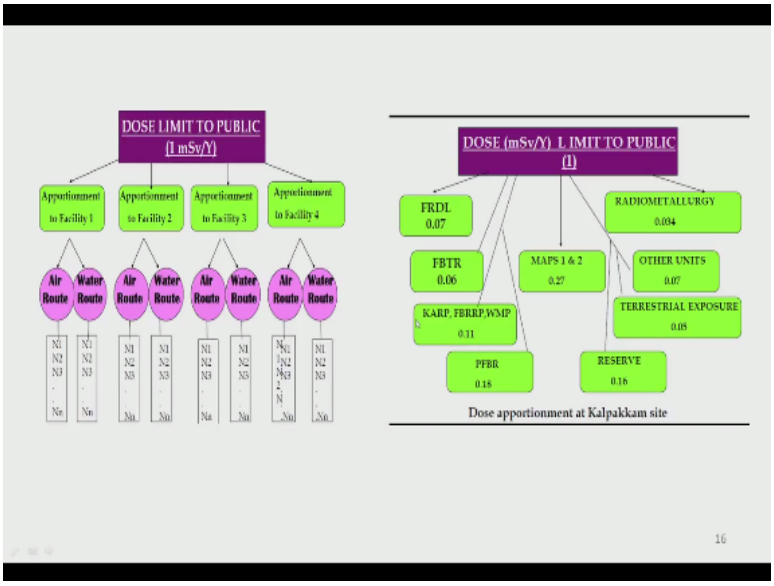

Now you can say this is the limit but in one location there could be many nuclear facilities we will take the example of Kalpakkam. So we have many facilities like the madras atomic power stations one and two we have the fast breeder test reactor we have a fuel reprocessing development lab we have the Kalpakkam reprocessing plant we have the prototype transmitter reactor coming up now then we have the radiometer labs and so many, so when we look at the dosage which will be received by the public.

It is very important to see that it should not be multiplied by the number of facilities so when we have the dose limit for the public of one Milli-Sievert per year we apportion it among the facilities so the maximum release per facility will come down of course we know that two routes are route and the water route through which it can go to the human beings or the cattle and then it can come through the pathways different pathways we discussed so this is just to give you your dose apportionment of the Kalpakkam site.

So here if you see in the site selection this point is also kept many for example are when it was supposed to be located at Kalpakkam the site was not chosen when a but arrows built the site also seen later one of the main reasons was that of course you have the seawater other thing you have the trained personnel in the fast reactor design who are eight Kalpakkam so when the designers are there close to the plant it is easy problems of coordination or less discussions are fast decisions are fast.

So that is the reason but then it also put a price that you cannot release more than a certain quantity.

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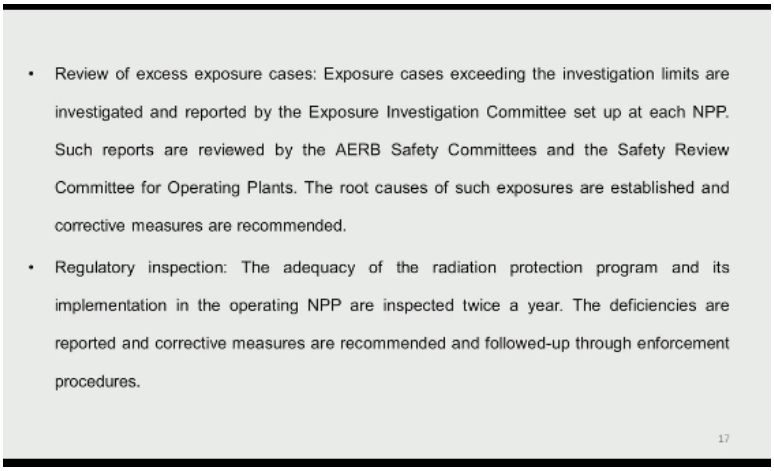

Now every nuclear power plant or every nuclear power plant at every location has got an exposure investigation committee so this exposure initiative in committee examines the exposure to personal where they have crossed the limits it could be the personal or in case it is some of the temporary workers who have gone in and come out even for them this exposure investigation committee will investigate send the report to the Atomic Energy Regulatory board and SAR cope and the root causes of these exposures need to be established and then only corrective measures if it is not clear maybe a AERB may say stop the operation no further operation.

So this has happened in quite a good number of cases then the regulatory inspection which we talked twice a year all the nuclear power plants are being inspected and the deficiencies in the health physics area specifically are enforced during after the inspection in case there are some deviations they are enforced with an iron hand.

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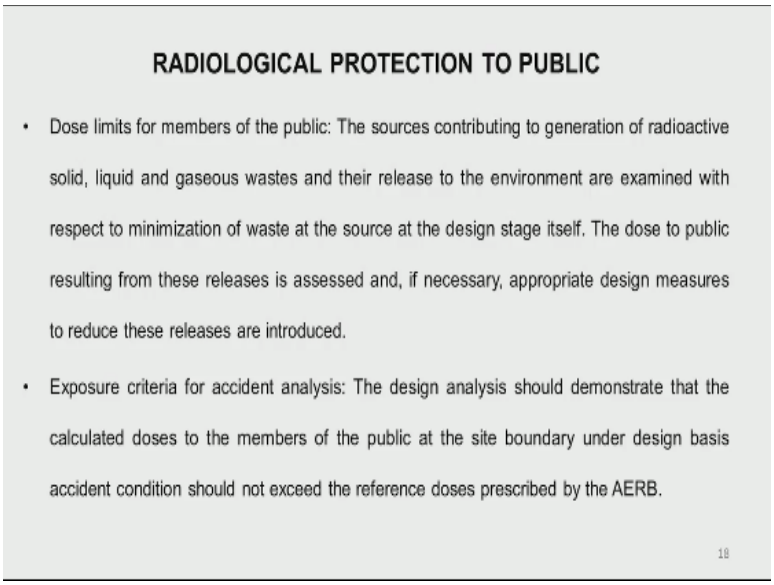

Now all this thing we will be talking about the exposure to the occupational workers of course we also talked about the budgeting of the release to the public now what are the sources by which the public can get radiation there maybe generation of solid liquid or gaseous wastes and they are examined of course and based on their activity are released to the environment either through water or through the air route so at the design stage itself we take enough precautions such that we do not cross the limits then in case of an accident also we have seen that the designers have to show that even.

In the case of an accident at the boundary the prescribed doses by the ARB or not crossed.

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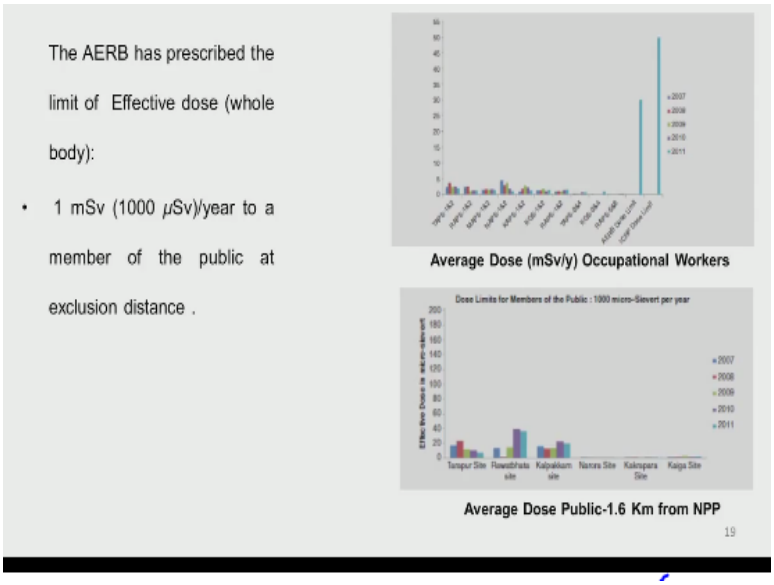

Here the ARB has collected the or presented the data from different power plants on the average dose in Milli-Sievert per year for occupational workers and the public if you see here the limit is something like this AERB dose limit is there whereas I mSV' of 50 Milli-Sievert per year but every year with dose limit is only 30 Milli-Sievert per year and you see all the things are much below and if you really look up the as we proceed further and further they are very minimal then come to the average goes to the public.

You see what is the dose limit is about thousand Milli-Sievert per year we are in the range of 20 to 40 and at some places like Kiger kakrapar and all this you can very easily conclude that this, I was talking they are all the old units and in the new units our designs are much better but still this is safer but this does not mean this is unsafe one big problem when we say it is safer a very logical person will say that means earlier. It was unsafe no he does also safe it is safer so this. I think one has to appreciate the RG that things are improving in the nuclear arena every time every time we are improving ourselves.

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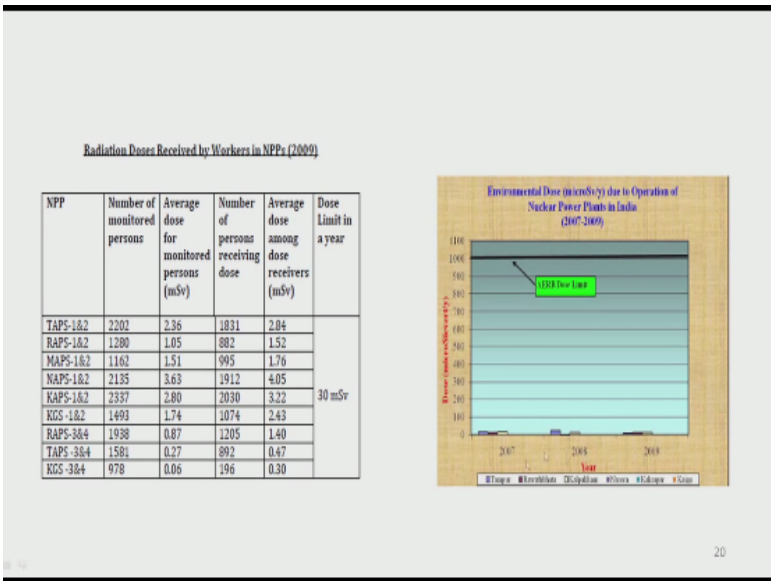

This is to give you your actual data of the radiation dose received by workers in the year 2009 Tara pore 1 and 2 up to all the taiga units how many number of people were monitored what is the average dose for the monitored persons then what is the dose limit here is 30most of them have in the region a maximum to 4 so the same thing which we saw in my in the previous slide so we are much away from the limits radioactive.

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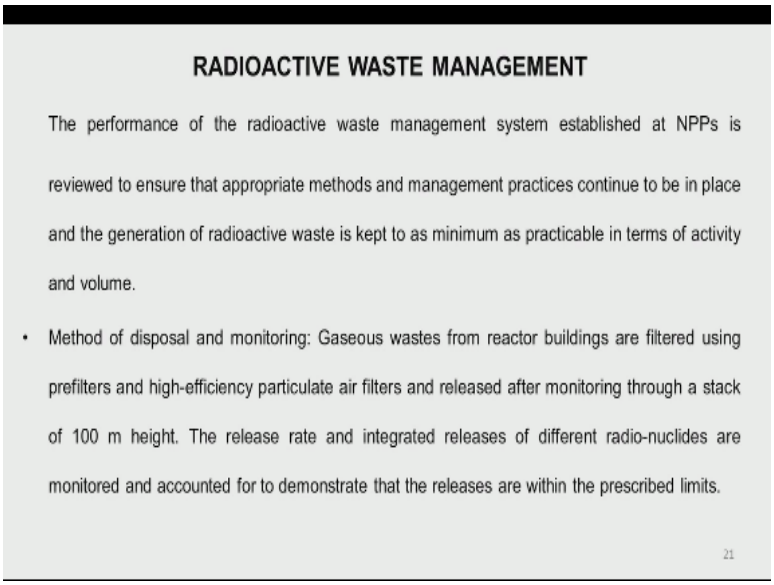

Waste management this radioactive waste is one about which people are quite worried. But as we have discussed earlier any radioactive waste management system is well established in the nuclear power plant and supporting units most of the nuclear power plants where they are located we have waste management facilities and the right people are there with knowledge of the waste management so that their idea is to minimize first is at the design stage also we try to minimize the activity and the volume of the waste plus once they are handling there also they carry out the process in such a way that minimum activity is getting released.

So the gaseous ways they are filtered using special free filters and also particulate air filters they are called as high efficiency particulate air filters or heap filters and release after monitoring through a stack the stack is quite high about hundred meters high so that by the time the plume comes down to the ground it is diluted such a level that practically it is at the background level these release rates not only the release rate and internal of the release is also monitored and accounted for and so that we can demonstrate that our releases are within limits mind you this is from the plant side.

We will we will allseeds later what the environmental survey lab does to come to check regarding the liquid waste.

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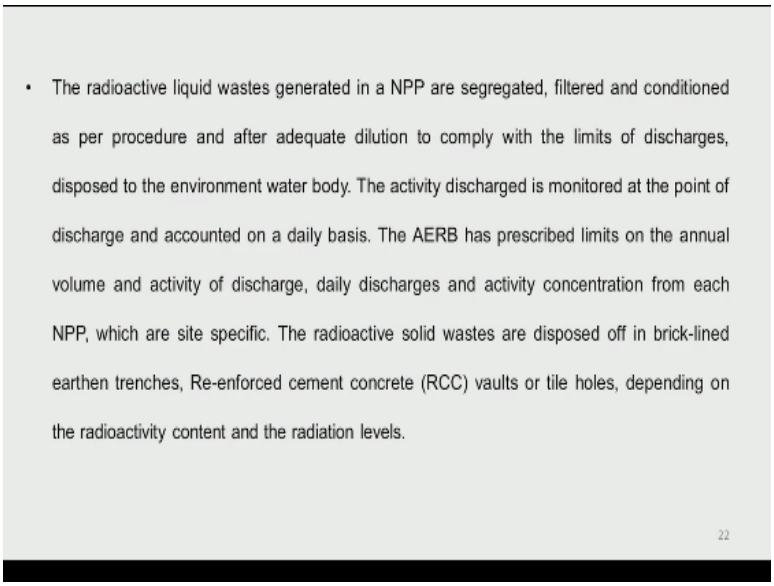

They are segregated filtered and then do the conditioning which we discussed during my talks on the waste management and of course adequately diluted and once they are within the limits of discharge we dispose to the water body and this is again accounted on a daily basis how much we are discharging as I got the solid waste they are put in brick lined earthen trenches of course of reinforced concrete and we have a lot of what is called as style holes in the concrete RCC vaults and then we put them and we also monitor the environment around these tile holes to see whether any activity is leaking out.

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- Authorized limits of discharge: The discharge of radioactive waste from a NPP is governed by the Atomic Energy (safe disposal of radioactive wastes) Rules, 1987. It is mandatory for a NPP to obtain authorization under the above rules from the competent authority for disposal of radioactive wastes.
  - The regulatory limits (authorized limits) of radioactive effluents are based on the apportionment of an effective dose limit of 1 mSv/year to public arising from nuclear facilities at a site considering all the routes of discharges and significant radio-nuclides in each route of discharge. Derived limits corresponding to the dose apportioned for different radio-nuclides are established taking into account the site-specific parameters.
  - Authorized limits are set at a much lower value than derived limits to achieve effluent releases ALARA. The releases from NPPs have been only a fraction of release limits specified.

So the authorized limits of discharge or prescribed by the AREB so again if you see they are based on the apportionment of effective dose limit of 1 Milli-Sievert sphere per year so this 1 Milli-Sievert per year includes all through all routes as I mentioned through the air route through the what you call water route all the routes this is the things but as regards the nucleates we have a derived limit based on the effect that they may have on the human beings so we have derived our concentration limits as I explained to you earlier again.

I repeat the authorized limits are kept much lower than the derived limits from the point again from the principle that is as low as reasonably achievable.

(Refer Slide Time: 45:43)

So friends this lecture has given you an idea about how the AREB is able to implement or actually implementing in the nuclear power plants the dosages we will continue with some more information in the next lecture thank you.

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