Indian Institute of Technology Madras
Present

NPTEL
NATIONAL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING

NUCLEAR REACTOR AND SAFETY
AN INTRODUCTORY COURSE
Module 09 Lecture 01
Quality Assurance

Dr. G. Vaidyanathan
School of Mechanical Engineering
SRM University

Good morning, everybody. In the last two lectures, we had a glimpse into how the various events are being analyzed and how we are predicting the response of different types of reactors to an initiating event. We also saw how we validate the computer codes, which we have developed for predicting the response of the plant to these transients.

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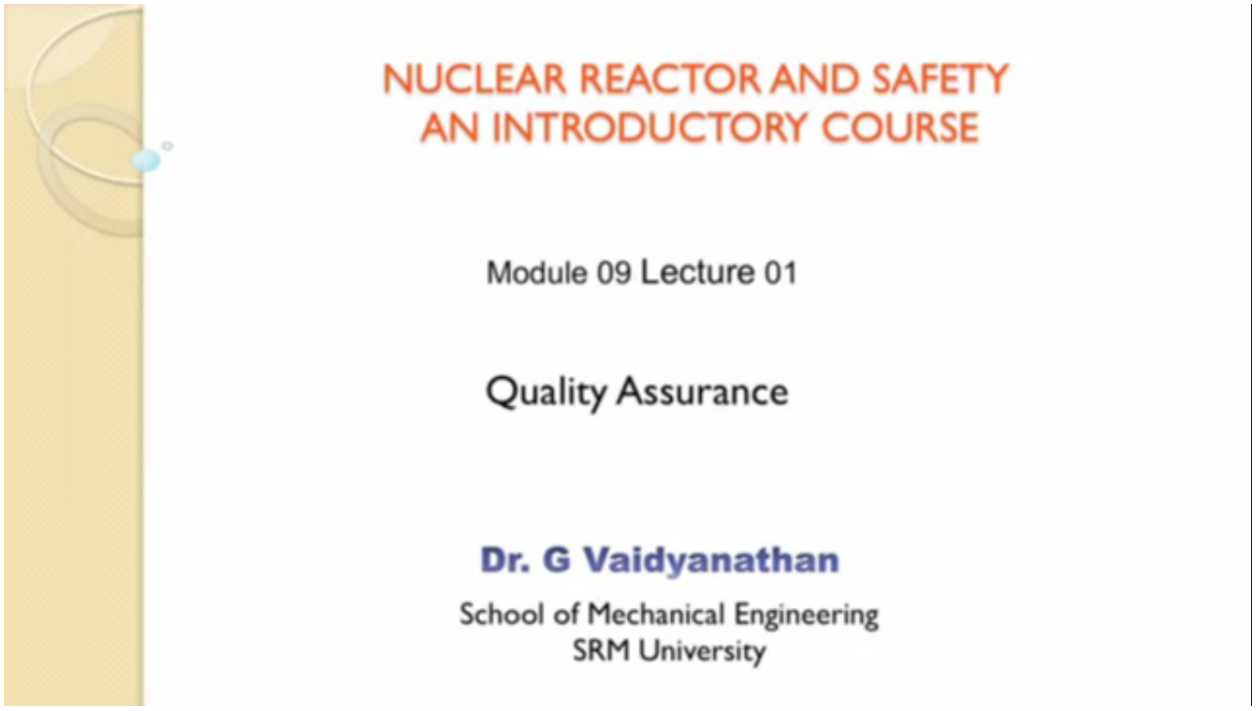

Now let us go into the most important aspect, which is very truthfully followed right from the conception of nuclear power plant and till the plant is designed, operated and even the commission. So, in this respect, I will take you through this lecture on quality assurance.

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INTRODUCTION

- Quality assurance is an essential aspect of good management. In the nuclear systems it encompasses all the planned and systematic actions necessary to provide adequate confidence that an item or service will satisfy given requirements for quality. Quality assurance is implemented through the realization of a quality assurance programme (QAP). The QAP is an integral part of the plant design and provides for a systematic approach to all activities affecting quality; including verification that each task has been satisfactorily performed and that necessary corrective actions have been implemented. It also provides for production of documentary evidence to demonstrate that the required quality has been achieved.

This quality assurance is not a new word at least as far as any industry is concerned because in every manufacturing industry, before we start the manufacture, we do have a quality assurance plan. Then we go about the manufacture.

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INTRODUCTION

- Quality assurance is an essential aspect of good management. In the nuclear systems it encompasses all the planned and systematic actions necessary to provide adequate confidence that an item or service will satisfy given requirements for quality. Quality assurance is implemented through the realization of a quality assurance programme (QAP). The QAP is an integral part of the plant design and provides for a systematic approach to all activities affecting quality; including verification that each task has been satisfactorily performed and that necessary corrective actions have been implemented. It also provides for production of documentary evidence to demonstrate that the required quality has been achieved.

So what is a quality assurance? So now let us look at what is this Quality Assurance. Basically, it is a set of planned and systematic actions, which need to be carried out so that an item or an operation is done to satisfy the requirements of quality. So then what is quality means any equipment should operate reliably with maximum availability when we want it to operate. So this in total picture is called as a quality assurance plan.

Now if I want to have quality assurance, we must have list down what is our plan, at every stage what I must do. So, first, when we look at a nuclear power plant, we look at the design. So in design, how do we achieve quality assurance?

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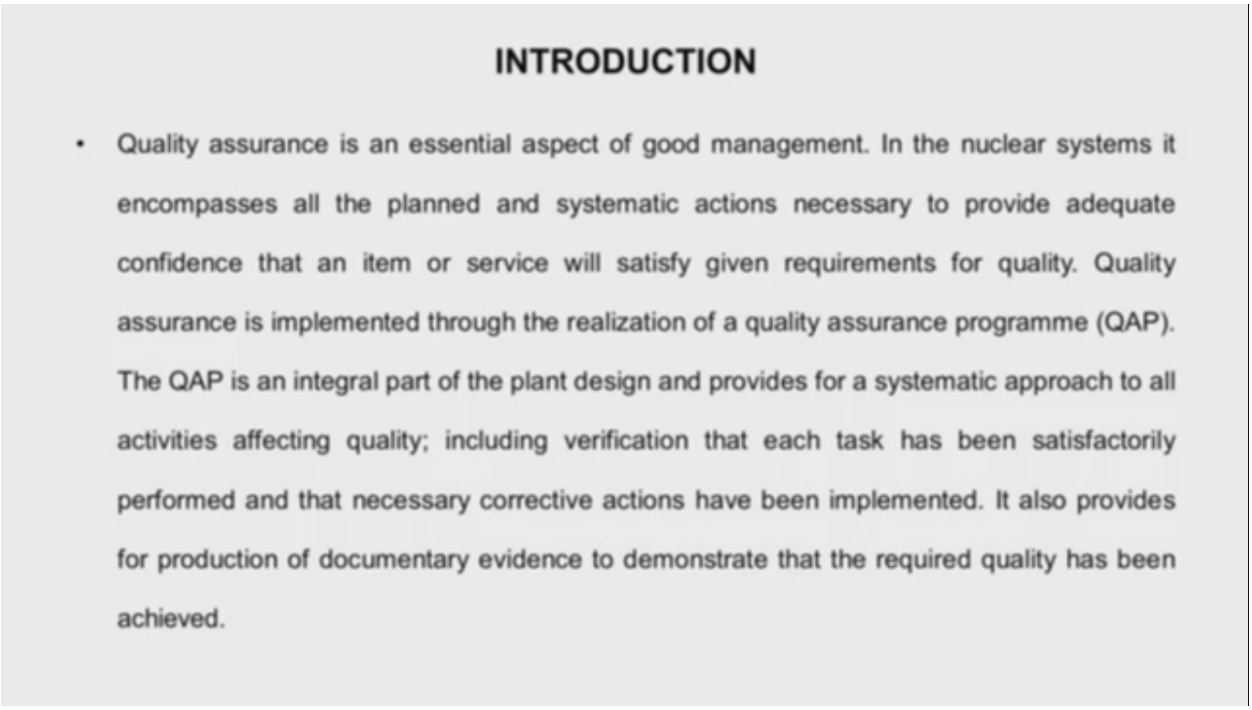

Okay. I have designed the thing. Have I verified my calculations? Is my model right? Here in the last lecture, I gave you an example of validation. This is a part of quality assurance. Then in case we find a deviation, so we need to correct it and then implement the rest of the program. So not only that, in quality assurance, every stage is documented. So the clear history is available at any stage.

I can just give you an idea. Suppose a component has been manufactured for the Fast Breeder Test Reactor in -- in the 70s. Today if there is a fault with that equipment, I can trace out completely fabrication, whether there was anything missing, anything inspection or anything I can find out. All the things are documented and safely kept.

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- The establishment and the implementation of a QAP for a nuclear plant is essential for achieving quality in design, in manufacturing, in commissioning and in operation, besides maintenance, surveillance and in-service inspection. The organization having overall responsibility for a nuclear power plant is also is responsible for the establishment and implementation of the overall quality assurance programme for that plant. This lecture deals with the various aspects of quality assurance for a nuclear power plant.

So to achieve first is as I said design, quality in design. Then when you go to the manufacturing, at every step what sort of tests I had to do? How I should satisfy myself that my manufacturing is perfect? Then I go to commissioning. When I go to commissioning, when should I say my plant is commissioned? What are the things to be -- points to be checked? What is the checklist based on which I will say it is commissioned?

Same thing in operation. How do we achieve? Then maintenance, then surveillance and in-service inspection. So an organization has to be set up which is responsible for quality assurance at every stage of the plant. So in this lecture I will take you through the various aspects of quality assurance.

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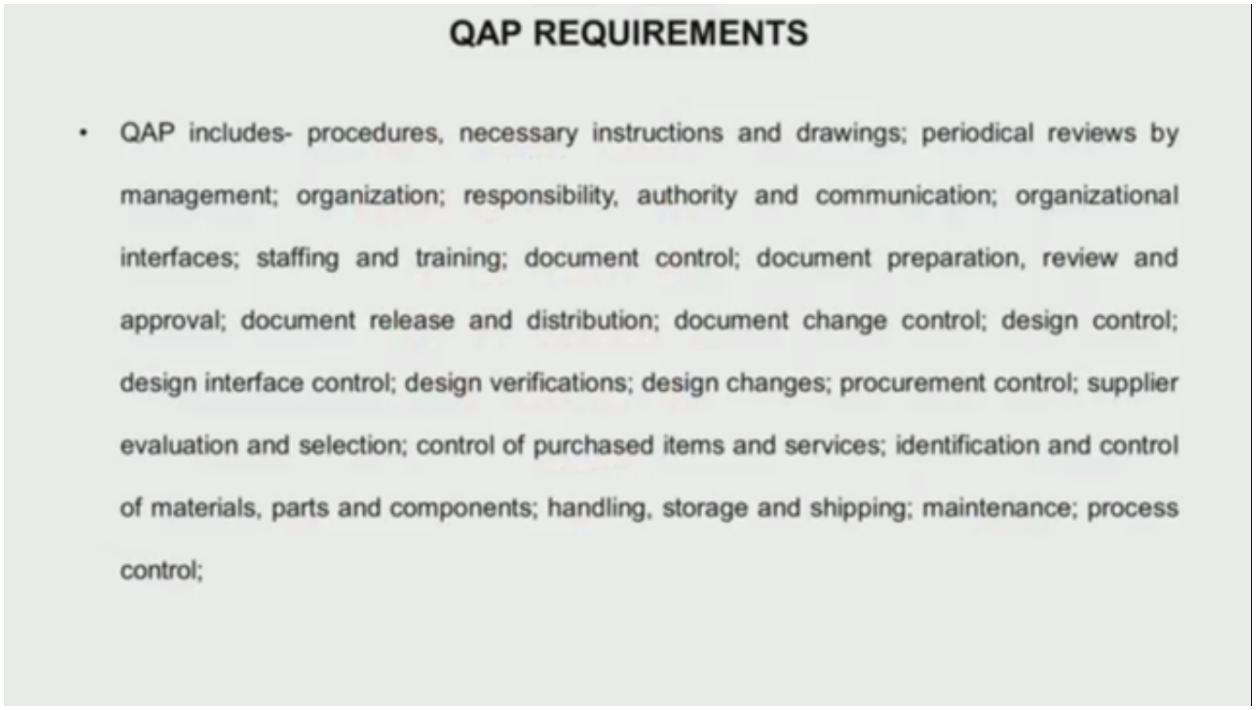

Now, if you ask me, if you say quality assurance plan, we always say QAA. QAP is a common jargon used in the industry, manufacturing industry is very common. Of course, in our nuclear plant, we talk about it every day. So what it is? It's the endless thing. It includes procedures. It includes instructions. It includes drawings. For example, you have to achieve a certain dimension and certain dimensional tolerance. Let us say I want 12 plus minus 0.1 mm in one part. Another part may be 25 plus minus 0.2. Everything, all these are reflected in the drawings with necessary instructions.

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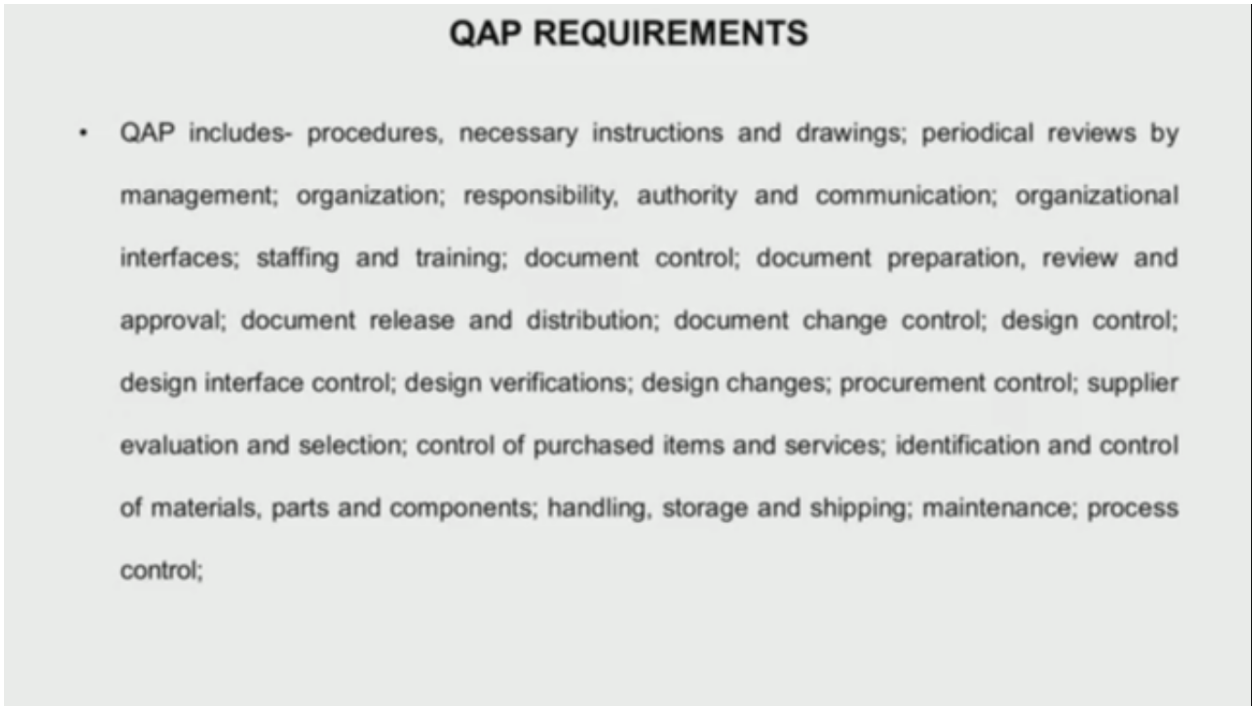

Then when we review the drawings and any -- every stage where there was a review, these reviews are to be recorded. Then in the QAP, we also have to tell who is the person responsible and who has the authority. Every stage is not cleared by the same person to say, "Yes, it is okay." If one person checks, there will be another person who says is it okay and these things need to be communicated up and down so that everybody is aware. So it includes interfaces between different stages of the manufacture, of the design, everywhere. So interfacing, it should be very clear. So a document is made. It must be sent to whom? Who all it should be sent? Even that is a part of the Quality Assurance plan.

Staffing. Let us say I have to operate a plant. I know that there is a minimum requirement of at least one engineer in the control room and assisted by two operators. Then there is need for local operators at different places. So I have to tell what is the minimum staff requirements and that should be followed. Then training the people. It is very common. Training is without a training.

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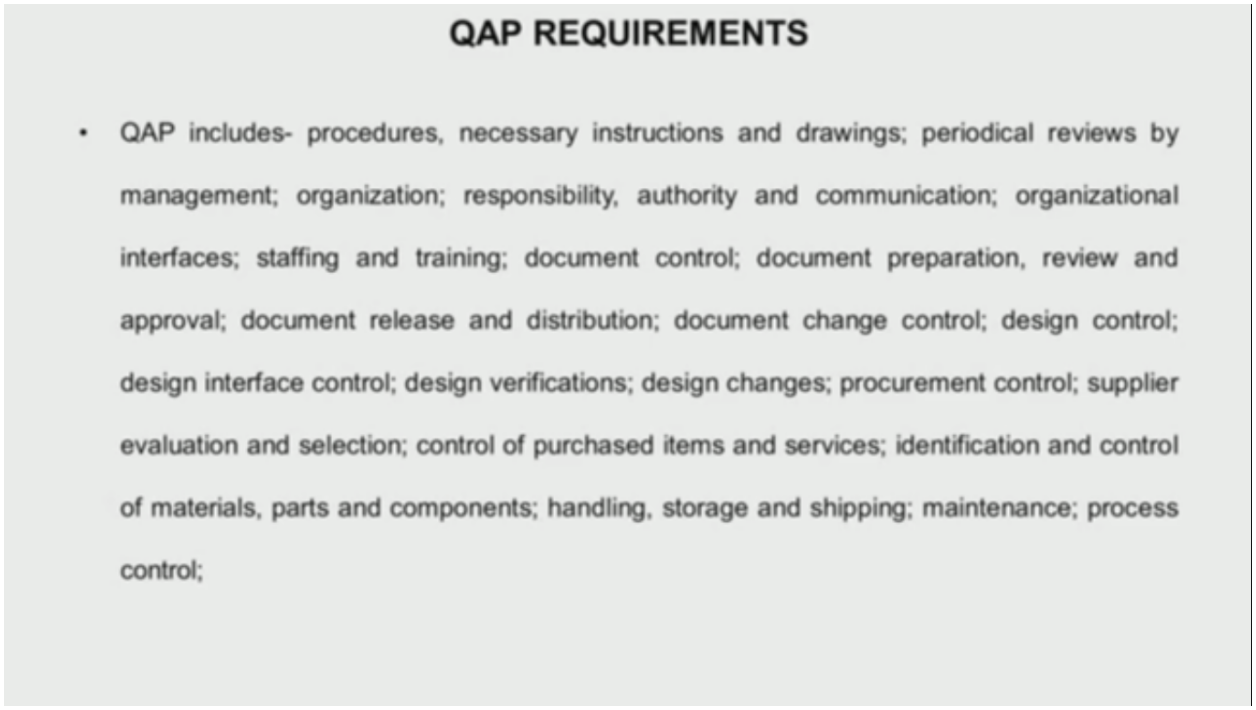

And document preparation and document control. I mentioned every stage you need to have a document. Then reviewing and approving. Who approves this document? And its release and its distribution to the different agencies. Then document change control. Suppose let us say there is a design change or there is a revision of a particular document in view of the observations. Then there has to be a change. So who approves that?

Then design interfaces. The designer might have an interface with a manufacturing agency. So where is a designer come in the interface? For example, if there is a deviation in any manufactured product from what is indicated in the drawing, there are two approaches. One is the designer looks at it. He says no, it is still acceptable. He agrees. So he gives a design concession to the manufacturer saying that you can go ahead. This is a document which is cleared by the designer. Otherwise designer says no, it is not acceptable. He gives a rejection. So these things are the designer interface.

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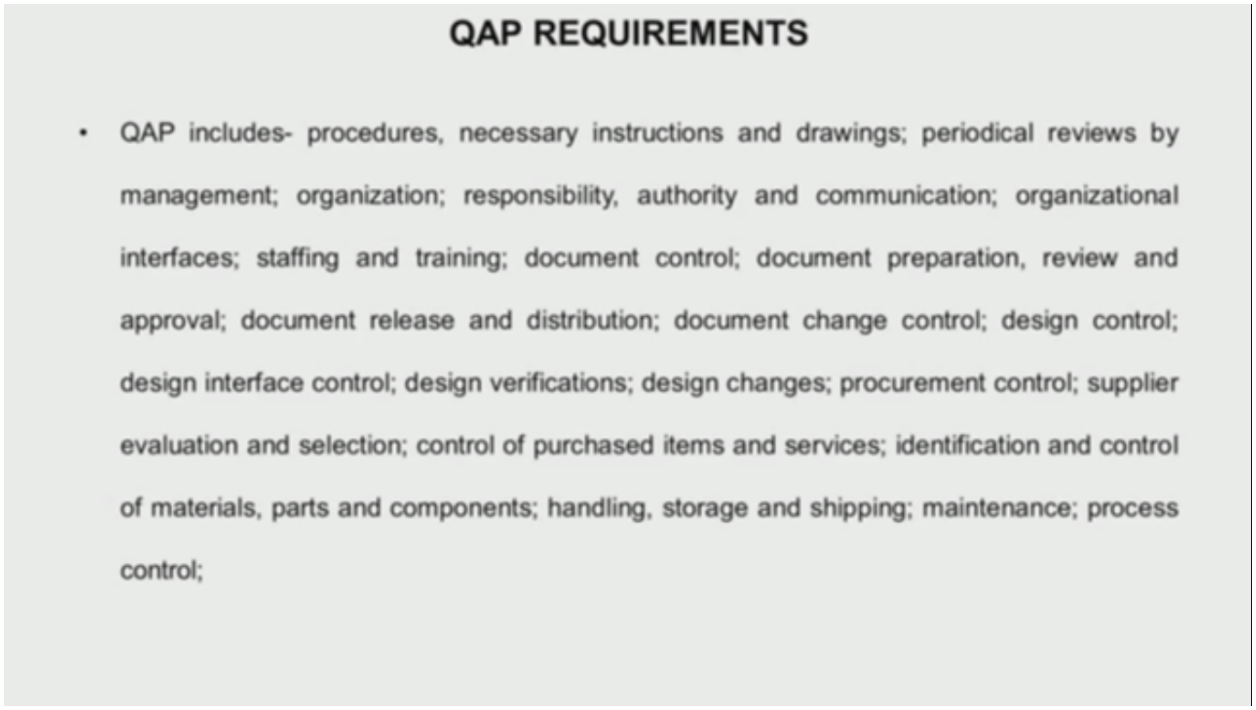

Then design verifications. I mentioned you must know that the design verification is there. Design changes. Maybe we had made the documents of the design. We discussed it in the safety committees. The safety committee on review let us say suggested a change. In the light of the regulatory authorities' observation, you make a change. This design chain must be again put revisions of the design document made.

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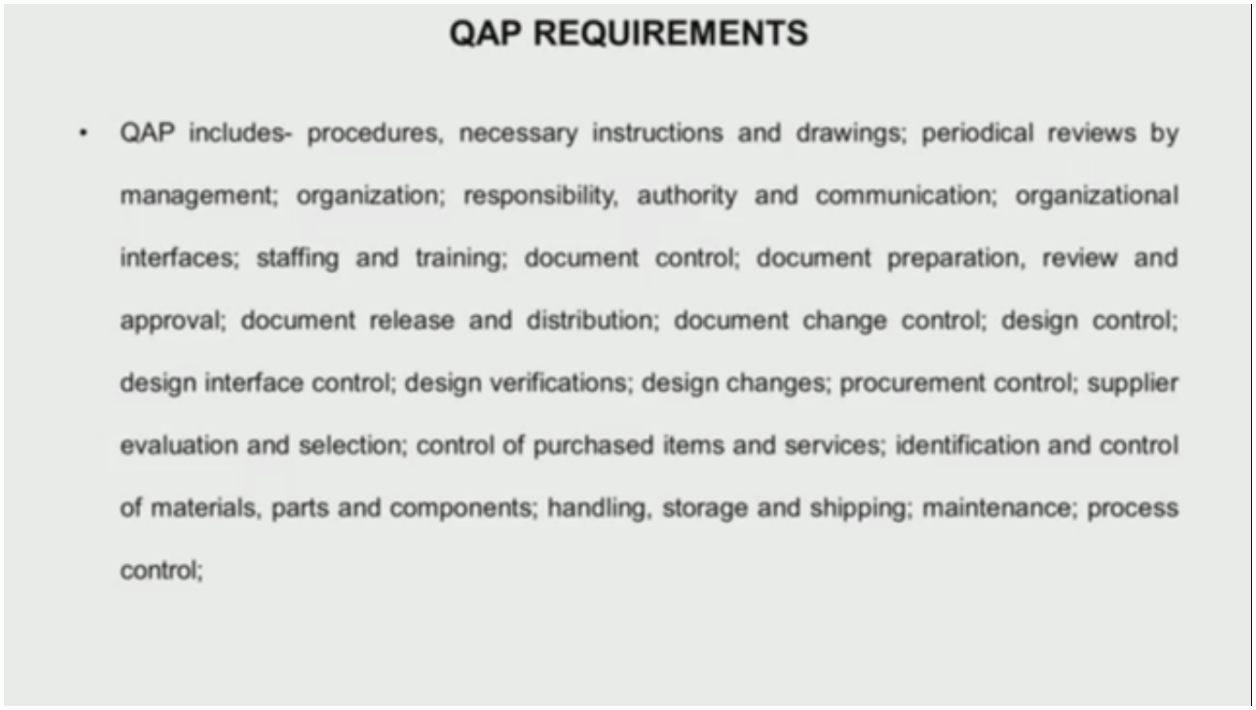

Then what are the requirements for procurement and control? I have to procure a material. I have to procure a machine. What should be the agency? How we should go about it? So all these are -- will be there in the document plan. Then supplier. Evaluate a supplier. There may be many suppliers of a particular equipment, but you need to buy the equipment from a supplier who has got a very reliable -- he should be a really reliable supplier. He should preferably be a original manufacturer or he should be a very reputed agent plus he must have provision for after sales service and maintenance. So all these need to be assessed. That is where we say supplier evaluation and then selection.

In fact, in the nuclear power industry, before we get into ordering the components for a plant, we go around manufacturers in that area, and we evaluate them, and then only we shortlist who are the people. Then only we start issuing the documents or tender documents for the procurement.

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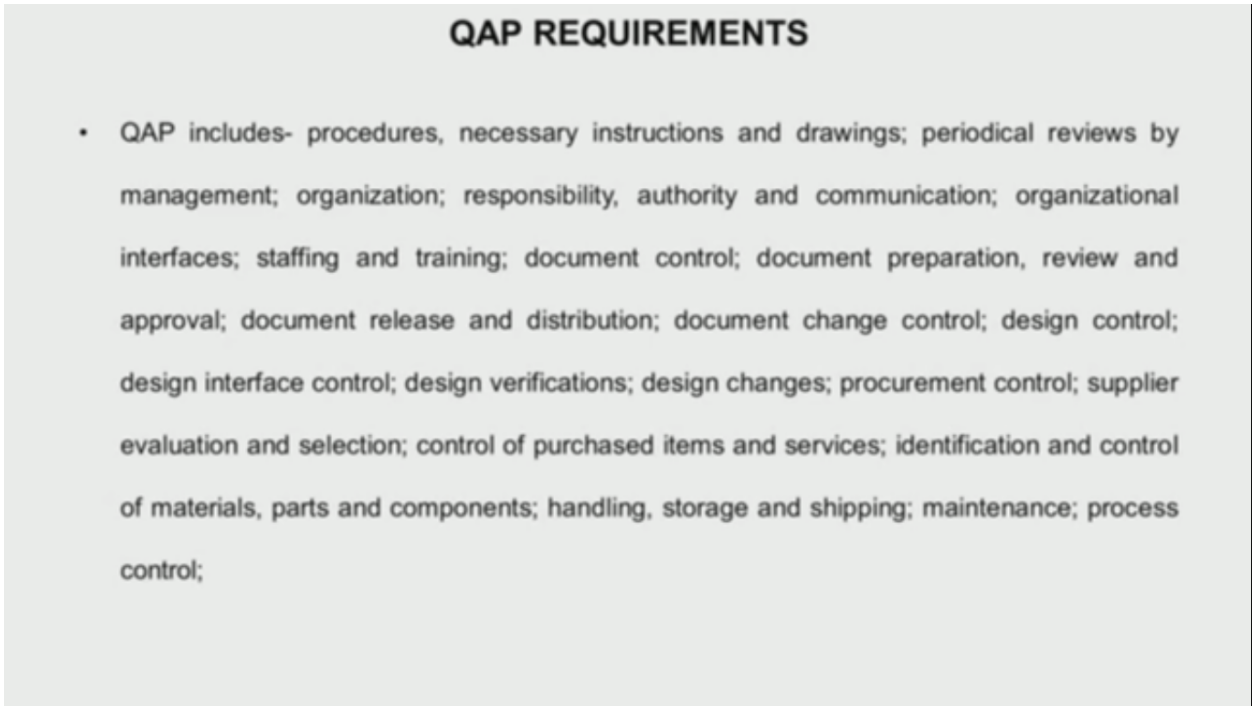

Then let us say you have ordered. Your items are coming. So quality assurance, quality control at the plant is anyway there. Now how the items which are purchased, how they are to be controlled? How they should be preserved? Because a component might come this year. It might be put into the plant next year. So how do you preserve it? Even this is a part of the quality assurance plan.

Then you must be having your tag or identification of different materials. You must know where different parts are located, where should be all these things, again, appears to be simple, but for a large plant, everything is systematically has to be planned.

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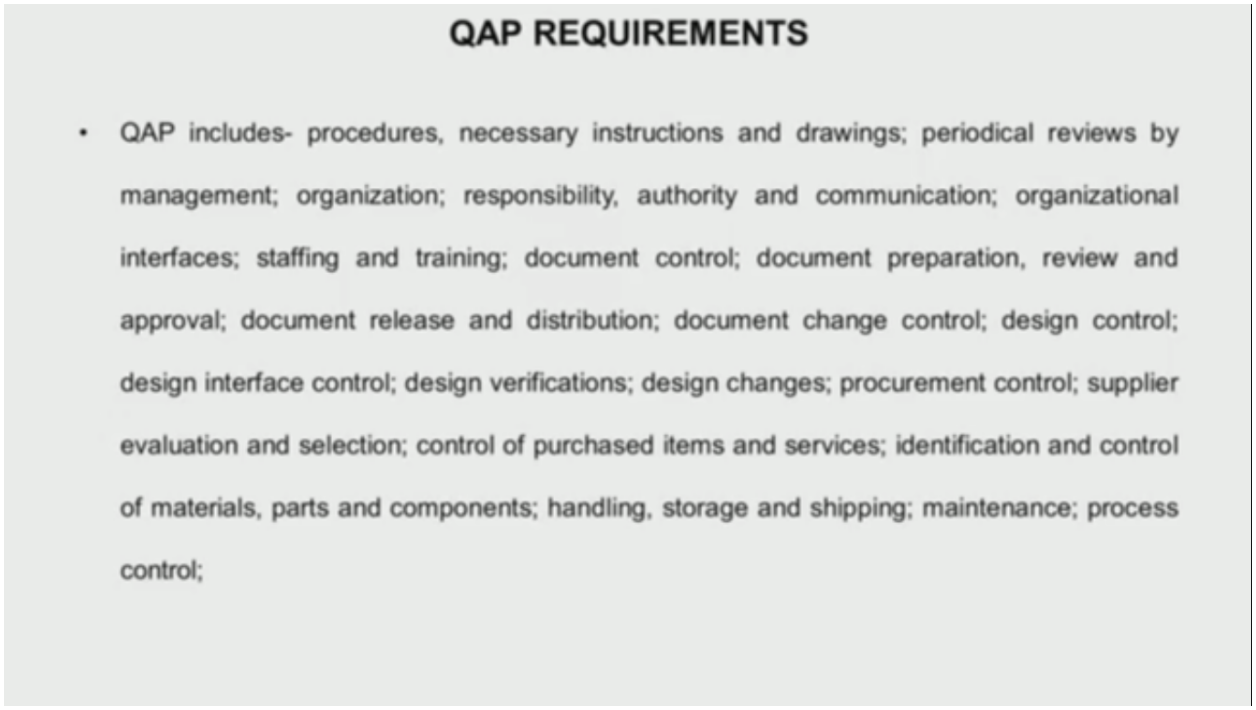

Then when it comes from the company, how it is to be shipped? I forgot. Shipping is very important aspect. During shipping it should not get damaged. So how the packaging should be? These things are very, very important for the assuring the quality of a nuclear power plant. I repeat no doubt such plans are in existence for other industries also, but in the nuclear, we follow it threadbare because we know that at any stage, there should not be a cause for release of radioactivity due to anything which is not a quality product.

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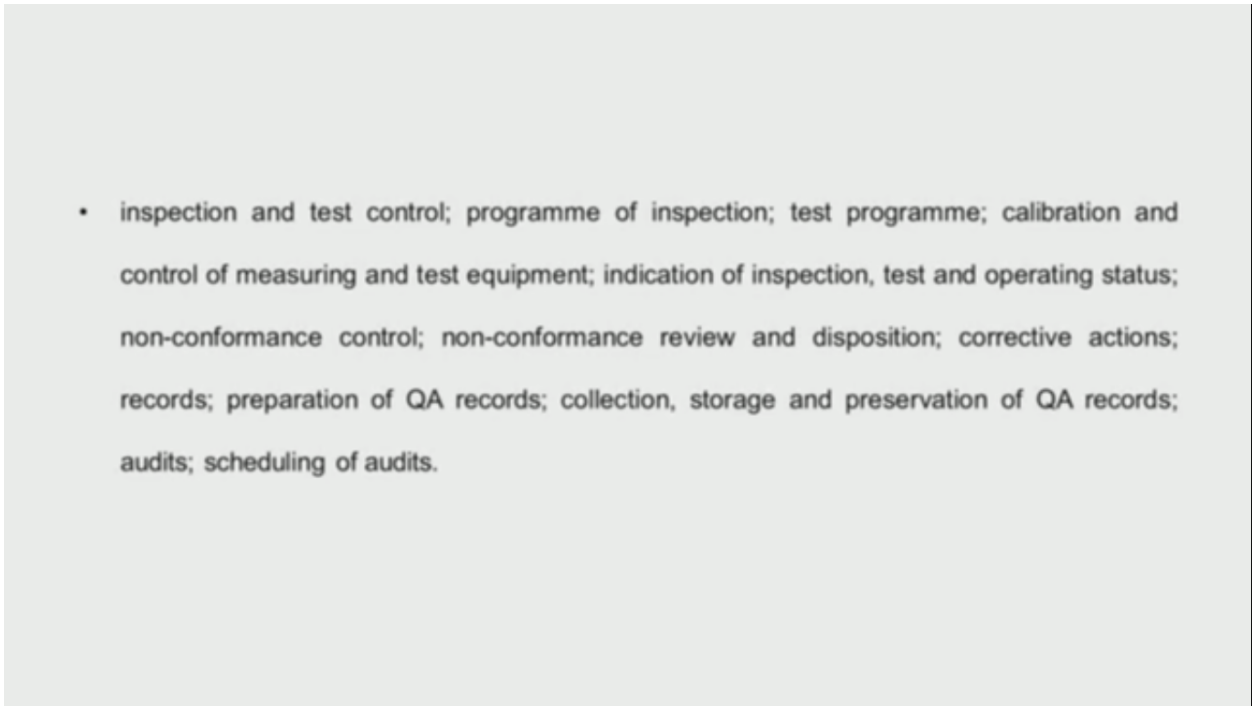

Inspection test control I mentioned, so the inspection program. Who will do the test? Whether the operator who is going to do the welding, whether he is trained? Whether he has been tested? In fact, you would be surprised many times a welder is qualified on the day morning and then only he will be put. He won't be every day or every alternate day he need to be tested because we need to see that he is in the best of health to do the job.

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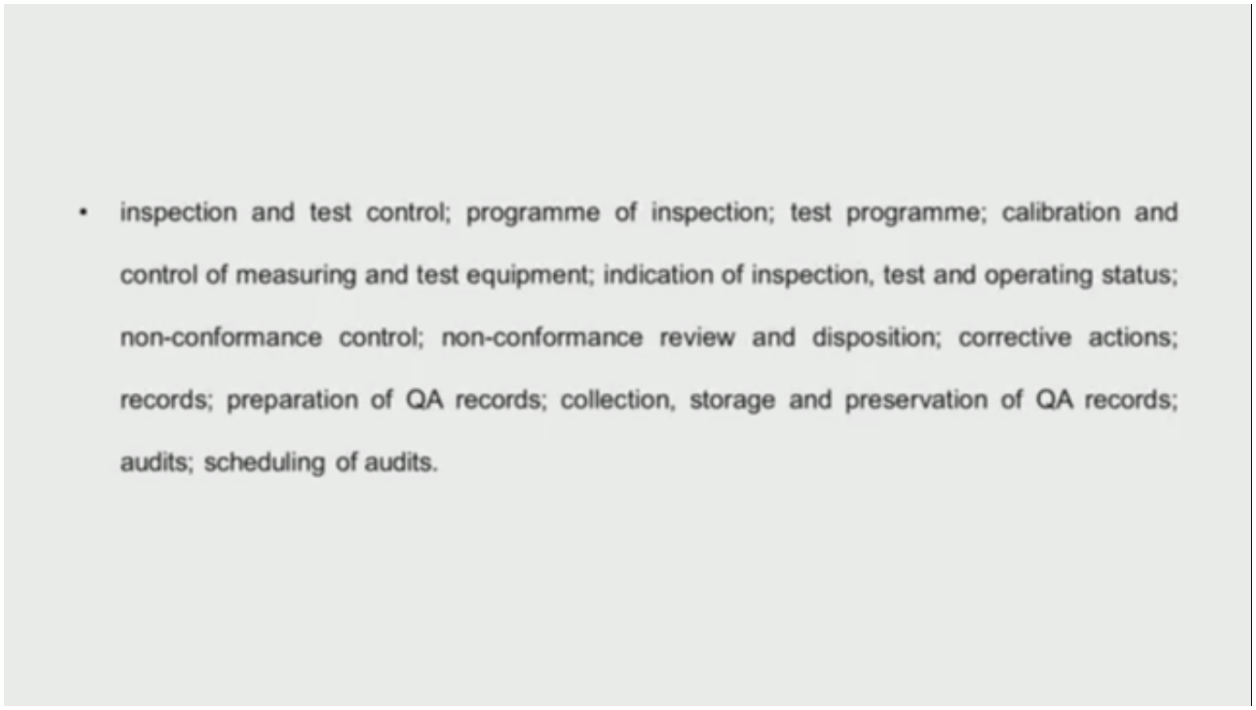

Then the equipment which he is using for inspection, whether they are calibrated? Whether they are really giving you the actual condition of the equipment or the actual dimension? So all these things are included in the quality assurance plan, and as I mentioned in case there is a non-conformance, how do you go about it? There should be to whom it should be given or this much range you can accept. All these need to be documented. Then what sort of records, how do we preserve them? And earlier and all we used to preserve them in hard copies. Today we have soft copies and then not only that, the quality assurance records are audited from time to time by different agencies. We will look into this in the further slides.

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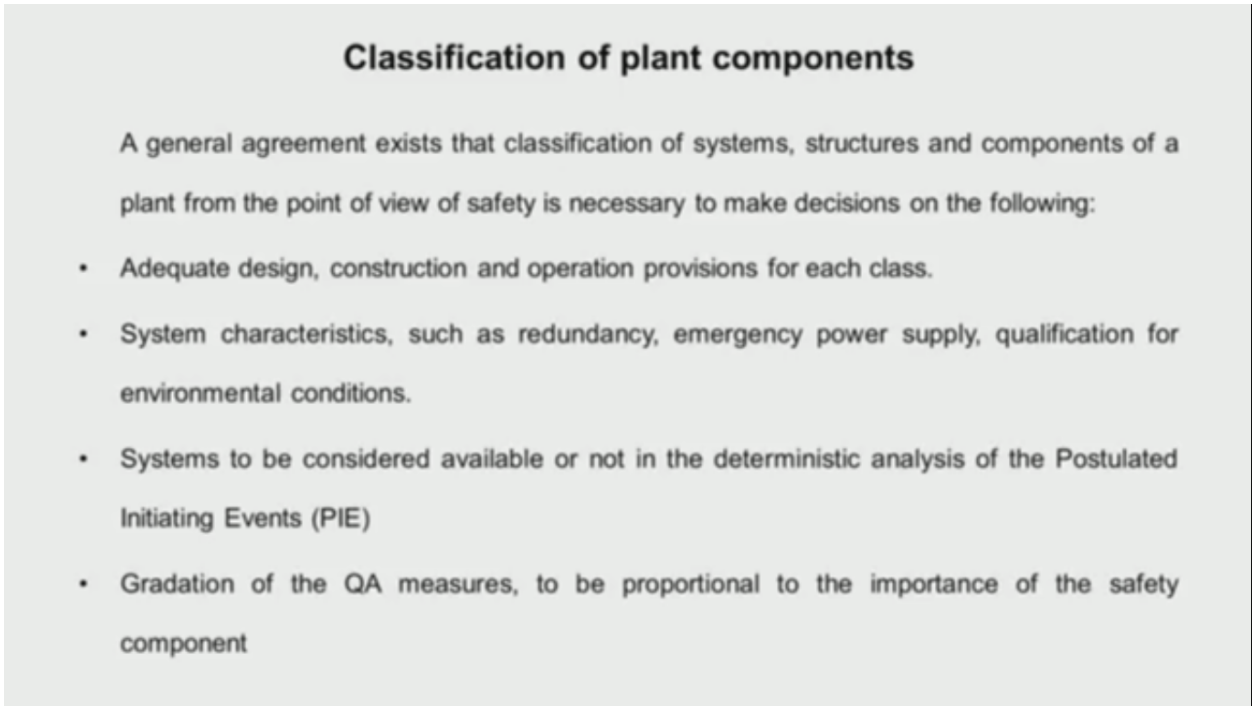

Okay. Classification of plant components. What does this classification -- why we talk about classification? Let us look at a nuclear power plant. You have got the reactor core, very important, up to the steam generator, yes. If you take a reactor, if there is any problem, radioactivity again come out, but in the case of steam generator, it is not that much. Only water may come leak out.

But if you go further to the steam water system, let us say there is a valve leakage or something, it is not that much of a worry. So we want to give the highest quality assurance to the reactor core components, may be a second level in the -- to the steam generator and your third level. Why? All these quality assurance involves large amount of testing, documentation, and verification and audit. So it becomes uneconomical if you do it for a component, which is not that much in the safety category.

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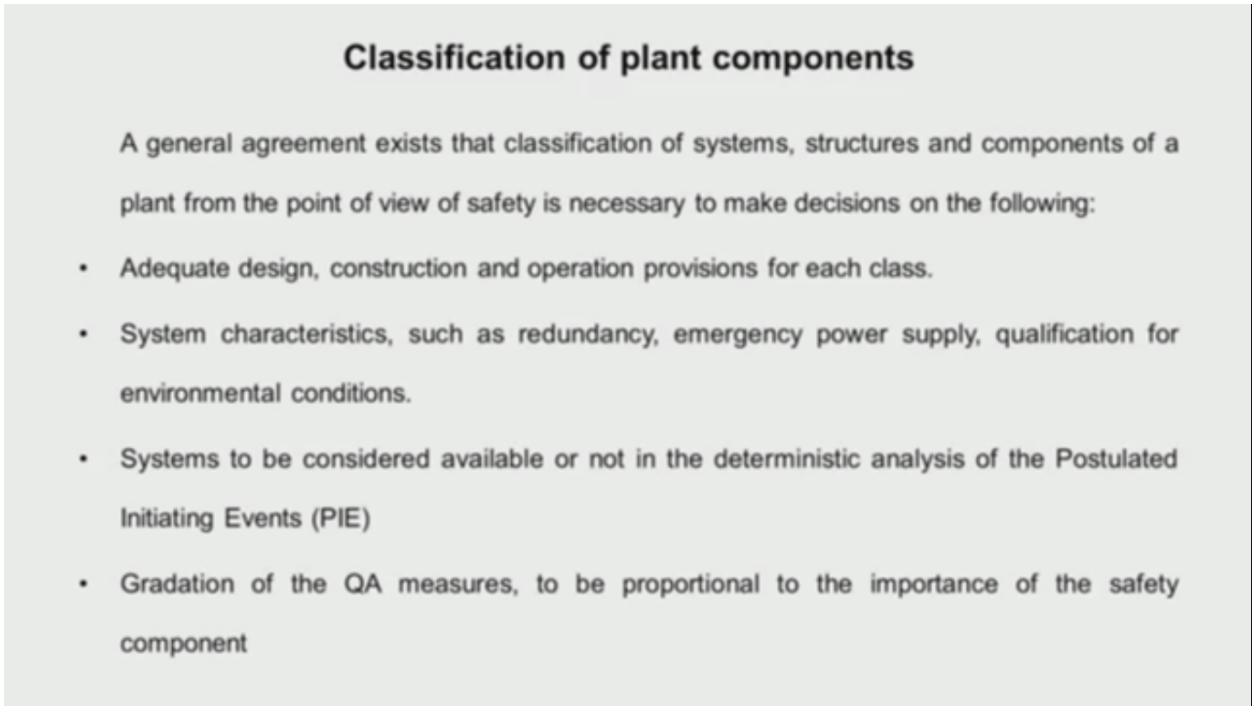

So, basically, we need to make a decision on how to classify the different components. Now let us look what are the points we have to keep in mind. So for every class, we have to tell what should be the design criteria, what should be the construction criteria and operation criteria. For every class, there would be a difference. Then what about the redundancy, emergency power supply, and how they are for each every class, and whether the availability of that those systems should will come in the way of safe operation of the plant?

In a similar way, the Quality Assurance also is graded. If this is Class 1 on the reactor, Class 2 for the steam generator, and Class 3 for the rest of the plant.

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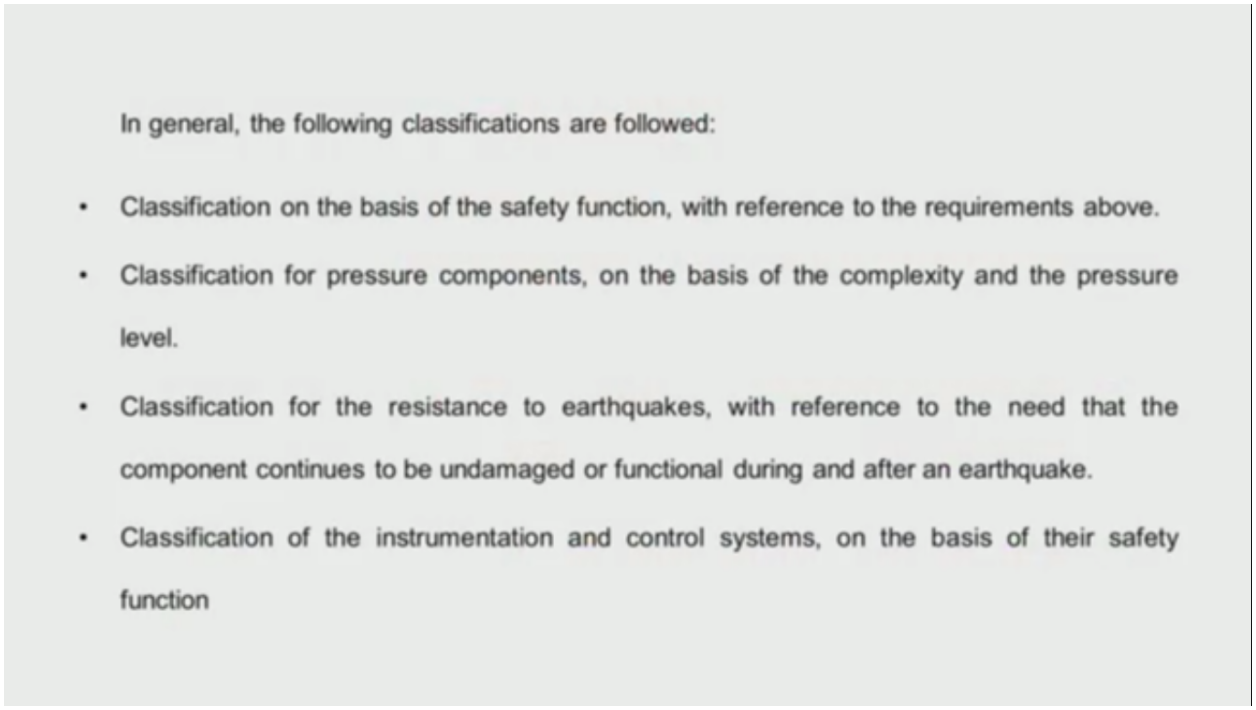

Let us see what are the classifications. So this is basically on the safety function. You take a pressure component, basically, a pressure vessel. Yes, it should be in the highest class. Then coming to earthquakes, again, we have to see whether that component, if it gets damaged, whether it can affect the operation of the plant. If it is going to operate the safety of the plant, then again it has to be in a higher class. Similarly, the instrumentation, the control systems, again, based on what sort of a safety function they need to adopt. So, finally, safety is the watchword.

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- The system of vessels, pipes and pressure components which form the primary cooling system of a PWR (reactor vessel obviously included) is in Class 1, the highest one, as the failure (break) of the system constitutes a serious LOCA.
- The core emergency cooling system is placed in Class 2, as its failure doesn't cause directly and necessarily an accident.
- The compressed air system which supports the emergency cooling systems is in Class 3 as it is considered a normal, not highly stressed system.
- The station fire fighting system is not placed in a safety class (or it is in Class 4) as it is considered that the specific industrial standards in force already offer sufficient guarantee by themselves if needed.

So the vessels, the pipe, and the pressure components or the primary cooling system of a nuclear power plant are put in Class 1. Let us take -- we are talking about a pressurized water reactor so that you know in case of any failure of this, we can have a loss-of-coolant accident, so we need to give it the highest class. The emergency cooling system for the core, anyway, that won't be continuously in operation. It will come only when there is a failure like LOCA, which is a bit of a lesser probability. So we put it in Class 2.

Then we look at the support systems like the compressed air system and other which are going to be supporting the emergency cooling system. We put it as Class 3. Then we look at the station firefighting system. You know in a heavy water reactor, this fire water system is used for quenching the -- putting the reactor core, submerging the reactor core in case of a very large LOCA, but here there are enough industrial standards which are being followed presently, so there is no need to unnecessarily put a another new classification. So we follow the industrial safety standards, which are being followed everywhere for this firefighting system.

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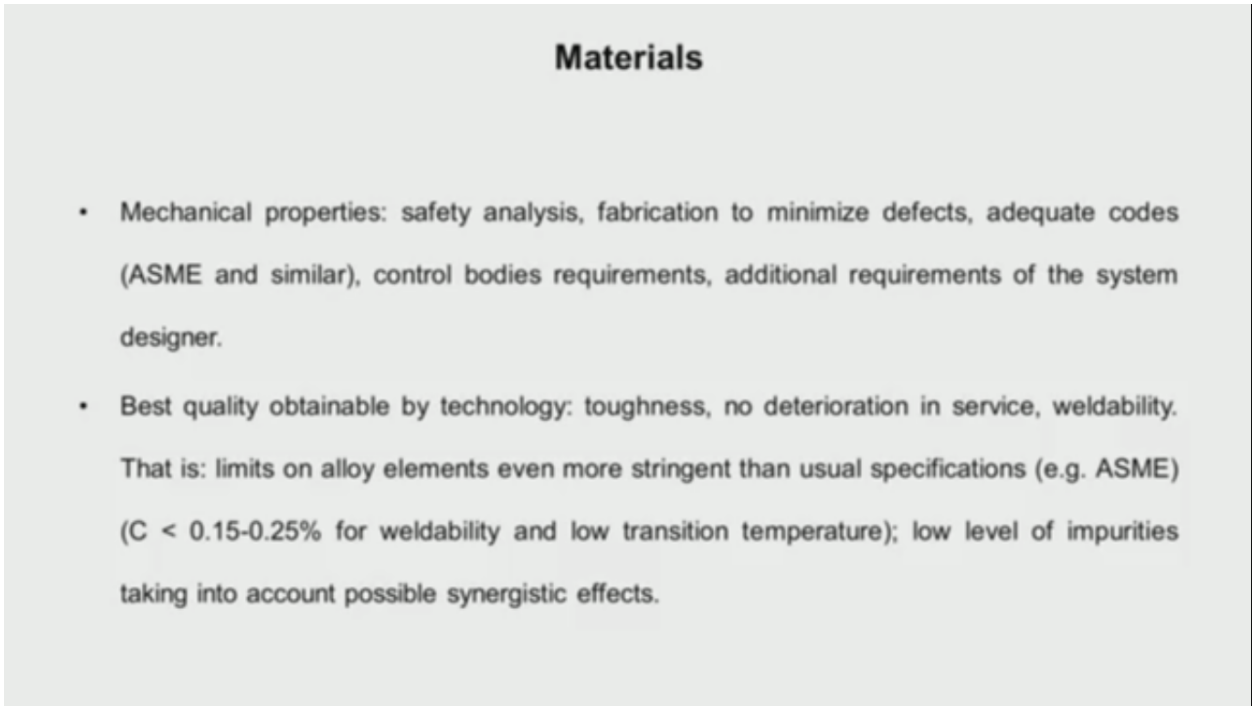

Okay. We come to the materials. Now when you say the materials, we will say austenitic stainless steel as per some standards, let us say ASTM standards. Okay. If there is any deviation from the ASTM standards, we need to mention. Then what would be the fabrication standards? If it is as per ASME, we can code the relevant ASME sections, and then need not stress further because most or nearly all of the fabricators know the ASME codes.

Then any other additional requirements, for example, when we buy pipes, we normally go for measurements of the pipe, how they are, we procure them, and then we do random ultrasonic testing to know the thickness, but in case of sodium systems where the austenitic stainless steel pipes are used, we want 100% ultrasonic and when it is welded, again, 100% radiography plus 100% ultrasonic testing. So these are some additional tests. So we need to tell what are the additional tests. Of course, the designer will specify this additional testing.

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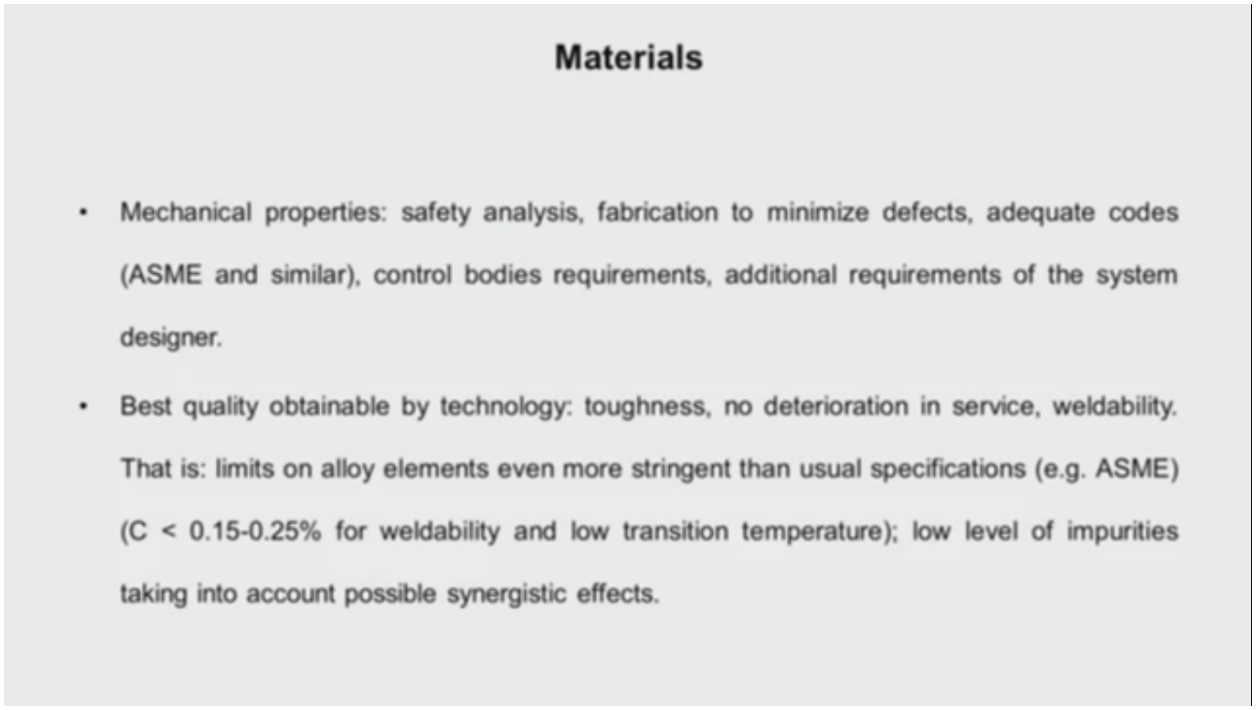

Then any limits on the alloying elements. For example, Carbon should be less than 0.15 to 0.25 for weldability consideration or what sort of impurities you would not like to have, which because it can cause corrosion by the coolant. So these sort of things are to be specified. This specification has to be drawn up for the materials very clearly.

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- Weld procedure qualification tests for submerged arc welding of the main vessel shell and cladding: destructive tests; metallographic techniques to check that Heat Affected Zone (HAZ) reheat cracks are absent.
- Procedure for the evaluation of defects found in service, to be agreed upon before start of service.
- Assessment of the absence of danger of stress assisted corrosion for the water chemistry and flow rate conditions as applicable.

Then how do I qualify the procedure? You have got a certain procedure for welding, and the welder has to follow that procedure, and he -- we should satisfy that he is able to do a good sort of weld. Then the destructive tests, if any, of course, in the case of nuclear power plants, we mostly go for non-destructive testing, and whether there is any need to do a metallograph of the heat affected zones. Basically, when you do welding, you know, the area around the weld does get affected by the heat. Whether it has changed any characteristics of the material if you would like to know? I think that also needs to be specified.

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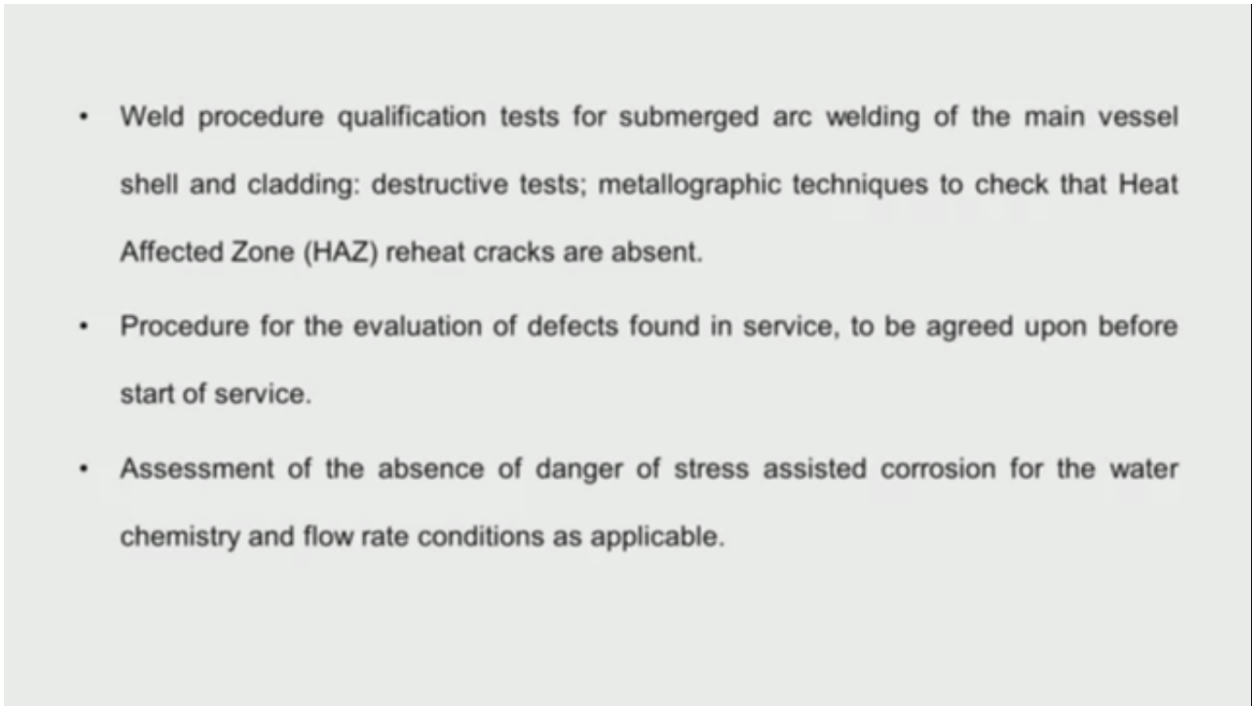

Then okay, now defects are found. How do I evaluate the defects? And how much of defect I can accept? So all these things. Then of course, in the material choice when I do, I have to keep in mind that in the presence of water and stress, corrosion can take place. So whether that is basically even though this is a part of the design basically, whether this is okay. So the material right from the beginning, the pro-fabrication, everything has to be under -- follow the Quality Assurance procedures.

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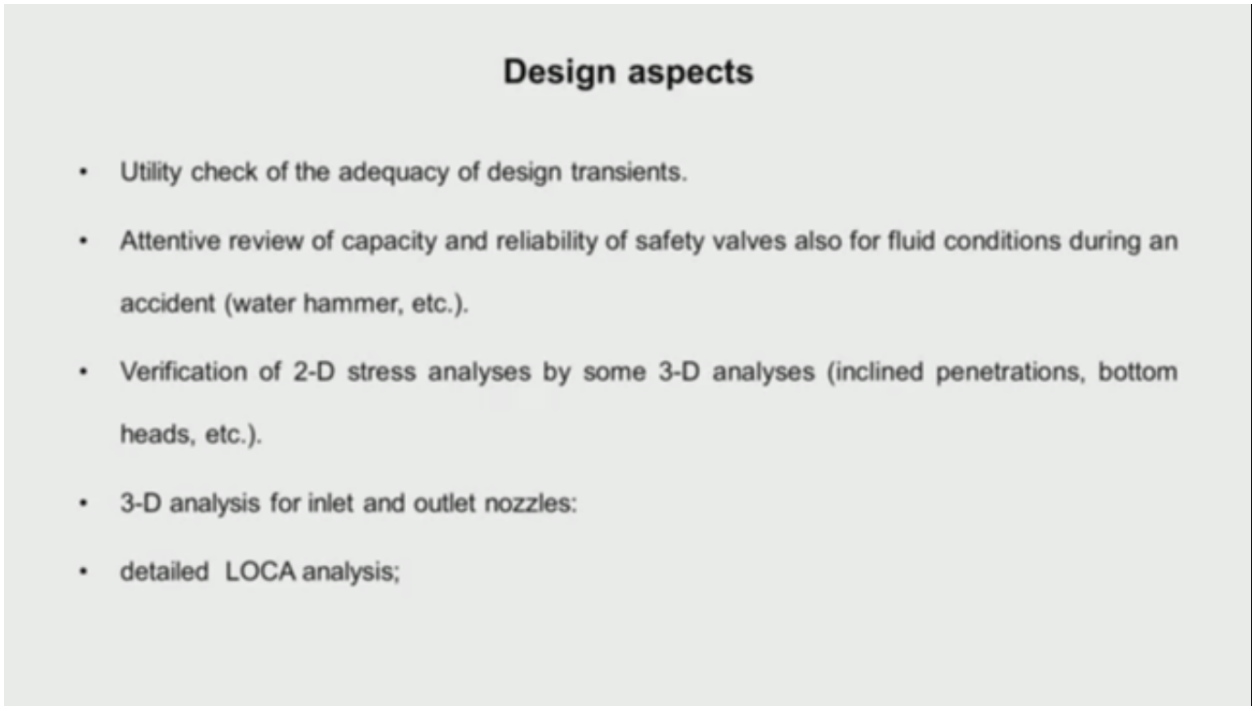

Now in the design, what we do? One, we talk about the postulated initiating events in the last few lectures. So every event gives a temperature or pressure transient to the plant and the design is governed not only by the temperature transient or the pressure transient seen. It also depends on number of times because repeated things can cause fatigue of the material. So this needs to be very clearly given by the designer.

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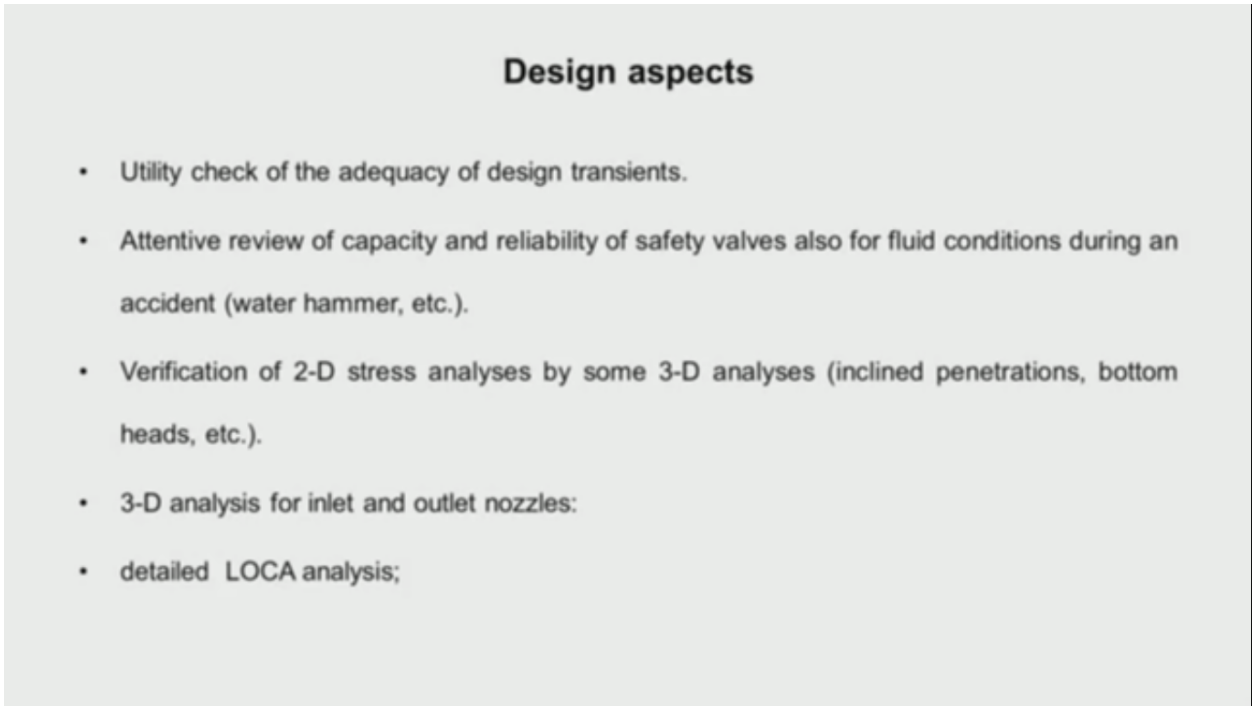

Then if you look at a safety valve, what should be the capacity of the safety valve so that in a given condition it is going to relieve? So this a designer has to in the -- assure that this will really take place. This is a quite an important aspect because in many times when safety valves are open and the pressure surges are there, something like water hammers, something like a hammering noise have been heard, and that is because of the layout of the piping and it can fail. Sometimes the pipes have failed when the safety valves are opened. So these things need to be kept in mind by the designer. So this is a verification, and the designer, and we may do a 1-D analyses or a 2-D analyses.

Many times we do a 2-D analyses because 3-D analyses is very time consuming, but in areas which are very critical areas, critical belts areas, we do a 3-D analyses and satisfy ourselves that the 2-D analyses is okay, well meeting our requirements. That is it is able to give an accurate prediction for our transient. Of course, detailed LOCA analysis needs to be done that has to be done for any light water reactor.

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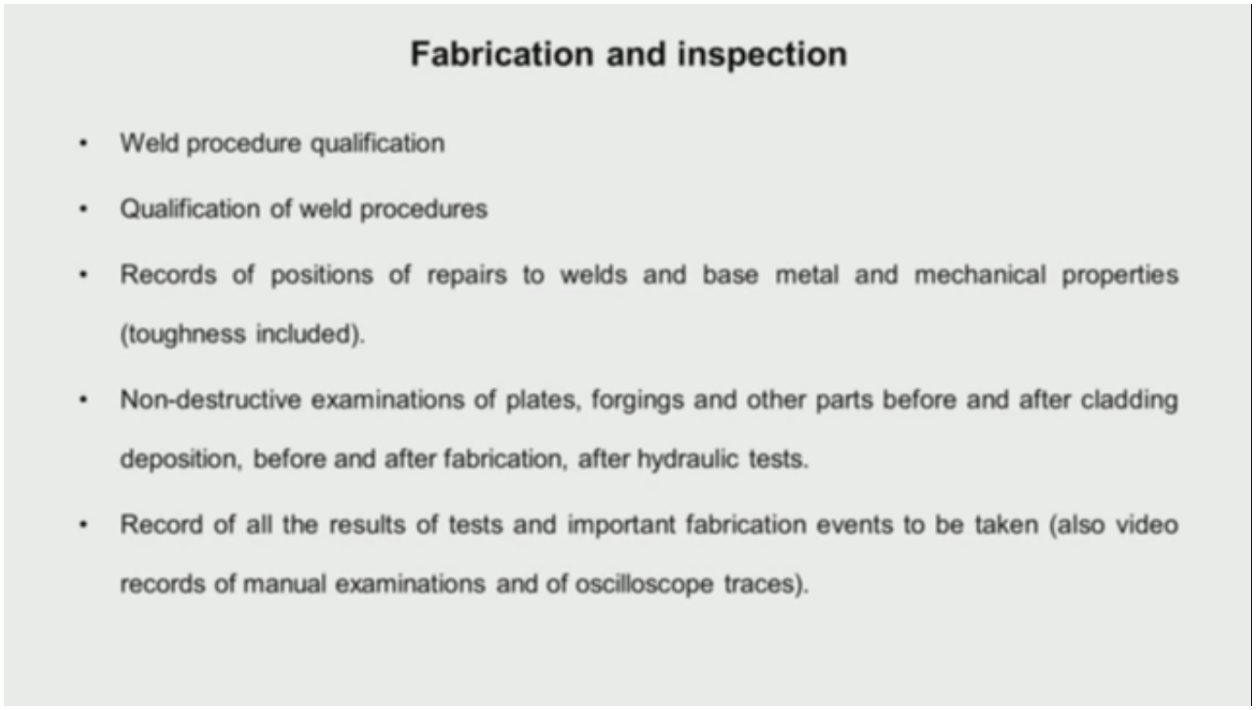

So fabrication, and inspection, weld procedure qualification, then how to qualify the weld, procedure qualification, then qualifying the weld, then positions of repairs to welds, and base metal. This position is very important. A component is in position, in a particular position, but the operatory will be having different positions. His ability to do a weld, blind weld, suppose he is here and he has to do a weld here, he can't see. It has to be seen. So what is the position? All these things need to be recorded so that you know if there is a problem in the weld, maybe if I change the position, the weld could be repaired. In fact, these are tested before we do the final weld on the actual component.

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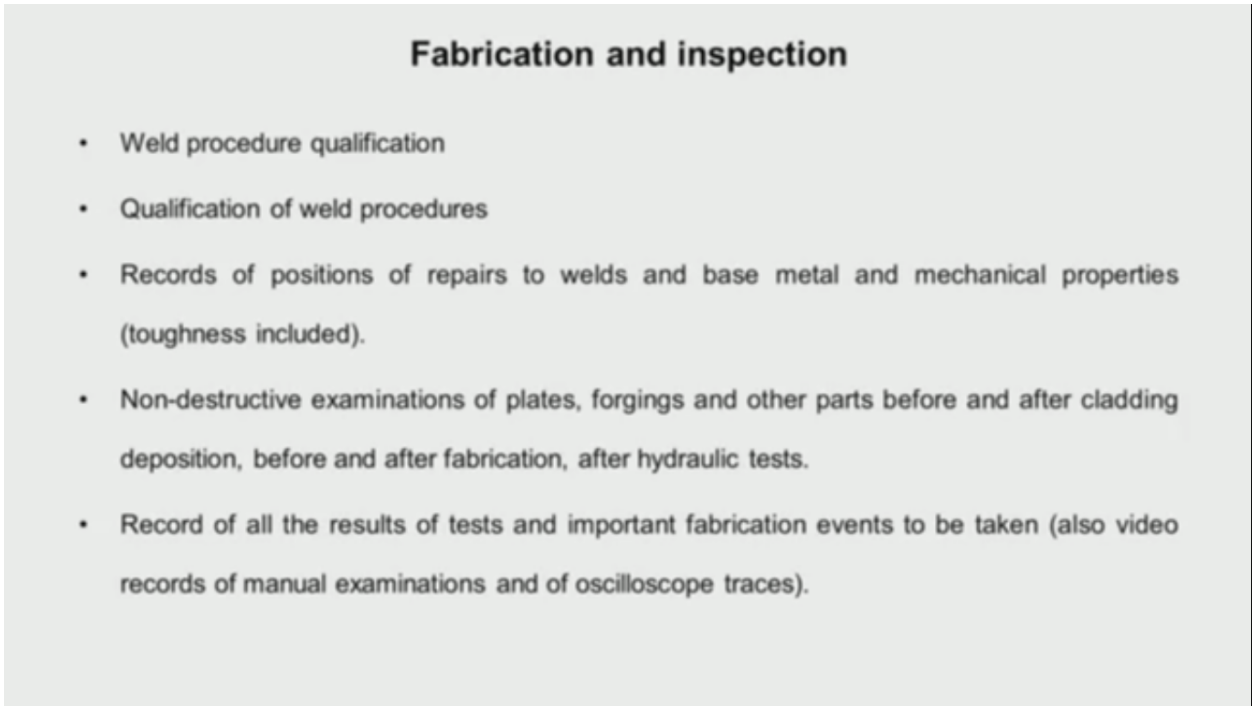

Now non-destructive examination. You have produced -- you've procured plates, forgings. Then you must check it before you fabricate. Then after you fabricate also, if you want to see some metallograph you need to see. Then suppose you want to do some hydro tests, you need to do them and satisfy yourself that everything has been fabricated well, and record all these tests so that we can have a record in case there's a problem, we can trace out the cause or the stage at which the error has happened, and once we do that, we will review our procedures so that next time when we make the same component, we don't get into similar problems. As I mentioned we have to learn from our own mistakes.

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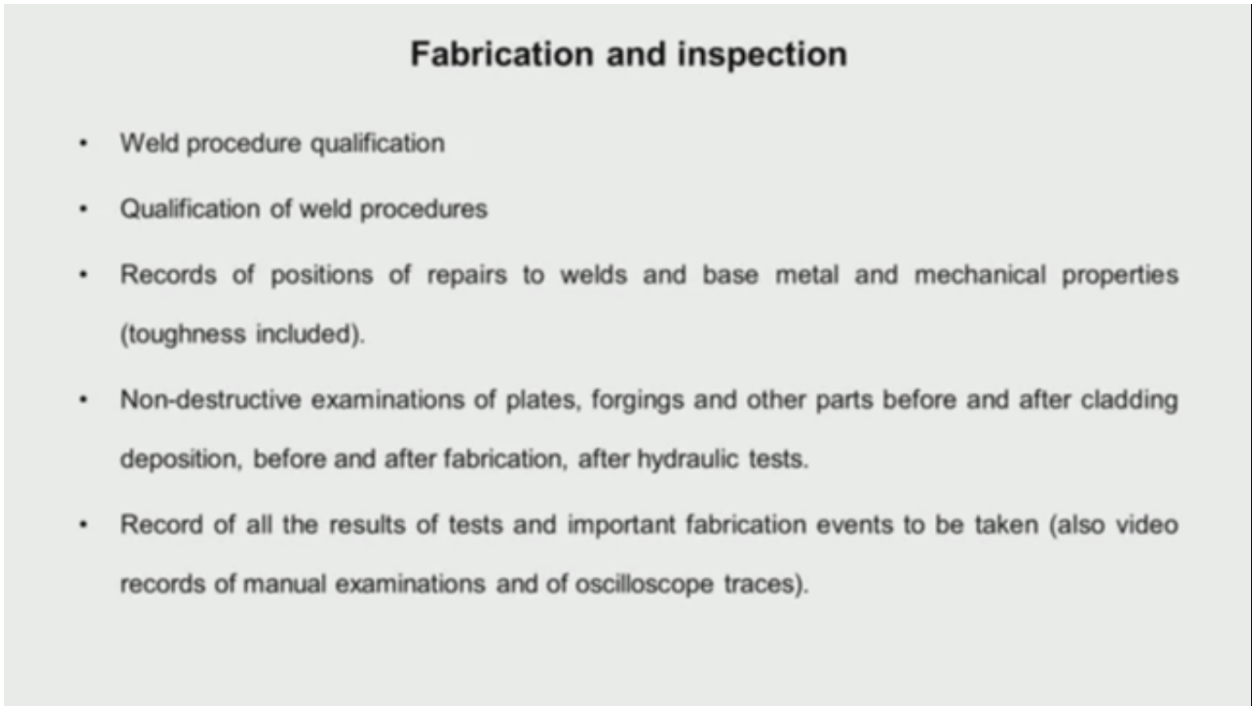

Nowadays, it has been a practice to not only have a written record. We also have a video record of the fabrication process so that we can easily find out how the thing has gone over.

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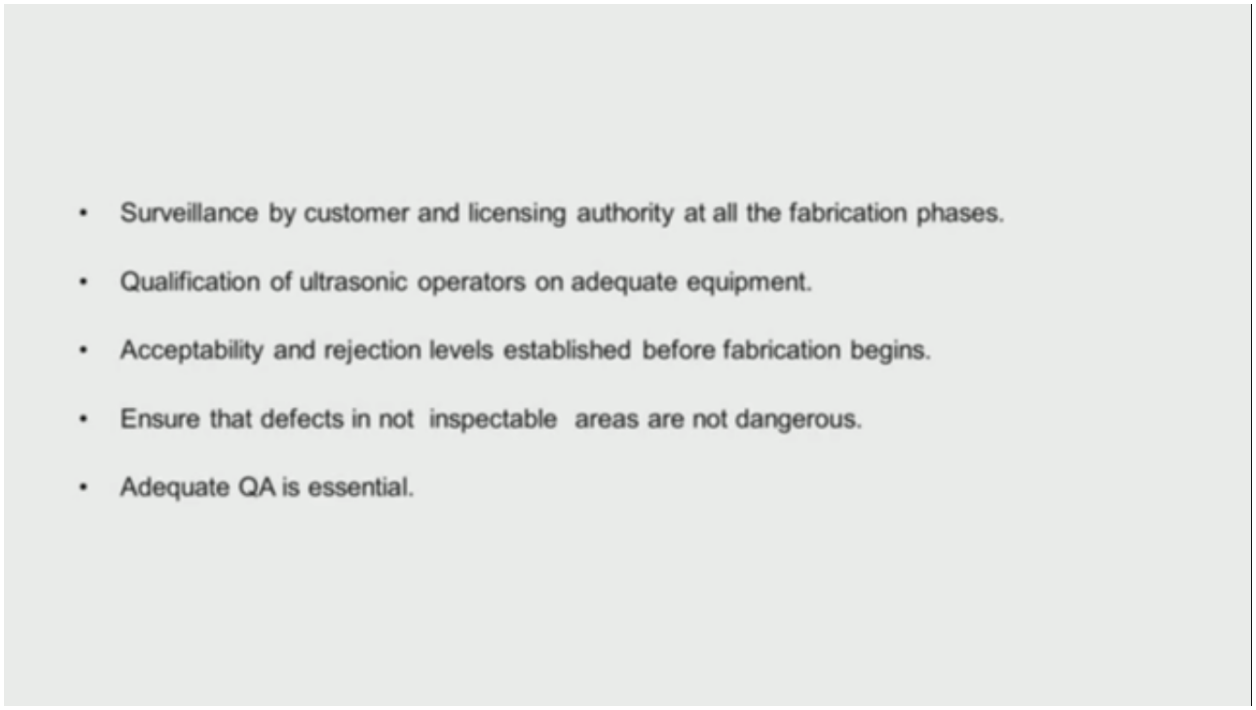

Then these things, the customer will have a surveillance of the fabrication facility at all stages so that he's satisfied that this -- it is moving at different stages. Then as I mentioned ultrasonic testing is a very special art. We do have equipments which are automatic and very good. Nevertheless, we need to qualify these operators who do the ultrasonic testing.

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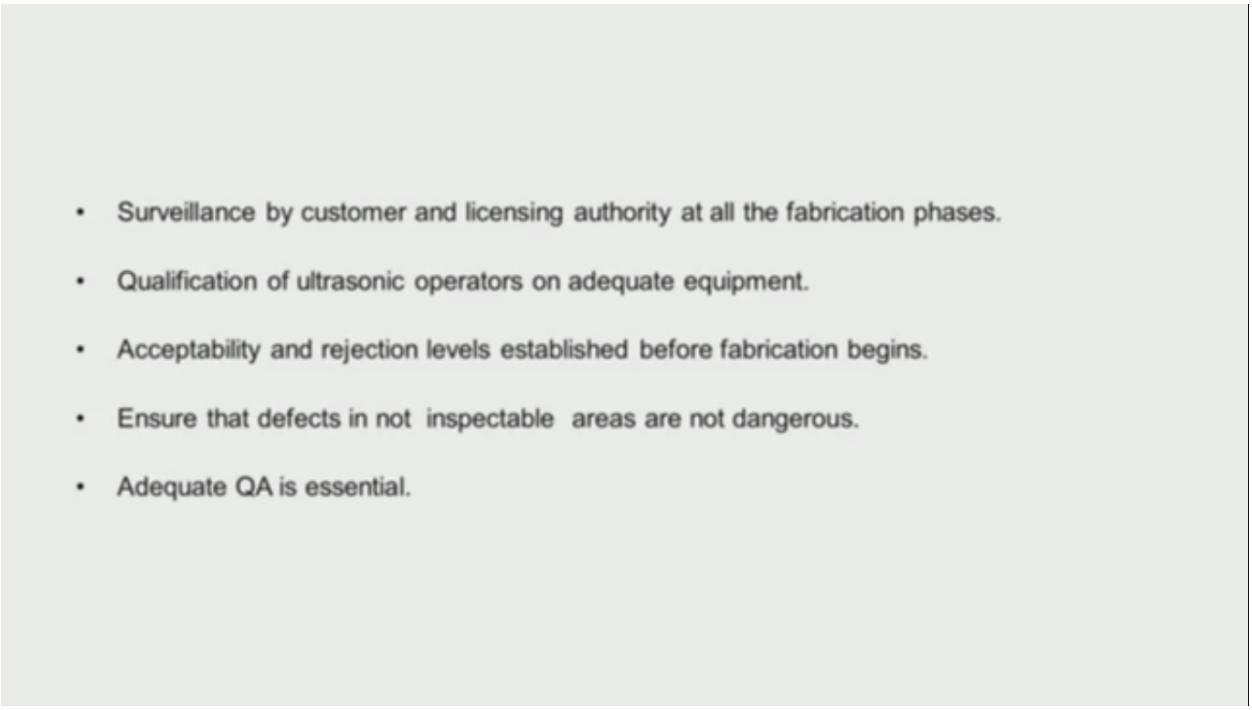

Then for any equipment, any quality check we do, we need to tell what is the acceptance level, what is the rejection level. Let us say in a weld, there is a porosity. How much porosity I can accept? How much porosity I cannot accept? So these things they have to be -- these things need to be specified even before the fabrication starts and one more thing.

Many times as I mentioned about a blind welding, sometimes inspection also becomes difficult. So if the inspection is going to be difficult, we need to accord the highest importance to those areas so that inspectability is not there for that area. No doubt it is our endeavor to all -- make all components, fabricate all components such that all welds are inspectable, but in some cases it becomes difficult. So in all these steps, adequate Quality Assurance is very essential.

Now let us say we have moved, fabricated. We have put in the plant. We are going to commission and operate the plant. When we operate the plant, we need to record what all sort of transients the equipment sees.

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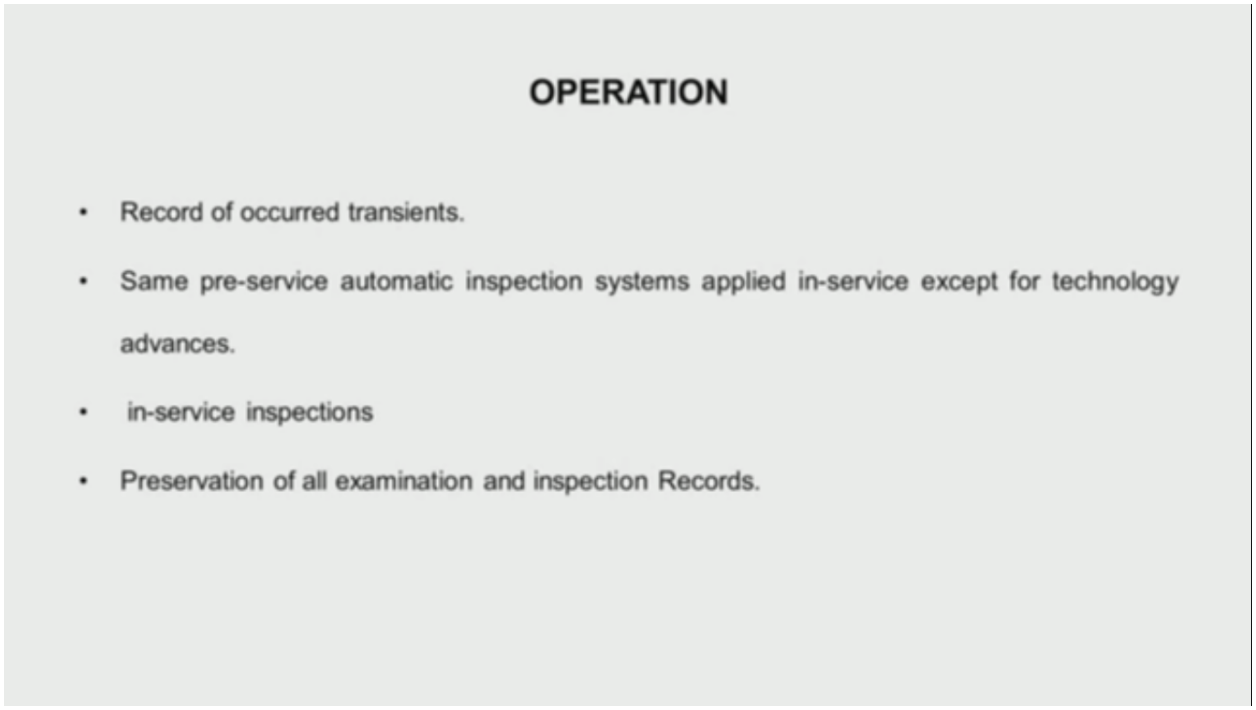

Of course, for some components like the turbine generator, all manufacturers of turbines, along with their turbine, they have a unit which records all the conditions through which the turbine is going, when it starts, what is the temperature of the steam it receives, what is the pressure of the steam it receives, how the pressure went down, how the temperature went down, everything is recorded. So like that we need to record practically the whole plant, especially, the safety related equipment very close to the primary sodium system and the associated things. The reason is in case of a problem, we will be able to trace when it happened and how it happened.

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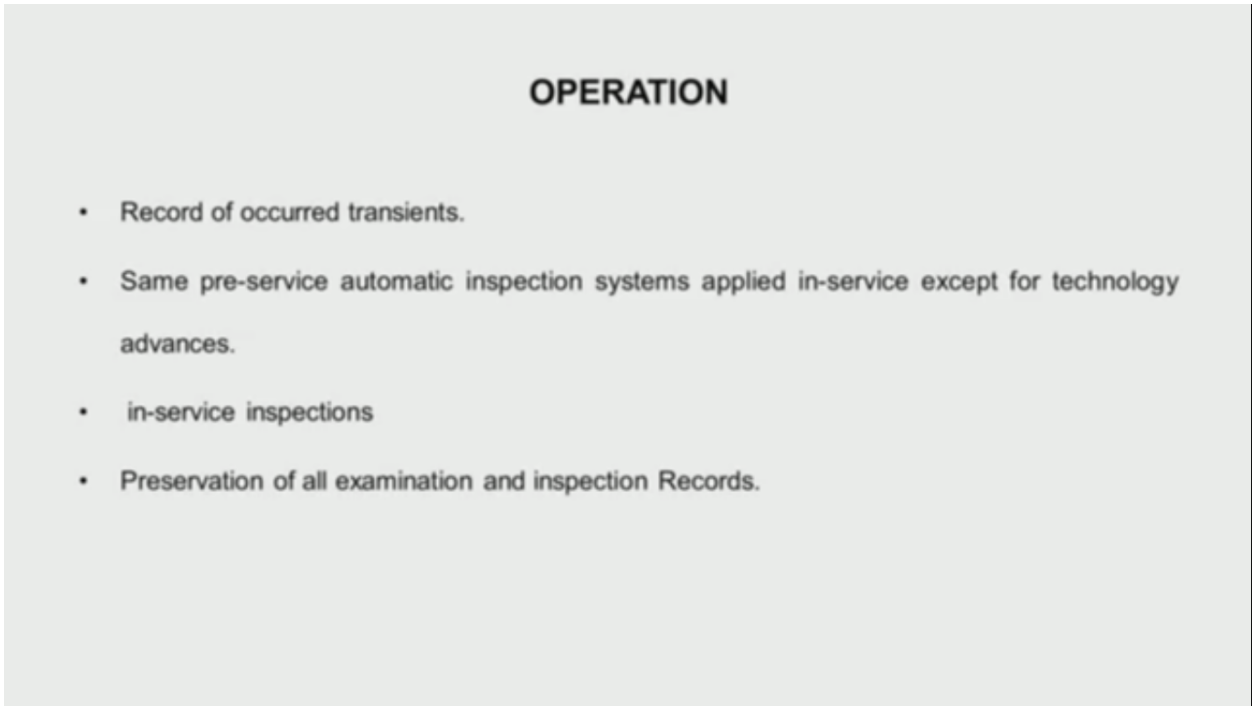

So then, in operation, we have to have inspection by the quality control or by some other means so that we know in service if anything has happened, we will know. For example, there are welds on the reactor vessel which are actually inspected from time to time to know their health because vessel pressure vessel is the main boundary for the release of any coolant and LOCA can occur. So we must see that the boundary is intact. In case we find some change in the weld based on the ultrasonic testing, we can stop the reactor. Then in all places, you may not be do in-service inspection so maybe you have to do the -- stop the plant and do the inspection. So this also will be recorded.

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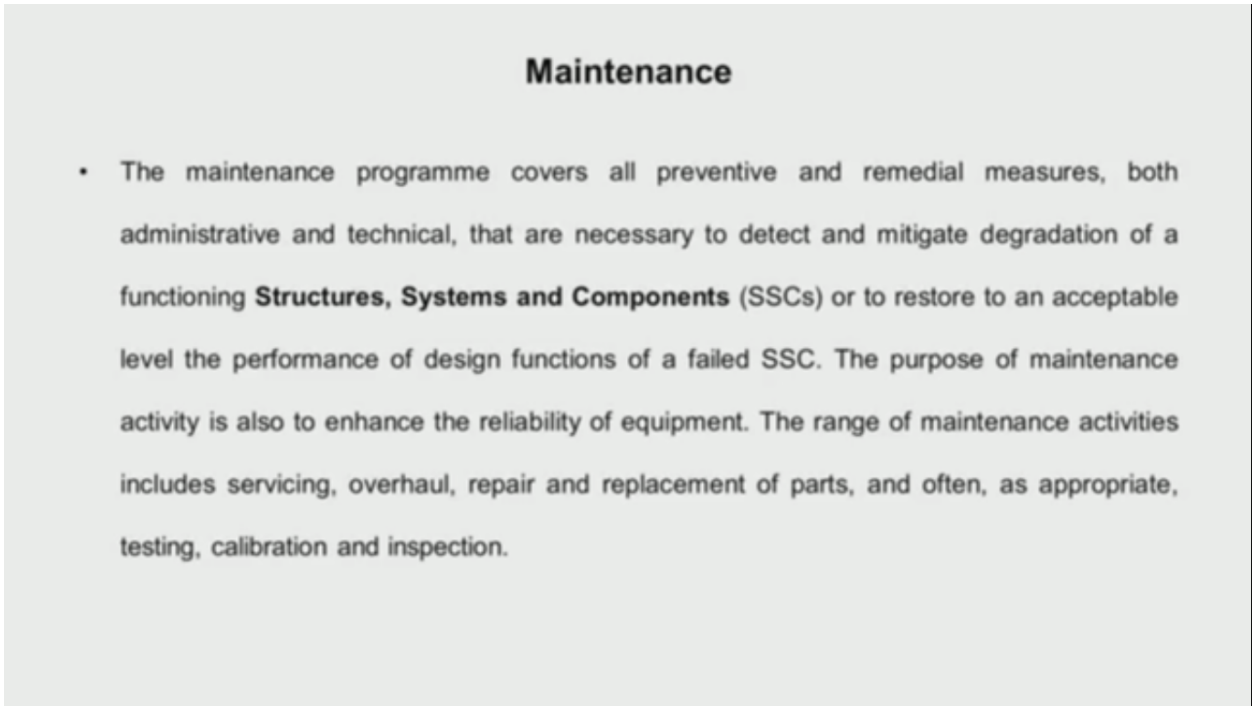

Then let us come to the maintenance. Now there are two types of maintenance. One, we can call as preventive maintenance. Then in preventive maintenance, we do a maintenance. We know this component can get some problem let us say after operation for six months. So I decide after four months, I will inspect this component and see whether it is in good condition. So here it involves an administrative and a technical aspect to be done that is at the end of four months I need to do it. So it needs to be -- if it is not done, the further operation clearance should not be given. So this is done on all structures, systems and components so that at any stage, if there is a tendency to fail, we know that is going to fail. Then this can include also repair, any servicing. So all these things need to be scheduled, so scheduled in the Quality Assurance plan for maintenance.

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- While there are various conceptual approaches to maintenance, the relevant activities may be divided into preventive and corrective maintenance. A considerable part of all maintenance activity is performed while the plant is shut down; however, maintenance may be planned and executed under power operation provided that adequate defence in depth is maintained. Preventive maintenance should include periodic, predictive and planned maintenance activities performed prior to failure of an SSC so as to maintain its service life by controlling degradation or preventing its failure.

So that is a preventive maintenance and when we do repair, a fault has happened, we call as a corrective maintenance. So as I mentioned, we need to draw the schedule, what is the period of inspection? What is the period of maintenance? Everything needs to be planned well in advance.

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Surveillance

- The objectives of the surveillance programme are: to maintain and improve equipment availability, to confirm compliance with operational limits and conditions, and to detect and correct any abnormal condition before it can give rise to significant consequences for safety. The abnormal conditions which are of relevance to the surveillance programme include not only deficiencies in SSCs and software performance, procedural errors and human errors, but also trends within the accepted limits, an analysis of which may indicate that the plant is deviating from the design intent. The operating organizations establish a surveillance programme to verify that the SSCs important to safety are ready to operate at all times and are able to perform their safety functions as intended in the design.

Then surveillance. What is surveillance? Surveillance means, you know, we talk about, you know, somebody, you know, surveillance has been kept over this person and that person. That means we observe the movement of the person and here in a nuclear power plant, we look at the equipment to see whether it is operating as per our requirements, whether it is operating as per the operating conditions, which we have said, and we should be able to -- when you do this, you can detect any abnormal condition.

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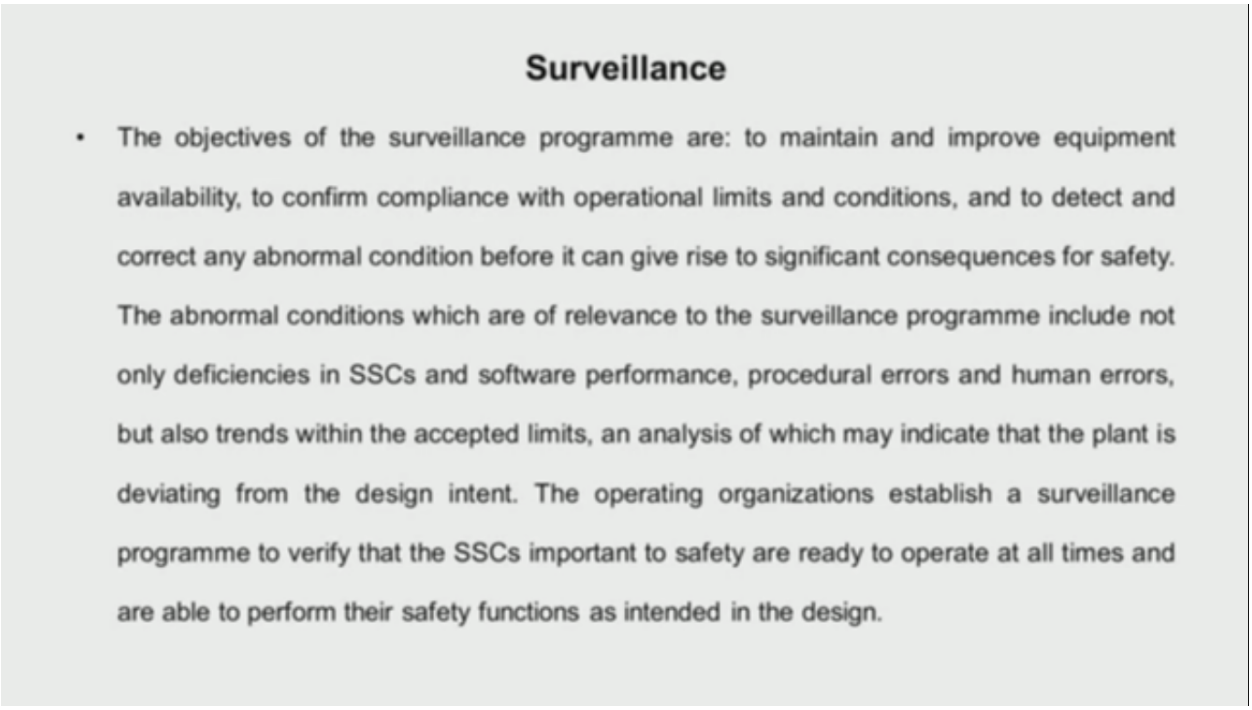

Let us say an equipment was operating and there was a small bearing failure or bearing, you know, loss of cooling. What will happen? When you -- when you are very close to the equipment, you may hear different noise, screeching noise. Oh, now I know that the bearing is going to be a problem. I take a -- immediately, I stop the motor and do what I should do. So here this is called you can call it as a walkthrough. Surveillance could be a walkthrough, and we should put in our program, what sort of abnormal conditions which we expect and we should also put down what sort of acceptable limits?

Suppose let us say there is a noise. Maybe normal noise was about 20 or 25 dB. It has increased to 30 dB. Should I act or should I worry only when it should be 40 DB or 40 decibels? So these are the things. So, basically, the operating organization will establish a surveillance program so that all the system's components are which are basically most important is safety are operational at all times.

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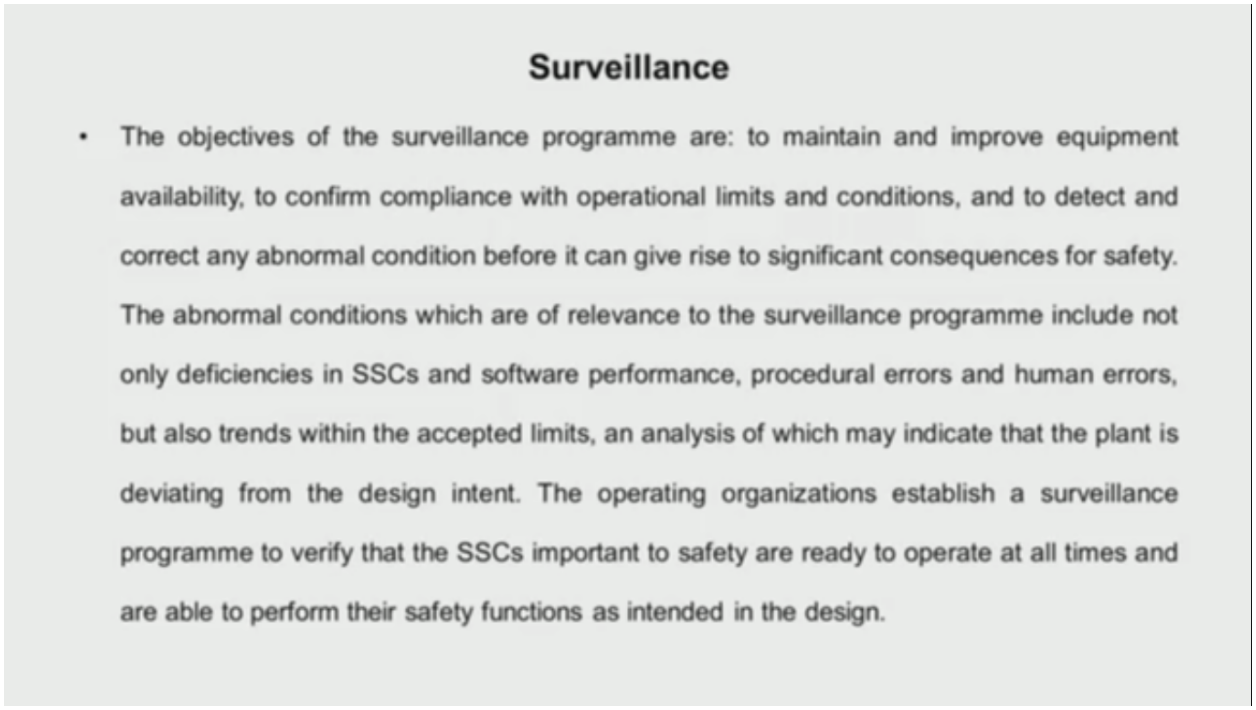

You might many times wonder sometimes people just walking through the plant just looking at things and going. You might be wondering they're roaming. It is not. They are doing surveillance. Sometimes the surveillance is done to see whether the operator is at the seat, at his position. Operator should not be moving away from his position for a very long time. The purpose of an operator is to attend to the function. So this is also one part of the surveillance, and we need to see that slightest changes which are there, we immediately react to the situation.

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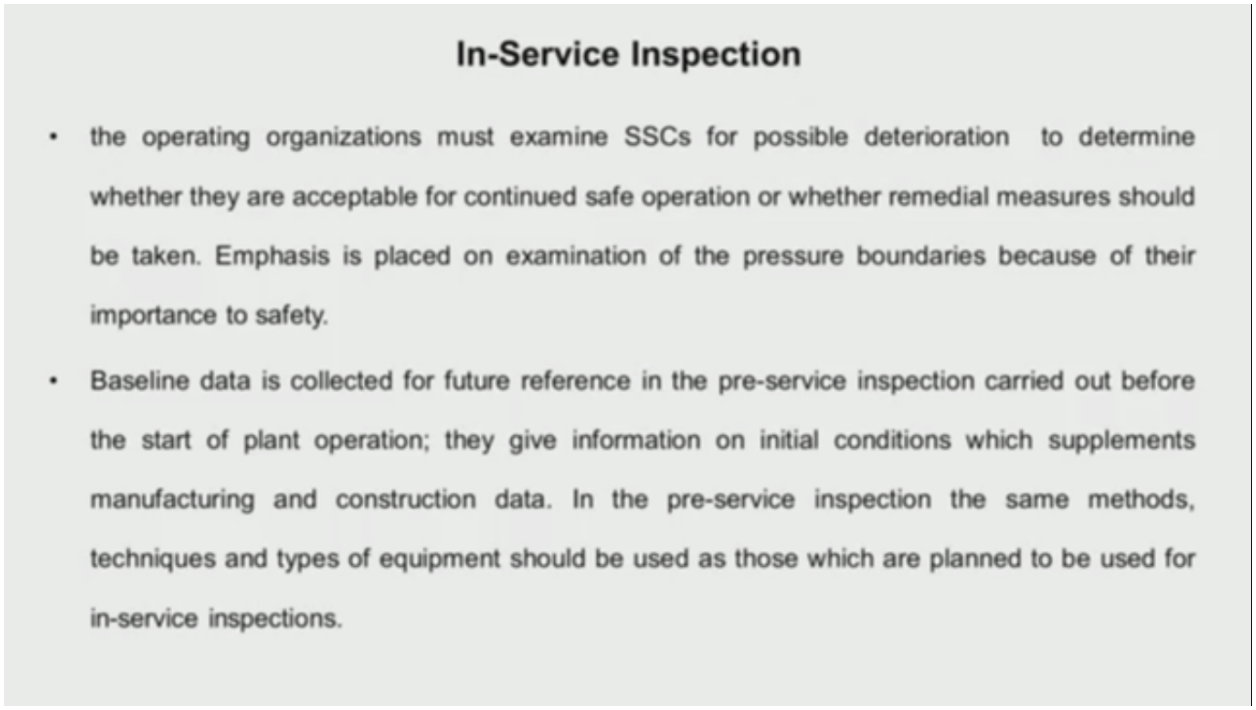

Then we come to the in-service inspection. Now as I mentioned earlier, inspecting the components in service is quite tough, difficult. So we need to define which components are very essential for continued and safe operation and in the fabrication of that component, this point has to be kept in mind that this needs to be inspected. So he has to make provisions in the design such that it can be inspected.

For example, we have tube to tube sheet welding for many steam generators. Basically, I am talking with reference to the fast reactor, sodium-cooled fast reactors, and the experience has shown that the leaks in the steam generator have mostly taken place at the welds, tube to tube sheet welds. Then when we looked at the tube to tube sheet welds we found it is not inspectable 100%. So designs developed by which the tube to tube sheet welding could be -- was made in such a way that it could be inspected 100%. So this way in the design itself you foresee that it requires in-service inspection. So I must design such that it is inspectable and again, as I mentioned, the emphasis is placed on inspecting the pressure boundaries because that is where our loss of coolant can happen.

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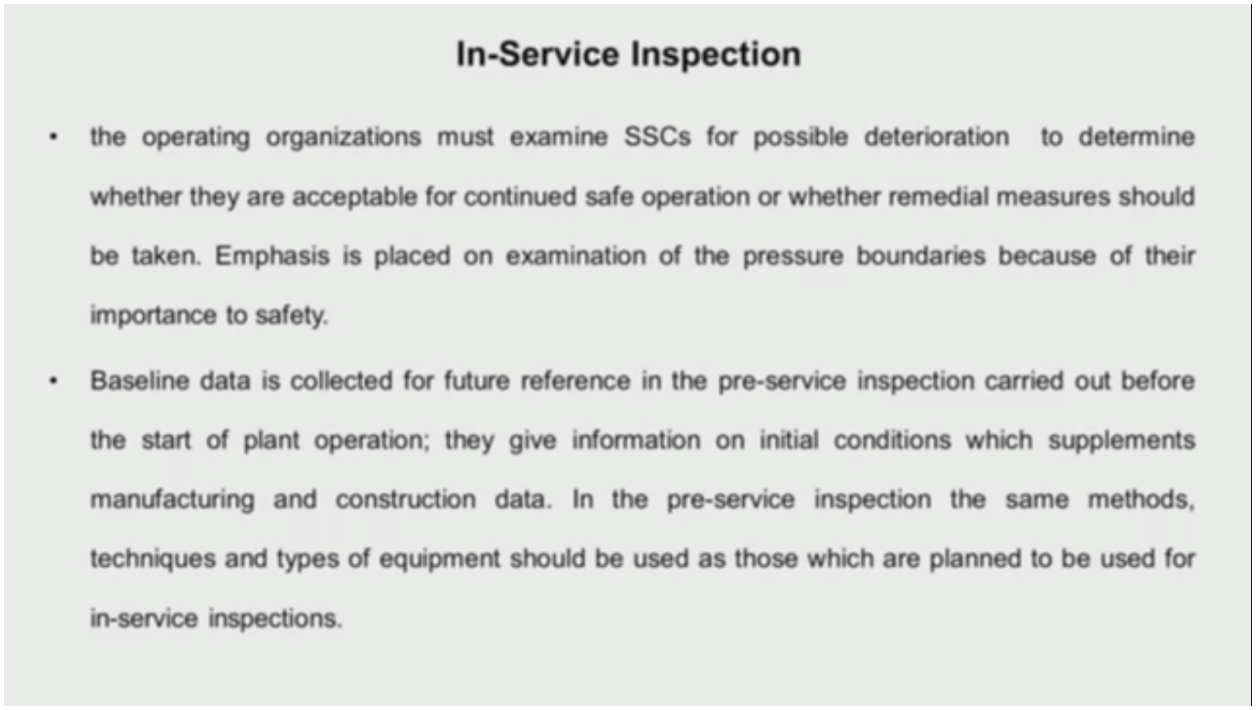

So when you say something has gone wrong, you require a baseline data. So baseline data before operations started, so we have the baseline data when it was fabricated. Then we have a next set of data when it has been commissioned, and then further during operation and if you see the change in that pattern, you immediately change a signature as they call. You look at it.

Now, again, I can give you another example. In one of the reactors, there was a component which was vibrating inside, but there are no vibration monitors, which can be kept inside the plant, but they had inspection, ultrasonic inspection of the primary vessel. So, and this was being done when the reactor was in service because it is outside the vessel, and that ultrasonic probe picked up some noise level and this noise level picked up, they found that this is not anything to do with the vessel because the resonance frequency of the -- frequency of the noise didn't match with the -- that natural frequency of the vessel. Then slowly when they studied further, they found it was due to a baffle movement inside. They shut down the plant and it was. So here, again, you see how an inspection, in-service inspection or a surveillance can help you.

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In-Service Inspection

- the operating organizations must examine SSCs for possible deterioration to determine whether they are acceptable for continued safe operation or whether remedial measures should be taken. Emphasis is placed on examination of the pressure boundaries because of their importance to safety.
- Baseline data is collected for future reference in the pre-service inspection carried out before the start of plant operation; they give information on initial conditions which supplements manufacturing and construction data. In the pre-service inspection the same methods, techniques and types of equipment should be used as those which are planned to be used for in-service inspections.

But mind you the same equipment which you used for inspecting earlier should be used later. You should not because again, the calibration, everything would change. So this is a very important aspect to be kept in mind.

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MS&I should include

- the generation of adequate written work procedures;
- the use of work order authorizations; the use of work permits in connection with equipment isolation; radiation protection of personnel; control of the plant configuration; calibration of tools and equipment; industrial safety controls; fire hazard controls; general risk assessment;
- the use of interlocks and keys; training and qualification of personnel; control of materials, products and spare parts; a control plan and programme for lubrication; housekeeping and cleanness; nomenclature, location and labeling of equipment;
- a preventive maintenance programme; generation and collection of records; retention of records;

Then all this maintenance, surveillance and inspection should include all generation of adequate records, procedures. Then work authorizations. This you must have seen whenever you go to a power plant, you will see some tag on some of the switches or some of the valves with some notings. Basically, it is an authorization given based on a work permit.

Suppose the maintenance person needs to do maintenance on a certain equipment, he just cannot go and start doing something. The plant might be in operation or it might not be right to go and work on that equipment now. Maybe there is a high level of radioactivity in that area. So he has to get a permit from the operation crew to say, "Hey, I want to work here. Can I work? When will you allow me to work?" All these things has to be there.

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MS&I should include

- the generation of adequate written work procedures;
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- the use of interlocks and keys; training and qualification of personnel; control of materials, products and spare parts; a control plan and programme for lubrication; housekeeping and cleanness; nomenclature, location and labeling of equipment;
- a preventive maintenance programme; generation and collection of records; retention of records;

And if he is going to work in an area where there is radiation, one has to see that there is an adequate protection which is equipments being taken by the people who are going to do the maintenance. Again, calibration of whatever tools and equipment they take, you should not forget industrial safety. Nuclear safety doesn't mean you don't follow industrial safety. Nuclear safety is in addition to industrial safety. Then like fire hazards or any other general risks you can take.

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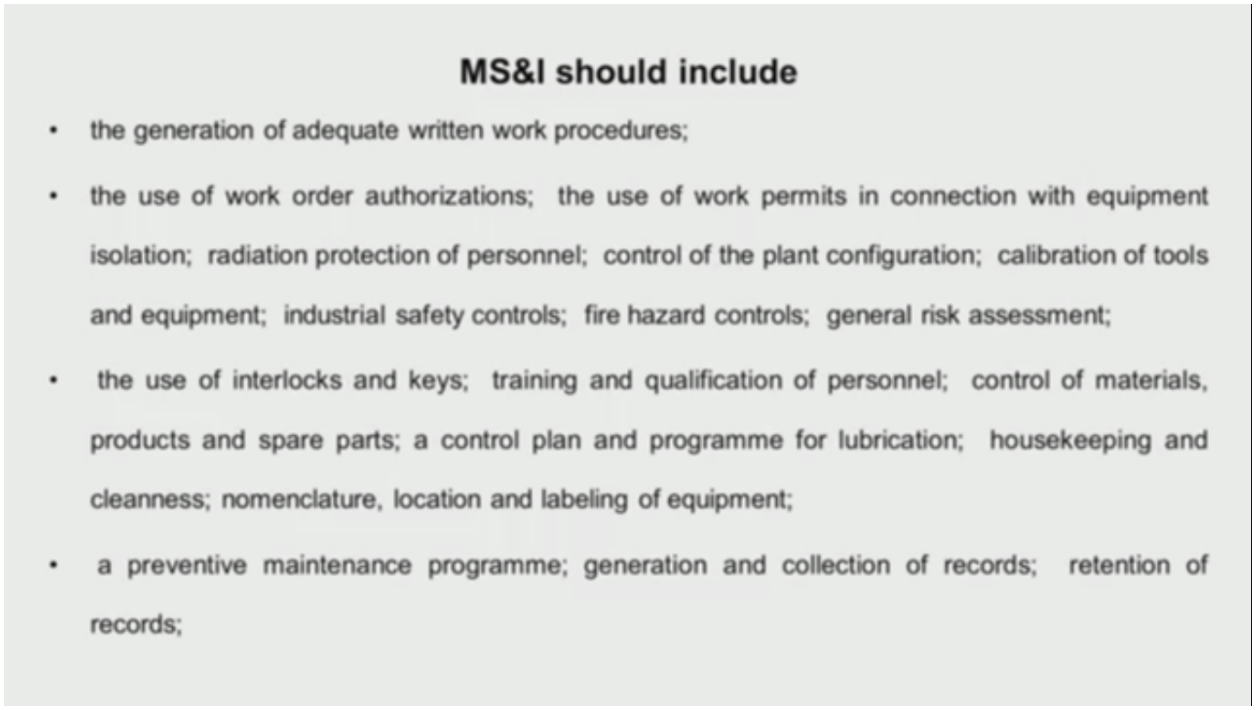

Then use of interlocks and keys. Many times we need to have an administrative look into before we start a particular operation. For example, I want to start up the reactor. Now when I have to start up the reactor, many systems need to be available, but whether all the systems are available, that will be individual crews, you know, decision, okay, to say that okay this is available. I have tested and then maybe he gives a signal to the control room saying that this is over. Like that all systems come.

So when all these systems had come, then the reactor superintendent decides, "Oh, everything is correct. Now I can start it." Then he will give put his key and give startup authorization. So this is again a, what we call, a part of the quality assurance so that it doesn't happen that just like that your plant can -- person -- any person can start. So these are all called for administrative control this gives. If it is automatic, there is no need for this.

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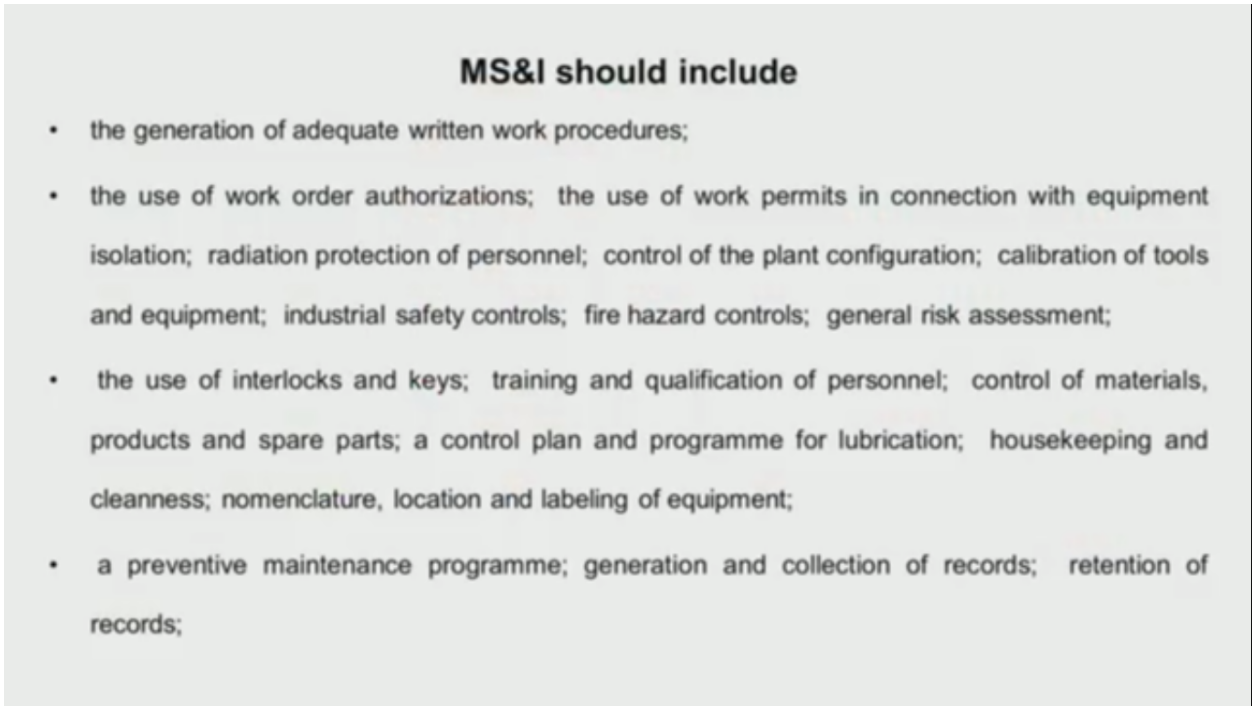

Then training and qualification of personnel is a very, very important aspect of quality assurance. We have to decide what sort of a training I should give? What sort of a training I should give to an operator? What sort of a training I need to give to your tradesman? What sort of a training I need to give a diploma holder? What sort of a training I need to give a person who is going to work in the radiation area? So all these are put down and the trainings are vetted. The person goes to the training. He goes through exams. He goes through checklists before he is authorized to operate.

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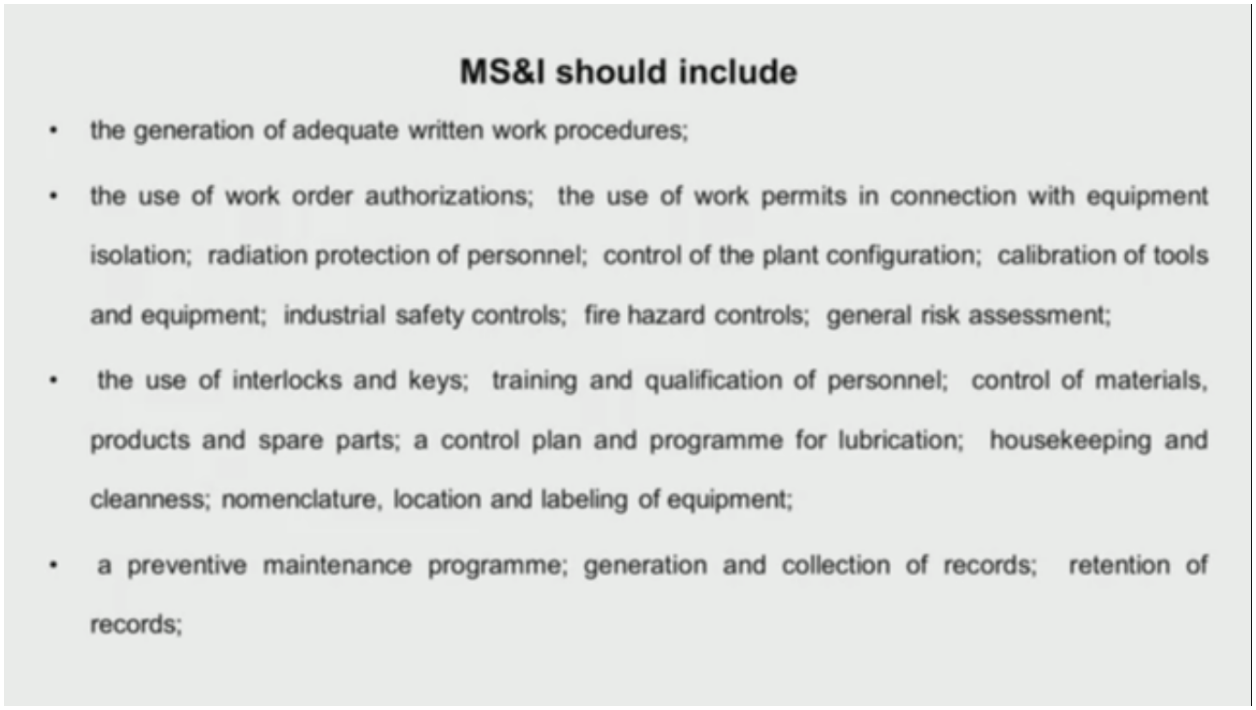

Then the control of materials and spare parts is very important. There is need to maintain a certain amount of spares. Then housekeeping is very important. We talk about Swachh Bharat. We should be everywhere it should have a clean condition. In fact, you might be -- I tell -- I see people telling hey, nuclear clean condition, nuclear clean condition means absolute cleanliness to the maximum possible. Then preventive maintenance programs, then generation of records.

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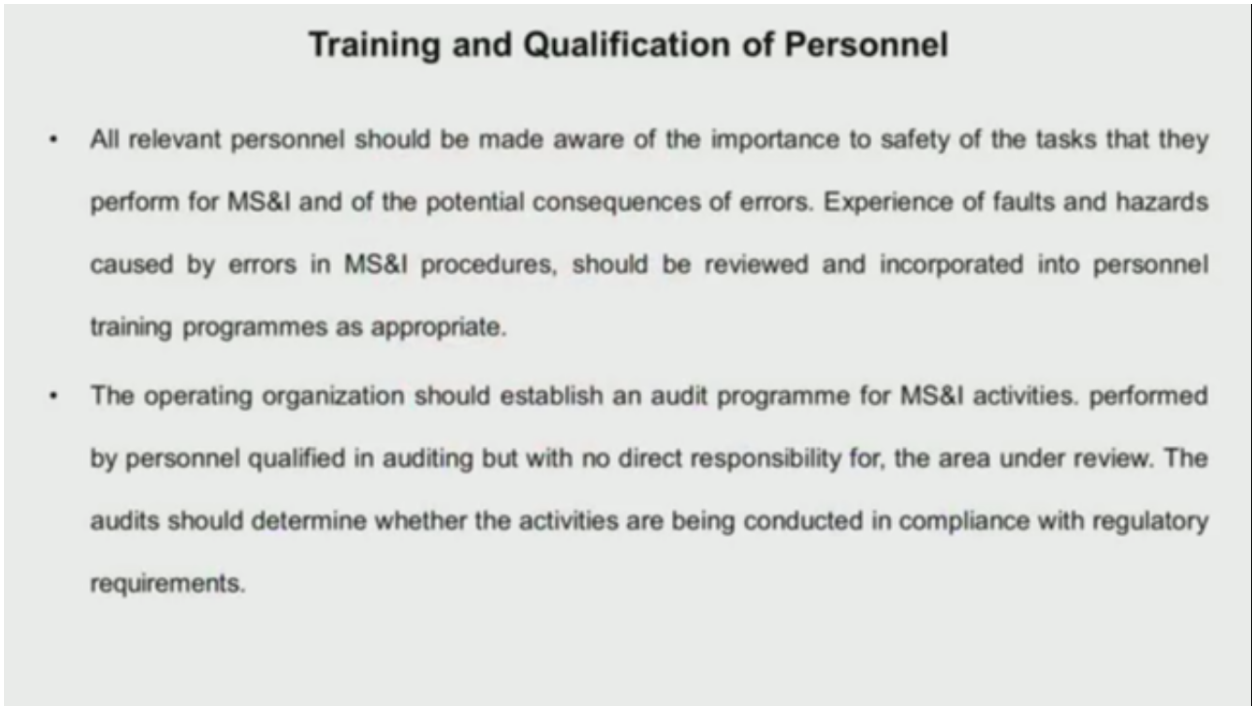

So this is what I said about the training of qualification personnel is very important and they need to be reviewed at every stage based on the feedback from the operating organization and the auditing of this should be done by the regulatory agencies so that to see. In fact, many times when the licenses are given to the operating personnel, the regulatory people need to be involved.

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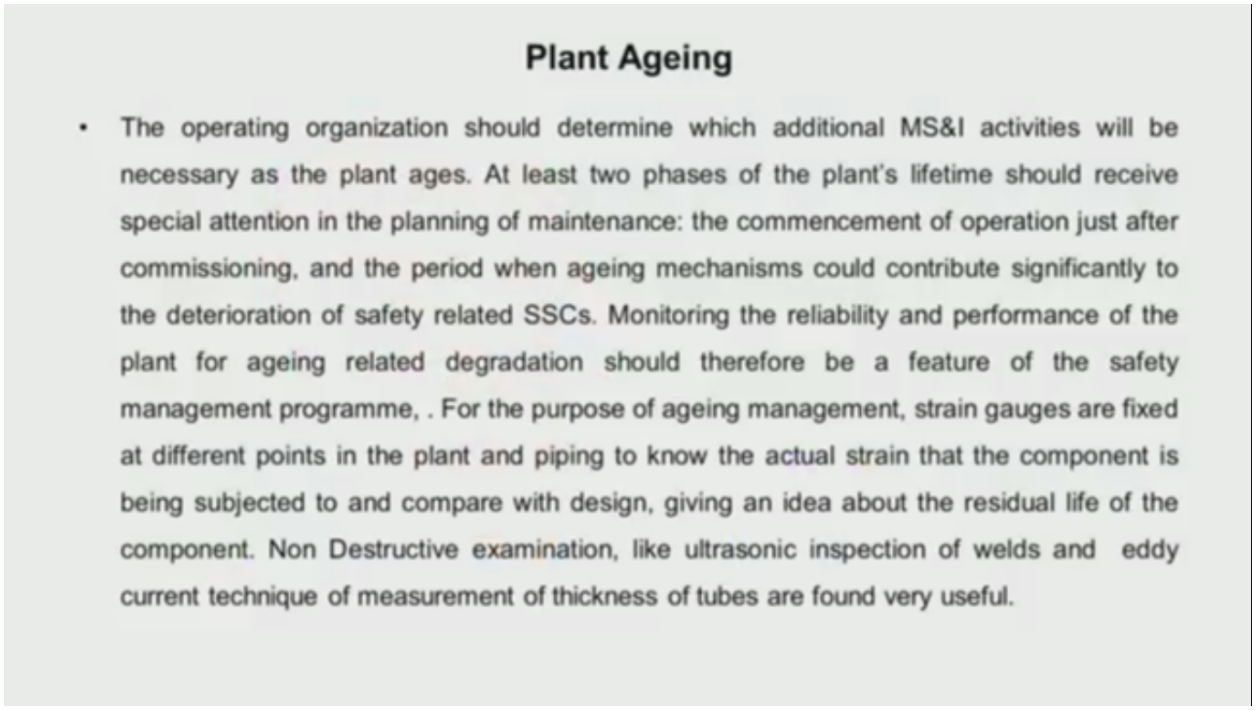

Now plant ageing, for example, I say I have put up a plant for design life of 20 years. Now 20 years is going to be over. I need to know whether I can extend the life of the plant. So this requires special attention. We need to be aware what sort of mechanisms are important which can cause material corrosion. It should be important or what is important?

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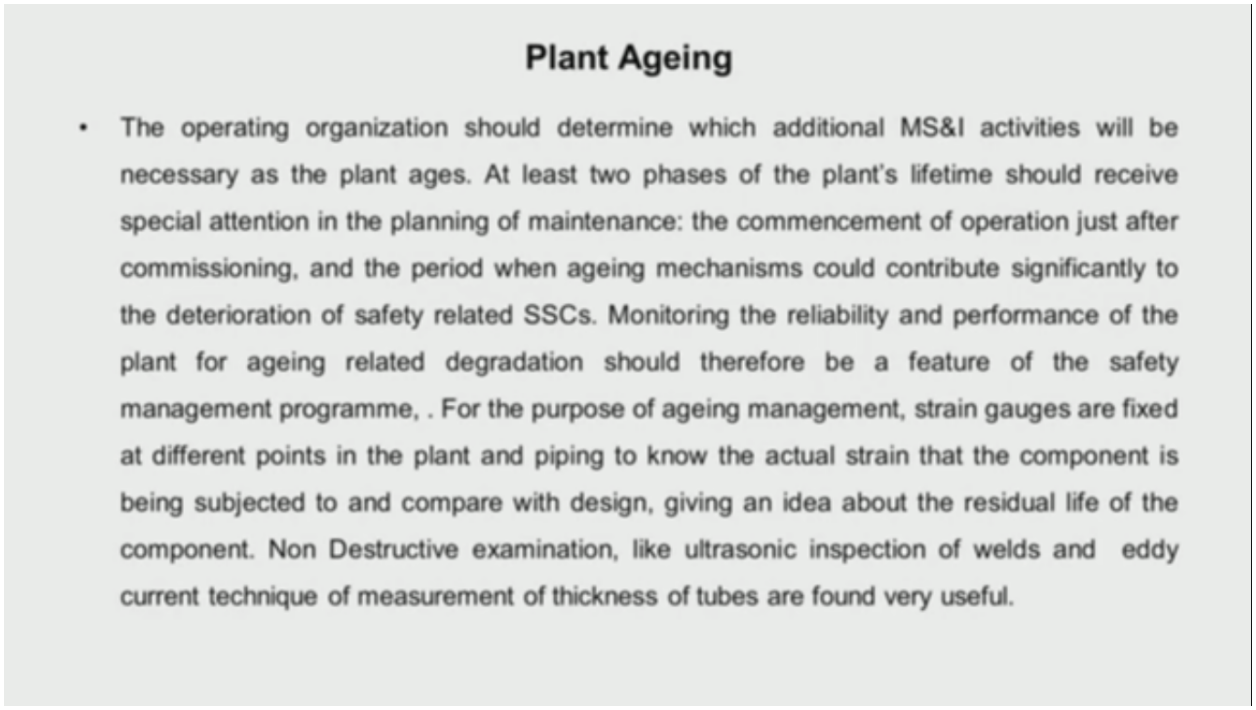

So we have to monitor the plant specifically for whether any degradation has taken place, whether the pipe thickness has come down, how much it has come down, whether the residual thickness is okay for continued operation? If so, how much? So besides the thickness etc., we also do strain gauge measurements in normally pipings in different parts of the plant to know what is the strain that the component is seeing and whether it is within the limits.

Surely, we use a lot of non-destructive examinations under this stage like ultrasonic inspection, eddy current inspection so that we get to know the true state of the equipment at the end of its operation and this data we give to the regulatory authorities before getting clearance for further operation.

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Quality System Survey

- A quality system survey takes place with relation to a prospective procurement of a service or an item. Generally they are conducted prior to contract award and are used to evaluate the overall capability of a prospective supplier/contractor including the adequacy and implementation of his quality assurance program.

Now as I mentioned initially, when we are going to procure any component or service, we do a quality survey of all the agencies and then only we award the contract. So this is called as a quality system survey.

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QUALITY AUDIT

- There are several groupings or classifications of audits depending on the relationships, external and internal, need for independence, and reason for the audit, verification of product, process, or system. as first-party, second-party, and third-party audits. First-party audits take place within the organization that is same as internal audit . Third-party audits are totally independent of the customer-supplier relationship . Third-party audits may result in independent certification of a product, process, or system.

Then audit, quality audit. Now within the vendor, he may have an internal inspection so that is the first stage in which he, his own people do the job and his own -- some another set of his own people may do the auditing to see whether everything is in line with the requirements. Then if suppose it is a very important equipment, we go for a second party to audit from outside organizations or it could be the customer himself the second party. Third, totally, neither the customer, neither supplier. It could be a third party inspection and this is decided based on the importance of safety of the components.

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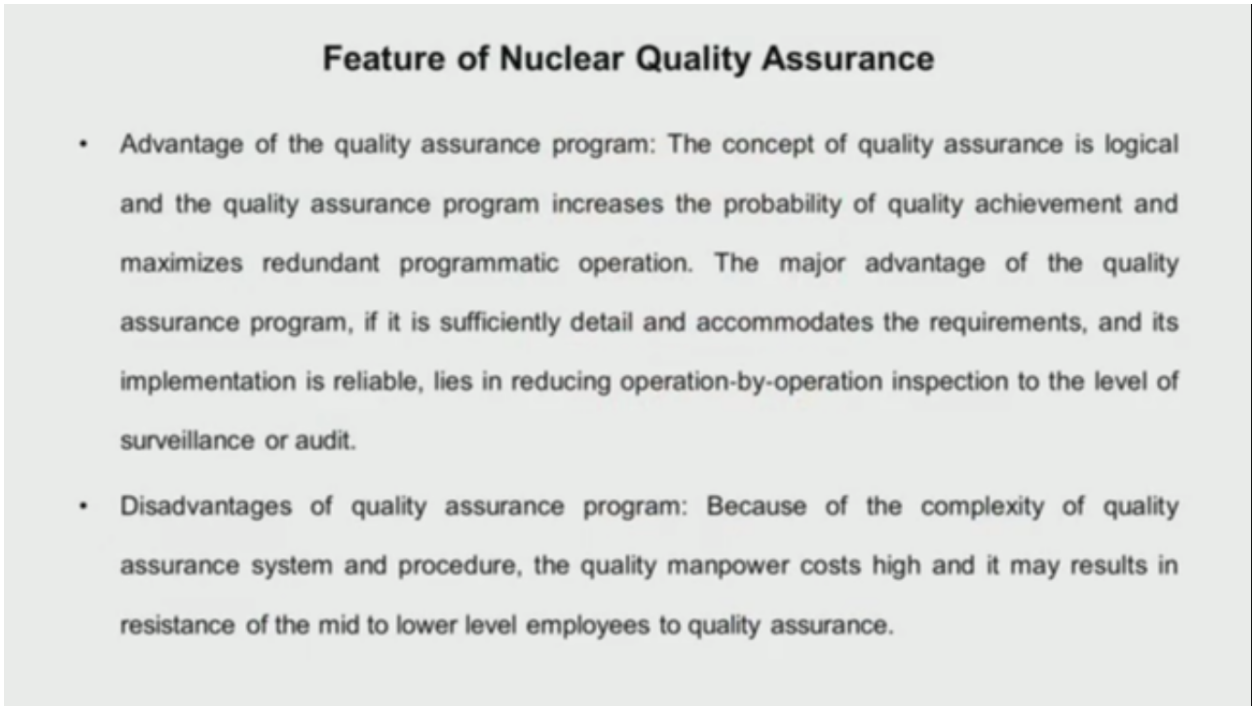

If you look what all I have told you, there are lot of advantages of quality assurance program that you are assured a very good what you call implementation of what is happening and it is you get a reliable component, reliable -- you're assured that plant is safe, but disadvantage it is complex. It is quality manpower would be very costly, and it may many times results in resistance, but then we have got to do that.

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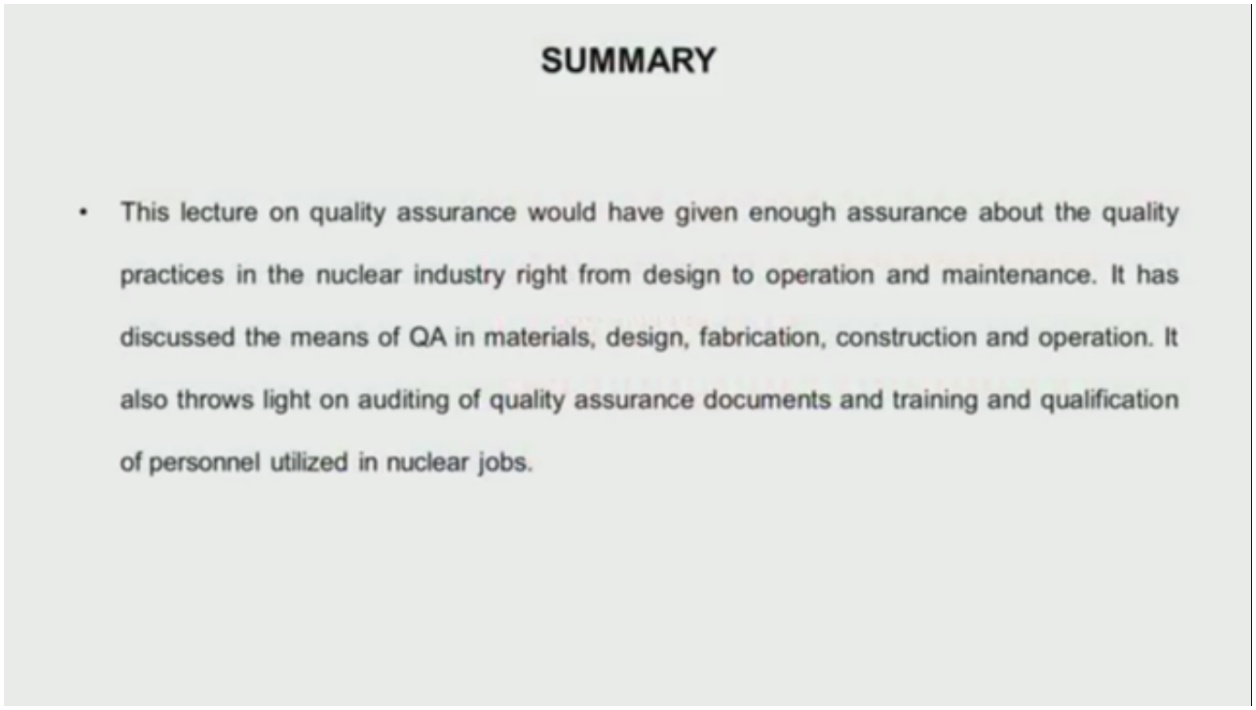

In summary, this lecture has given enough assurance about the quality practices in all facets of the design, construction, operation, maintenance, surveillance and inspection of a nuclear power plant. Thank you.

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BIBLIOGRAPHY

- 1. IAEA (1988) Code on the safety of nuclear power plants: quality assurance. IAEA Safety Series N.50-C-QA (Rev.I), International Atomic Energy Agency, Vienna.
- 2. IAEA (1979) 'Safety functions and component classification for BWR, PWR and PTR', Safety Guide N. 50-SG-DI, Vienna.
- 3. RULES FOR INSERVICE INSPECTION OF NUCLEAR POWER PLANT COMPONENTS, ASME Boiler and Pressure Vessel Committee on Nuclear Inservice Inspection, Section XI (2010).
- 4. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 50-C/SG-Q 'Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations-Code and Safety Guides Q1-Q14', Vienna (1996)
- 5. ATOMIC ENERGY REGULATORY BOARD, 'Code of Practice on Quality Assurance for Safety in Nuclear Power Plants', AERB Code No. SC/QA, Mumbai, India (1988)

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ASSIGNMENTS

- What are the requirements of a good quality assurance plan for NPP? What is the basis to classify the plant components into different classes? Give examples.
- What are the QA issues to be addressed for a NPP? Explain the same with reference to choice of materials, design and fabrication.
- What are the components of QA in maintenance?
- What do you mean by in-service inspection? Give 3 examples.
- What is the difference between quality system survey and quality system audit?

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