Chemical Process Safety
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Lecture 40
Risk Assessment

Welcome to this module related to the risk assessment steps. So in the previous module we had a discussion about the various tools available for risk assessment.

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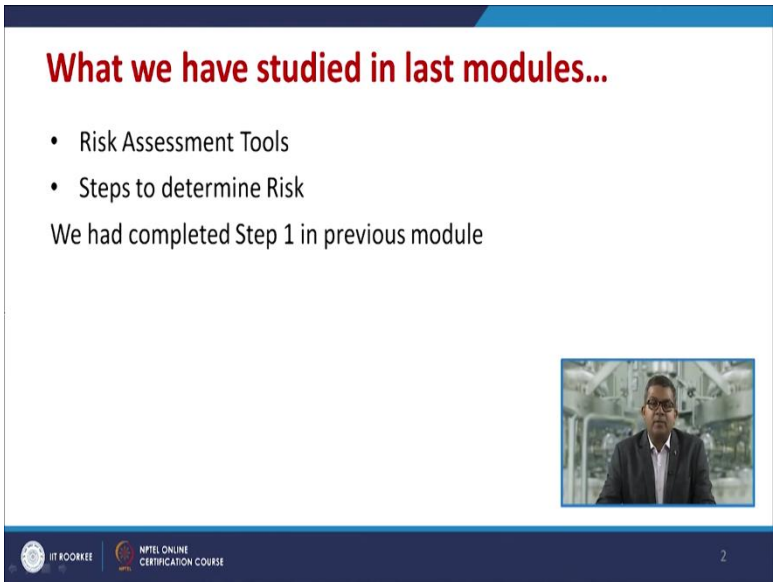

We have gone through different steps to determine the risk or analyse the risk assessment. So while discussing the various steps available for risk assessment or risk management tool we had completed the step number 1 in the previous module. So in this particular module we are going to discuss the other steps involved in the risk assessment or risk management.

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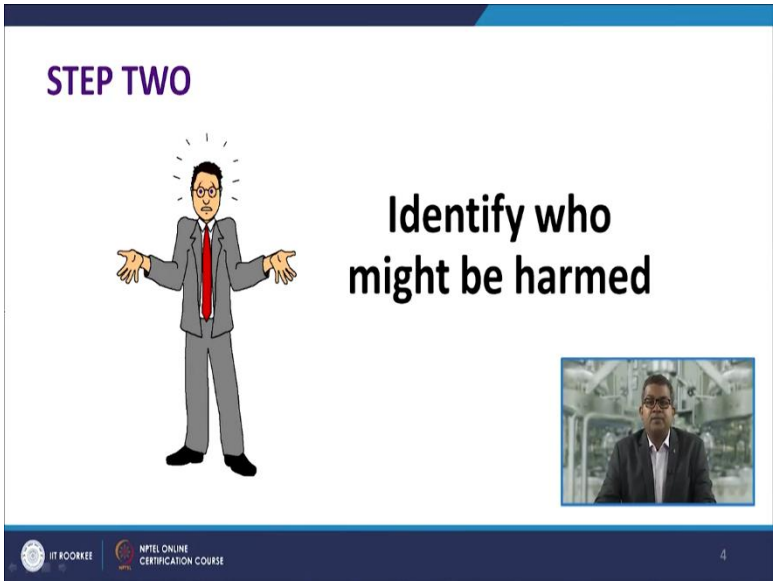

So this is again starting of this that how we have identified the hazard, now let us take the second step we need to identify who might be harmed in case of any eventuality, in case of any accident. So first thing that we must analyse the scenario and then decide who might be harmed and how, because unless and otherwise we do not have any clue that how they may get harmed then we would not be able to device the proper safety devices and we cannot analyse the risk assessment.

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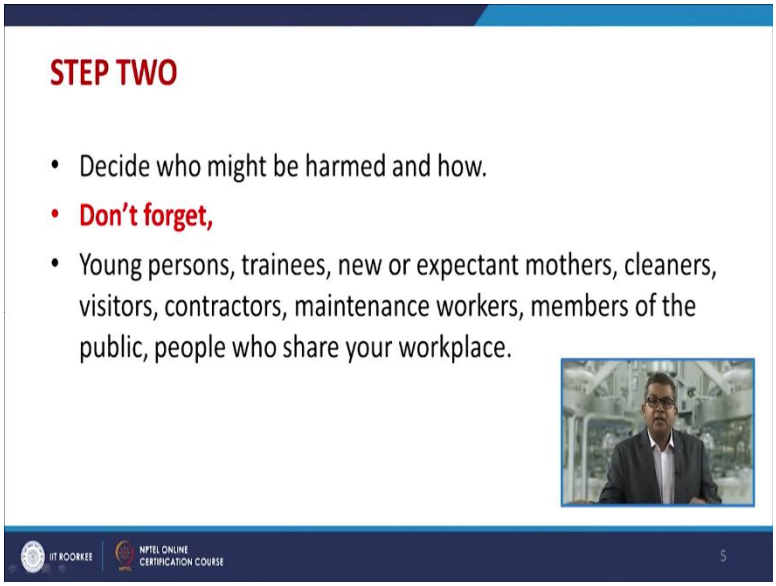

So do not forget, young persons, trainees or new expectant mothers, cleaners, sometimes the casual visitors to the plant, various contractors those who are involved within the periphery of the plant, the maintenance workers, members of the public, people who share your workplace,

they may be harmed in case of any eventuality, in case of any accidents that might occur in the plant periphery. Remember, we have not included those who are living at outside or those who are having their residences or workplace at the vicinity of the plant.

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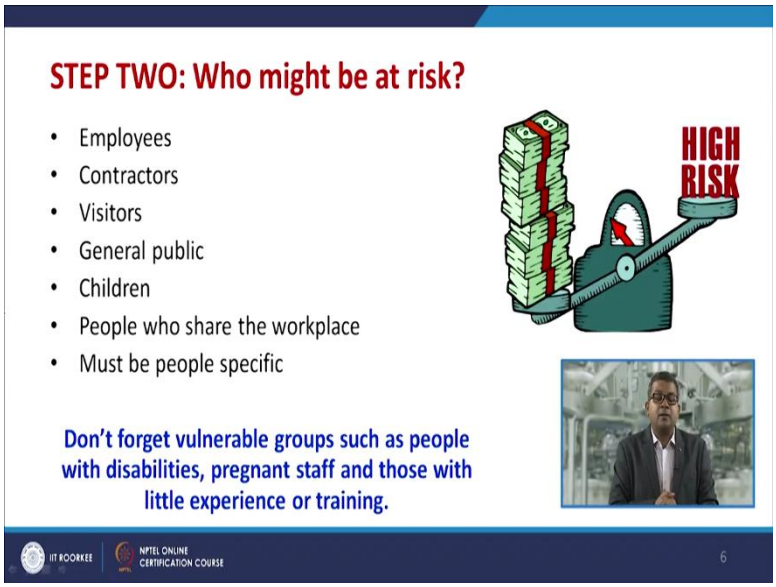

So in the broader spectrum we may enlist all those employees, visitors, contractors, general public, children, people who shared the workplace they must be people specific, or do not forget the vulnerable groups such as the people with disabilities, pregnant staff, those with the little experience or training. So you must analyse and you must enlist those who might be at the risk. Then once you analyse this aspect that those who are involved in that particular risk then you evaluate the risk that is what is the quantum of the risk.

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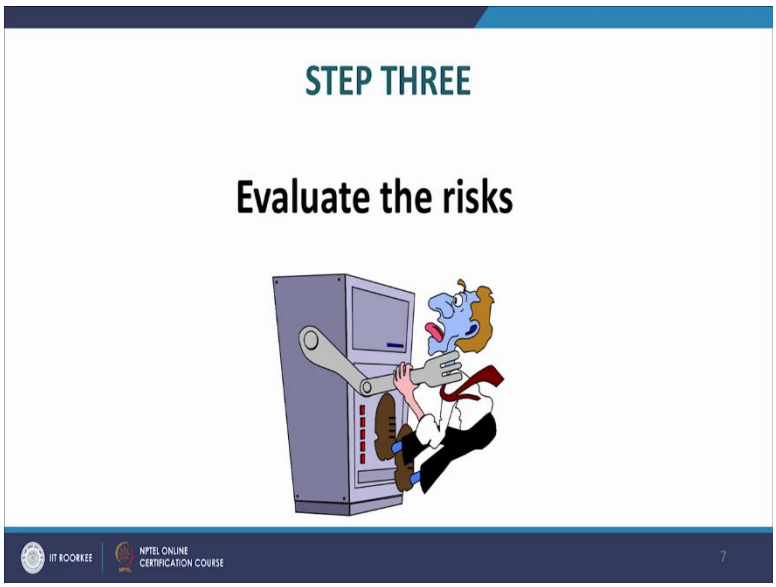

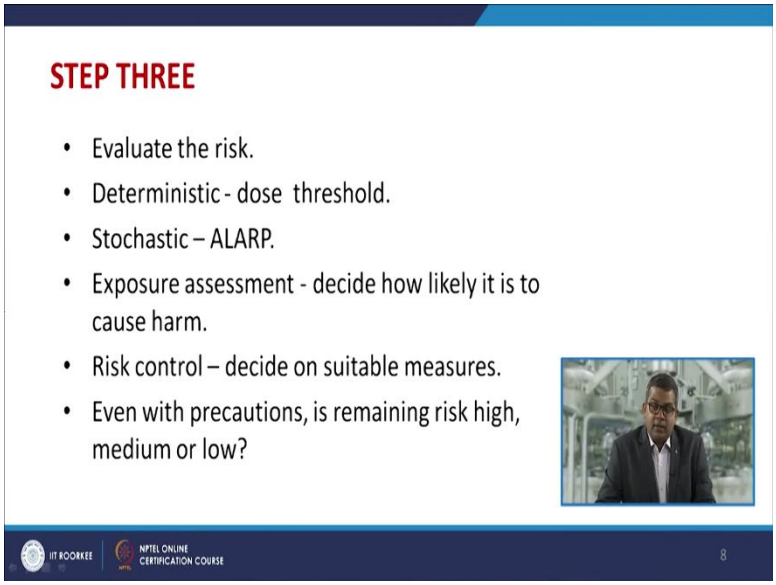

So, whenever you are evaluating the risk you determine dose threshold, etc. So while you are analysing the dose threshold then definitely you must look into other aspect of dose response, what are the different threshold limit values, etc. Then you go for ALARP, then you analyse what is the exposure assessment, decide how likely it is to cause harm, sometimes it may be at the regular frequency, may be gradual limits and sometimes within acceptable limits, etc.

Then you determine what are the different methodologies available for this control because there may be several other risk control methodologies or protocols are available within the plant then decide under suitable measures that which one you need to adopt, which one you need to apply in case of any risk. You need to follow the various precautions or even with the precaution you need to analyse is then any remaining high risk things or sometimes it may be medium or it may be low. So you must analyse all those things while evaluating the risk.

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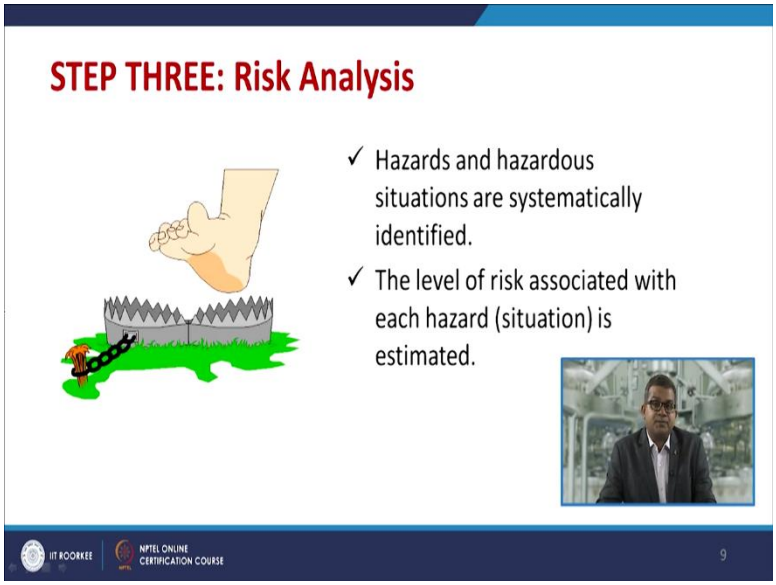

Now, based on your analysis, you just identify that what are the different hazardous and hazardous situations, they are systematically present at your workplace. That means sometimes it may happen that because a variety of reasons the temperature of a vessel may go on the higher side, it may lead to the pressure build-up. Once the pressure is built-up then it may be chance that the safety valve or the relief valve may get be actuated.

Then the substance may get released into the atmosphere or nearby people may get affected, nearby means within the plant and outside the plant. So you just analyse the systematically approach of those hazards or hazardous situations that may happen in that particular plant. Then you analyse the level of risk associated with each hazard that is the situation, you need to estimate, you need to quantify that particular risk or hazard. Reason is that on the basis of this particular hazard you can analyse or you can adopt the applicable protocol.

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Now usually you need to perform a judgement or a judgement is to be made as to whether the level of risk is acceptable or tolerable. Now remember, there is a threshold limit values or LD values, etc just to guide you whether this particular risk is acceptable or not because based on various kinds of dose, various kinds of responses, these types of limits being prescribed by various regulatory bodies which we had discussed in the previous module. So based on your evaluation we just analyse whether this is under the acceptable range or tolerable range, and if it is beyond then you need to go ahead with the proper protocols.

Now, this includes judgement on corrective or preventive measures because whether if they are acceptable then definitely you need to take preventive measure or corrective measures so that they cannot expose to or they cannot go beyond the tolerable limit, so a prior estimation or prior corrective measures or prior preventive measures are always advisable for these kinds of approaches.

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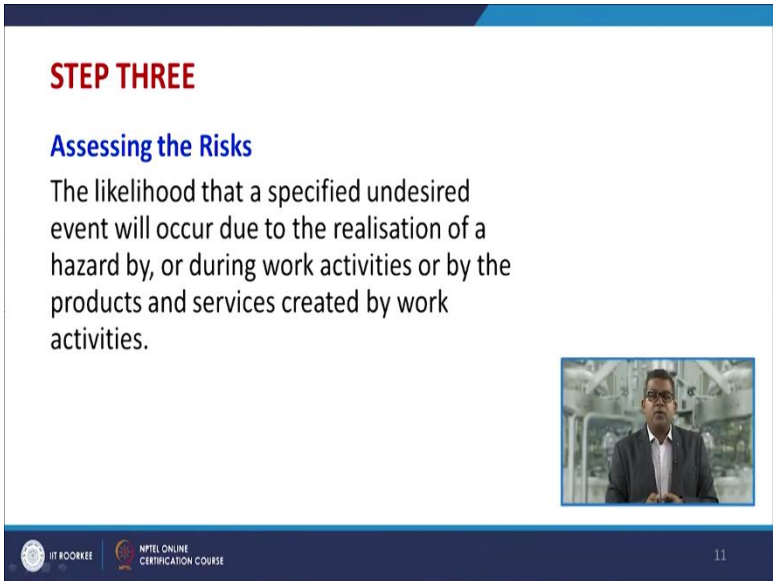

The likelihood that a specified undesired event will occur due to the realisation of a hazard by or during work activities or buy the products or services created by the work activities, this is the accessing of the risk.

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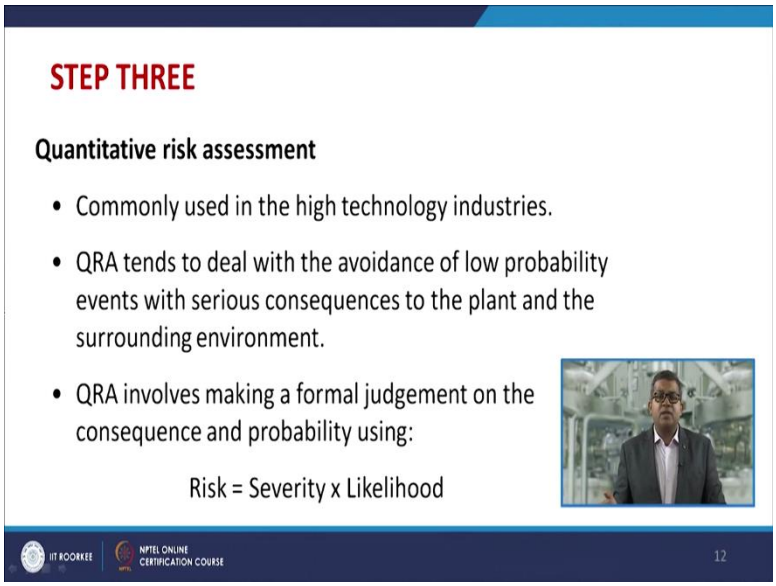

Now, let us have look about quantitative risk assessment. These are commonly used in the high-technology industries. Now, this quantitative risk assessment tends to deal with the avoidance of low probability events with the serious consequences to the plant and the surrounding environment, so that is why they are very important. Now this involves making formal judgement on the consequences and the probability using the formula, risk is equal to severity into likelihood, likelihood deals with the probability.

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So this in simple computation gives a risk value between 1 and 9 and enabling a rough and ready comparison of the risk. So the lower the number the greater the risk, and also that prioritises the hazards so that the control action can be targeted at higher risk. It is just like that you are having an H_2SO_4 concentrated H_2SO_4, it might spill or may not so what is the severity then you need to analyse and if this is within your range then you need to adopt a control action.

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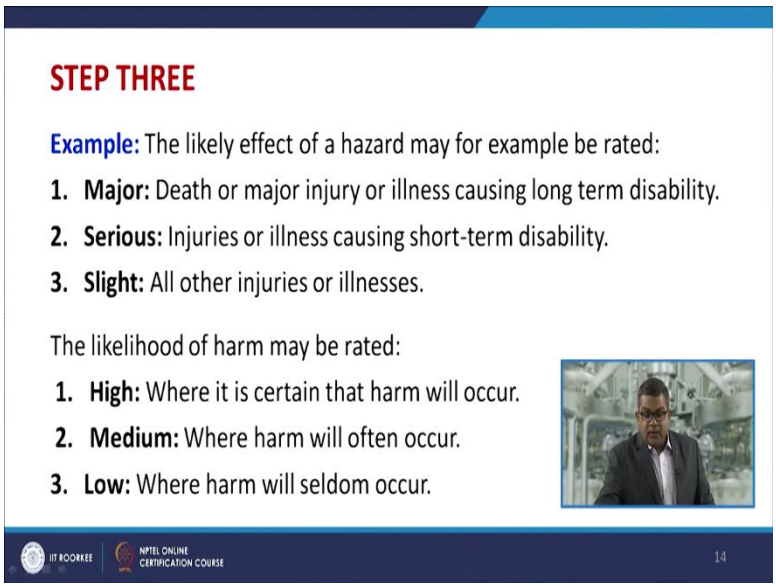

Another example is that the likely effect of hazard may for example for rated like major dead or major injury or illness causing long-term disability, maybe serious injuries or illness causing short-term disability. There may be slight aspects like all other injuries or illnesses, remember

every injury or every illness or every fatality must be recorded and they may be liable for the compensation.

Now the likelihood of harm may be rated as high that is when it is certain that harm will occur like spillage of H_2SO_4, leak of LPG, etc. Then the medium, where the harm will often occur, and the low where the harm will seldom occur. So sometimes the situation may happen where you cannot avoid the release of any kind of toxic or any kind of vapour. Then you may term if it is within the acceptable limits then you may term under the head of medium or a low one.

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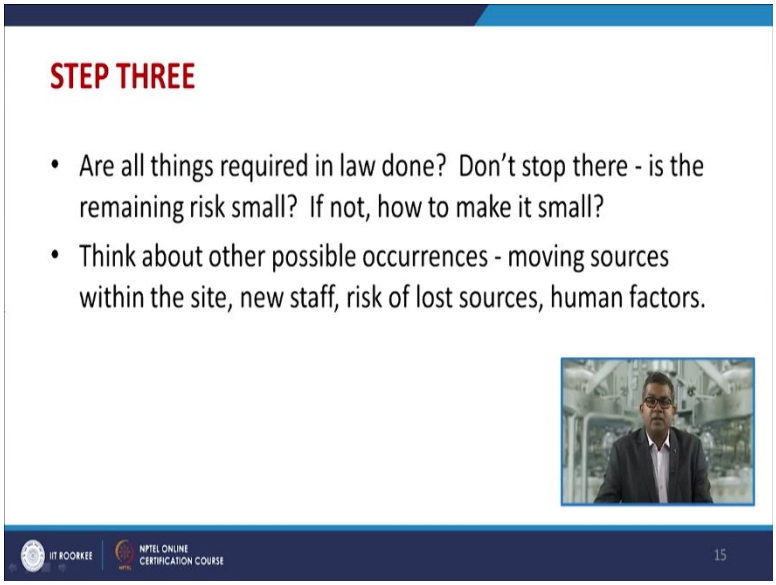

Now, all things required in a law done that is a big question, do not stop there-is the remaining risk small? If not, then how to make it small? These kinds of questions must be asked by you. Now think about other possible occurrences; moving sources within the site, new staff those who may not be technically competent, risk of other lost sources sometimes you may have certain other things those who are lost during the course of use, and all of a sudden that may create a problem. Certain human factors because several accidents in past they took happen just because of the human negligence, so you can factor may also play a vital role.

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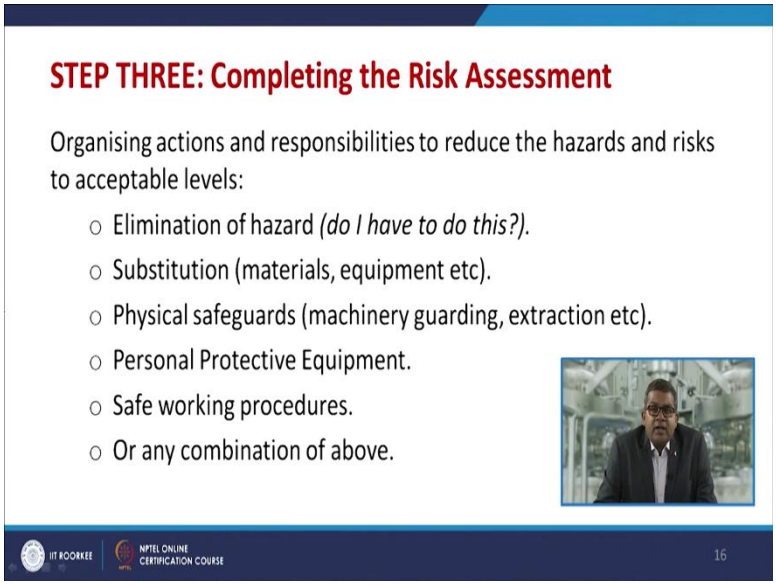

Then go for the completion of the risk assessment, so organising action and responsibilities to reduce the hazards and risks to acceptable levels, this is called the completion of the risk assessment. Now how you can achieve, by elimination of hazard, do I have to do this? This type of question must be framed and asked. Then go for the substitution like materials, equipment, etc.

You must adopt the protocols related to the physical safeguards of machinery guarding, extraction, etc. Sometimes you may experience if you go to an industry all kinds of police they are guarded by the covers, etc, these are called physical safeguards. You must go for personal protective equipment like head gears, goggles, gloves, splash suits, etc.

You must adopt and device safe working protocol, this is extremely essential, it is not necessary that you always follow ball by ball guiding factor laid down by the different regulatory agencies. Sometimes you need to develop your own safe working protocols based on your requirements. Sometimes it may be more stringent than the regulation, so the safe working procedure must be adopted. Or any combination, you may go ahead with any combination of whatever protocols listed just above.

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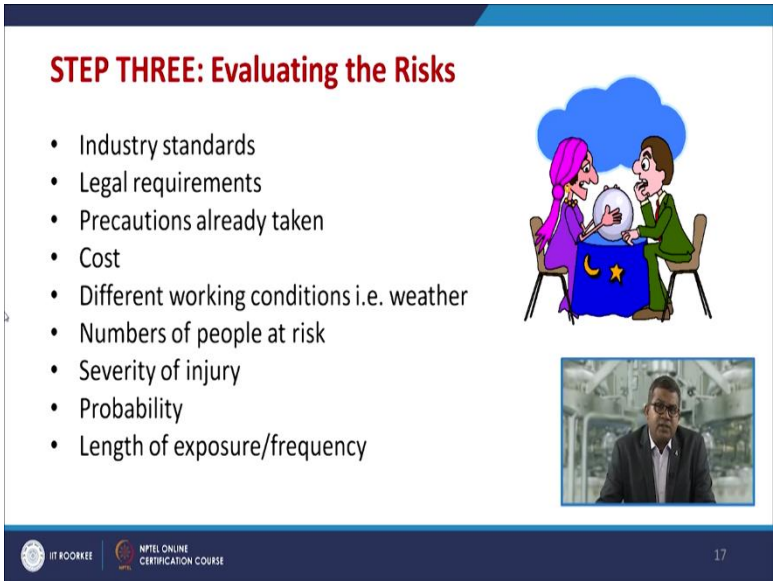

Now, based on various discussions you may evaluate the risks based on the various industry standards because similar types of industries may be there in global scenario so what is the industry standard. What are the legal requirements both global and national? You must be aware of those requirements and you must adopt those protocols within your industry. Then precautions already taken because some precautions may be inherently be taken by either employees or employer, etc.

Do not forget to go for the cost estimation because whenever you are adopting those kinds of risk protocols then definitely you are implying certain amount of money towards this. Then you must know about the different working conditions for example, the weather, weather may be critical. Sometimes in the northern belt of India you may experience the temperature atmosphere temperature ranges from 2 degrees Celsius to 47 degrees Celsius.

So do not overlook the impact of that particular weather maybe you made, maybe higher temperature, maybe fluctuating temperatures zone to either the material or the process, machinery, etc because this type of changeover may impact the storage condition of your industry, may impact the handling condition of your industry. Then you must analyse that how many people are at risk, analyse the severity of injury, go ahead with the probability calculations so that you can analyse that how much risk is there in your plant or equipment or layout plants, etc.

Then do not forget to analyse or record the length of exposure or frequency sometimes intermittent frequency. And we had a discussion about this in totality in industrial hygiene

module when we discussed about the length of exposure, sometimes intermittent frequency, sometimes the continuous aspect, so do not forget all these steps while evaluating the risk.

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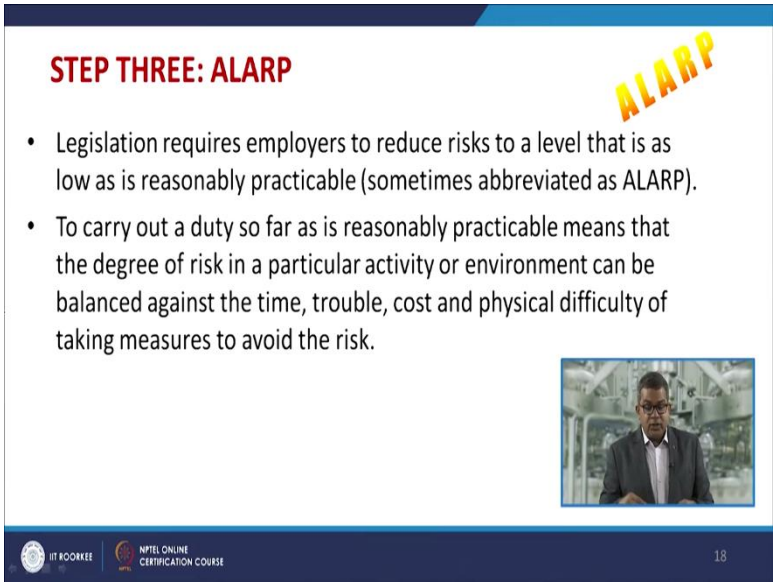

Then go for this ALARP that is the legislation required employers to reduce risk to a level that is as low as reasonably practicable, sometimes it is always referred as ALARP. To carry out a duty so far as reasonably practicable manner, that the degree of risk in a particular activity or environment can be balanced against the time. Trouble cost and physical difficulty of taking measure to avoid the risk, so you can go ahead with this ALARP.

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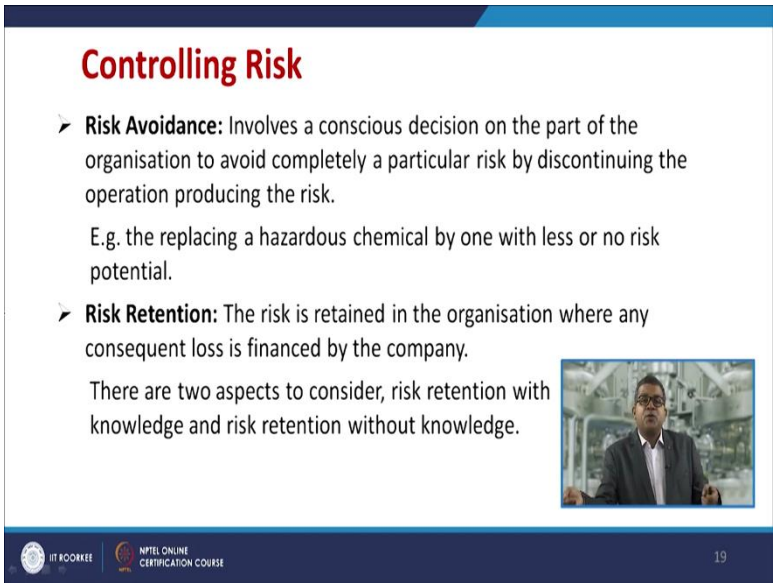

Then question arises how to control the risk, one aspect is that risk avoidance. This involves regular decision on the part of organisation to avoid completely a particular risk by discontinuing the operation producing the risk that means either you are having a substitution or you are in a position to compromise with the certain aspect. One example is that replacing the hazardous chemical by one with the less or no risk potential.

Sometimes you need to perform certain optimisation because if you are using the lesser hazardous chemicals that means sometimes you are compromising with the yield, sometimes you may compromising with the conversion, reaction kinetics, etc, so you need to optimise, you need to calculate that whether if you are having the lower yield then how much economic losses are there.

And sometimes if you are using higher hazardous chemicals with a proper protocol, proper safety protocols sometimes you may save certain quantum of money so you need to go for this optimization. Then the risk retention, now the risk is retained in the organisation where any consequent loss is financed by the company. There are 2 aspects to consider, one is the risk retention with knowledge and second is the risk retention without knowledge.

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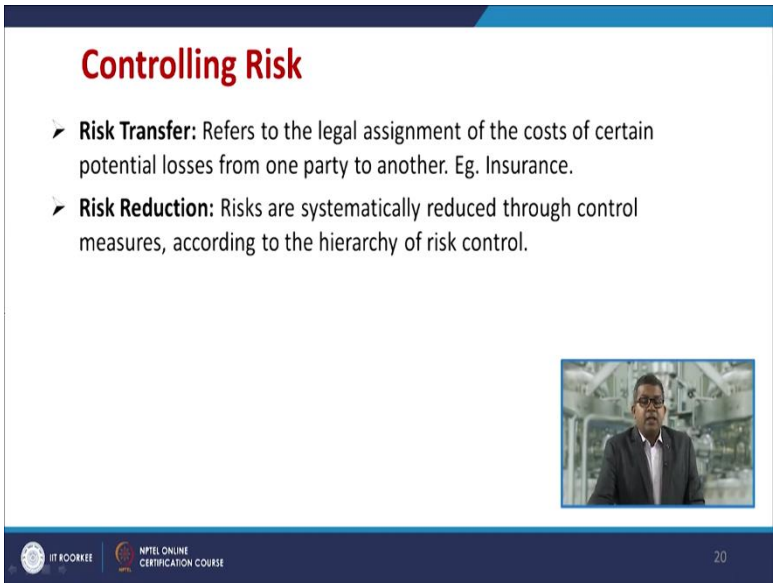

Another aspect is the risk transfer, this refers to the legal assignment of the cost of certain potential losses from one party to another that is insurance. Now remember, insurance again when you are going ahead with the insurance then again they are having certain set of rules. So if by any chance there is any violation of those roles, so sometimes the insurance company they may refuse to pay off the compensation.

So be particular about this particular risk transfer protocol. Then the risk reduction, the risk are systematically reduced through control measures according to the hierarchy of risk control. So we have gone through all the risk reduction aspects in the industrial hygiene segment, so by substitution, by other change protocols we can reduce the risk at workplace.

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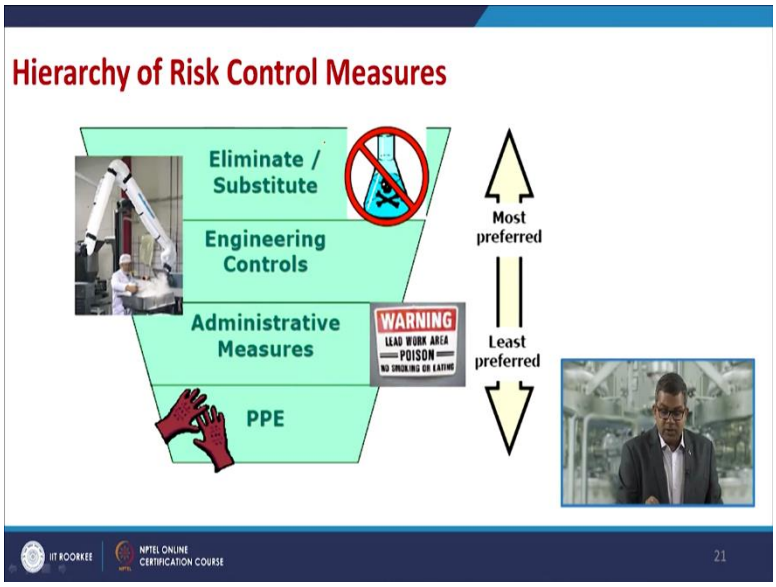

Now since we had a discussion about the hierarchy, so let us have a look at the hierarchy of risk control measures. You may eliminate or substitute the hazardous substance that is again subjected to the chemical kinetics or yield or conversion, etc. Then you may go ahead with different type of engineering controls, since these two things are supplemented then to implement all these things you must have administrative measures.

Apart from these administrative measures you must have administrative willingness to adopt all these types of protocols. You may have personal protective equipment or gears, etc. You may put various types of play card at the workplace like warning at work area sometimes fire and hazards, etc.

So, if you go to all those aspects, you may designate the hierarchy in terms of like these are the most preferred one and these are the least preferred one. The reason is that the personal protective equipment should be used as a last resort like for display of warning play card is the last resort because you are unable to eliminate, you are unable to substitute the things and you are unable to manage those things through your engineering control practices.

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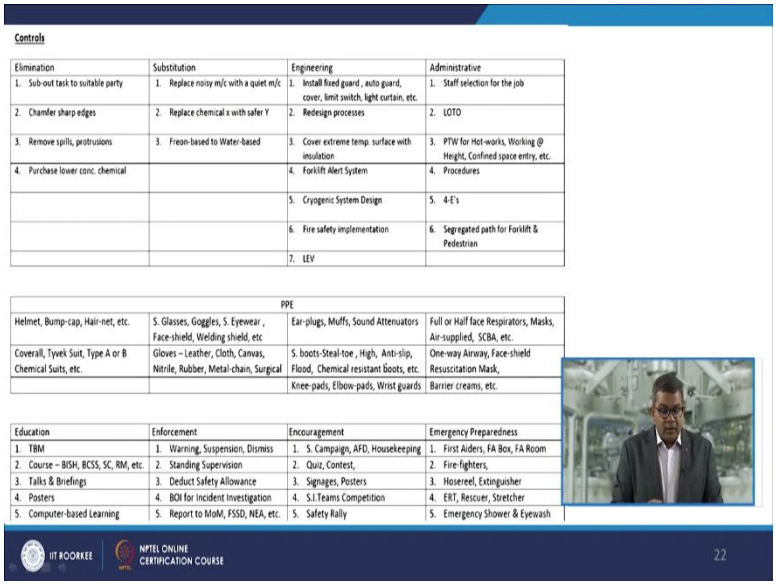

Now in this particular slide we have enlisted various kinds of control measures like elimination, substitution, engineering, administrative so a broad spectrum or abroad example we can learn from this particular table. Like sub-out task of suitable party that is the elimination then substitution, replace the noisy conditions with quite conditions, you may install a fix guard, auto guard, cover, limit switch, etc.

And administrative protocol says that you must have a proper staff selection for a job. Similarly, you can develop like in personal protective equipments like helmet, hair-net, etc. covers, splash suits, etc, glasses, goggles, etc, earplugs, muffs, sound attenuators, etc, so these are the certain personal protective equipment. Now how to use those PPEs again is a question, and those control measures and personal protective equipment they need to be properly educated. Managerial aspect, they must ensure that through enforcement that everybody should use all kind of this protocol.

Then the managerial aspect or administrative protocol suggests that they must encourage to use all kind of these things with the help of quiz, contest, different types of signage, posters, etc. Then based on the safety reviews and based on past practices how your system is prepared for emergency then you must train all those workers for this type of things like first aid box, first aid room, fire-fighting, etc so in the broad spectrum you can design, you can learn from this type of tables.

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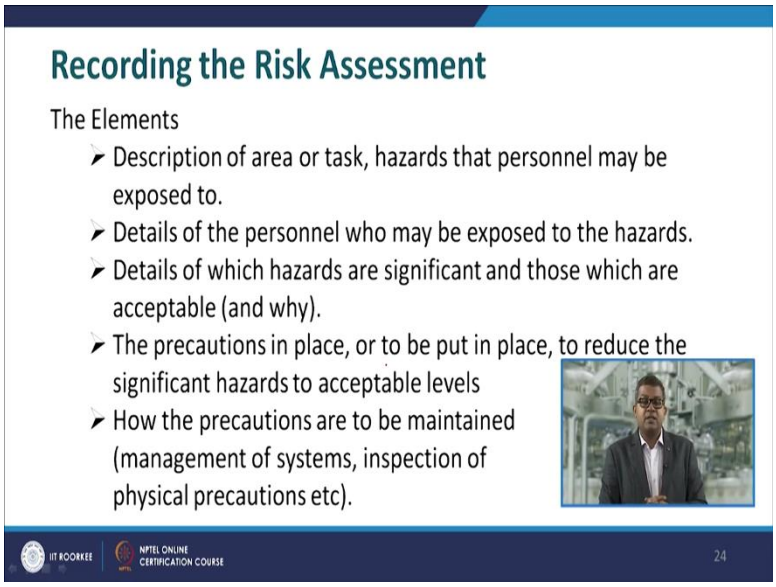

Now another step is that you record your findings, record keeping is extremely essential while calculating the risk assessment. The important elements are description of area or task, hazards that personnel may be exposed to, so you must record all those areas, categorise those areas. Details of the personnel who may be exposed to the hazard obviously those persons who are working in that particular arena may be exposed to that particular hazard.

You must have records or details which hazards are significant and those which are acceptable and why. Now, remember whenever you are discussing this, do not forget to refer the protocols as laid down by the various regulatory bodies. Then the precautions to be put in place or reduce the significant hazards to acceptable levels this must be recorded. How the precautions are to

be maintained or management of those systems, inspection of physical precautions, etc these things should be well recorded.

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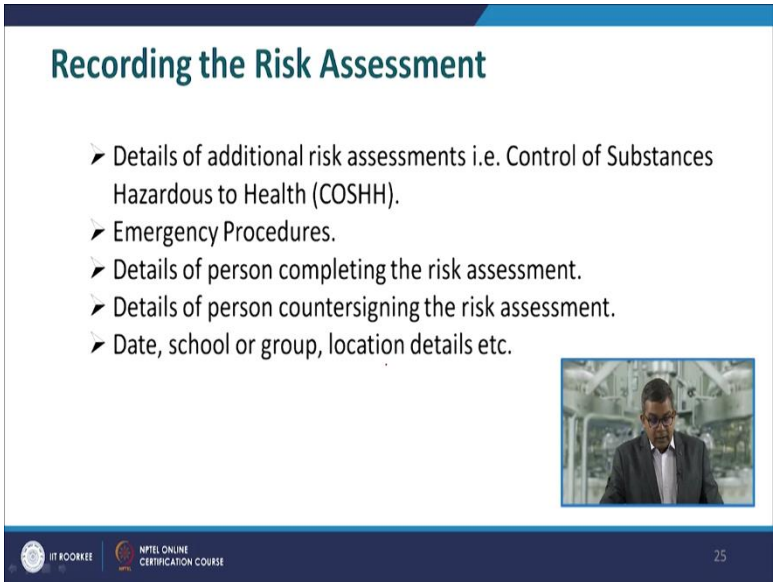

Then in addition to these recordings other points like details of additional risk assessment like control of substances, etc. Then what are the different emergency protocols or procedures, the details of person completing the risk assessment, details of person counter signing the risk assessment, it should be well-publicised and everybody those who are working in that arena must aware that those persons who are responsible for this type of risk assessment. Then date, school or group, location, etc all these things because these are the groups or schools or locations, etc may be vulnerable, so you must record all those things that may be within the plant location or maybe outside the plant location.

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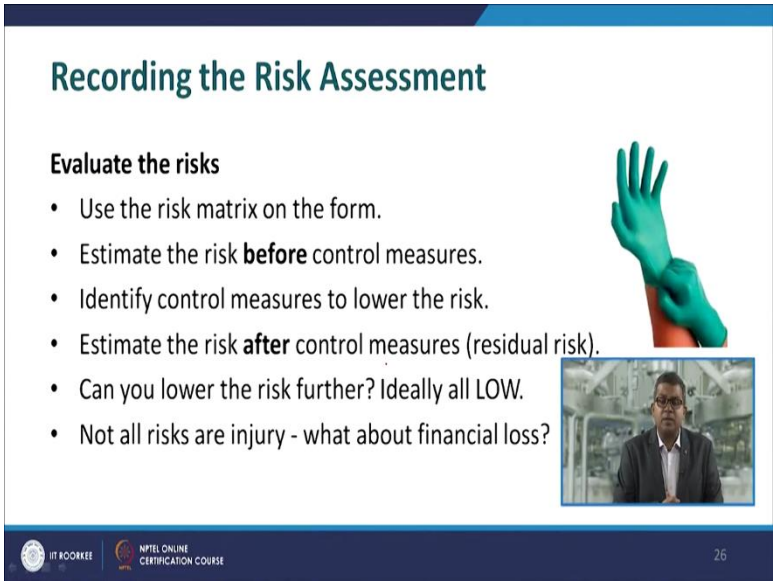

Then evaluation of risk, use the risk matrix on the form, estimate the risk before you adopt any kind of control measures because ultimately economic will involve. Then identify the control measure to lower the risk, estimate the risk after control measures that is the residual risk, then again you may ask a question, can you lower the risk further ideally all low? Should be, but in case if it is not there then you go ahead with the previous question being asked. Not all risk or injury, what about the financial losses because remember everywhere there are financial aspects involved in every aspect.

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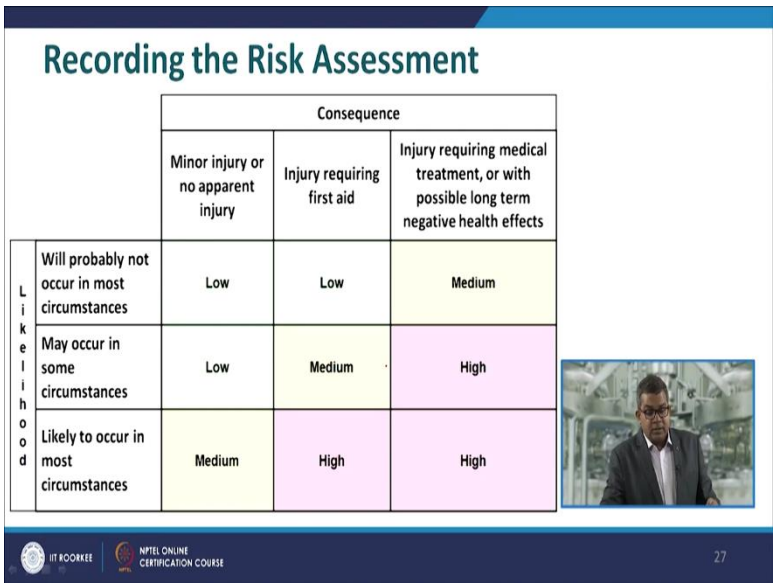

Then while recording the risk assessment you may adopt this type of a table. Like one part may include the consequences including minor injury or not apparent injury, injury requiring first

aid, injury requiring medical treatment or with the possible long-term negative health effects, etc. So you may ask that likelihood will the probability not occur in most circumstances if it is low, then the last aspect is medium then definitely you need to pay severe attention.

Sometimes it may occur in some circumstances minor injury may be low, the consequences may be on the medium side, then injury require medical treatment, etc if it is high then you need to pay severe attention. So you must record all those things based on your knowledge and based on your requirement. Then you must go ahead with various kinds of signature because the signatures always authenticate the things that those who are other signing authority or those who are the approving authority, they ensures that they have gone through all the protocols, etc.

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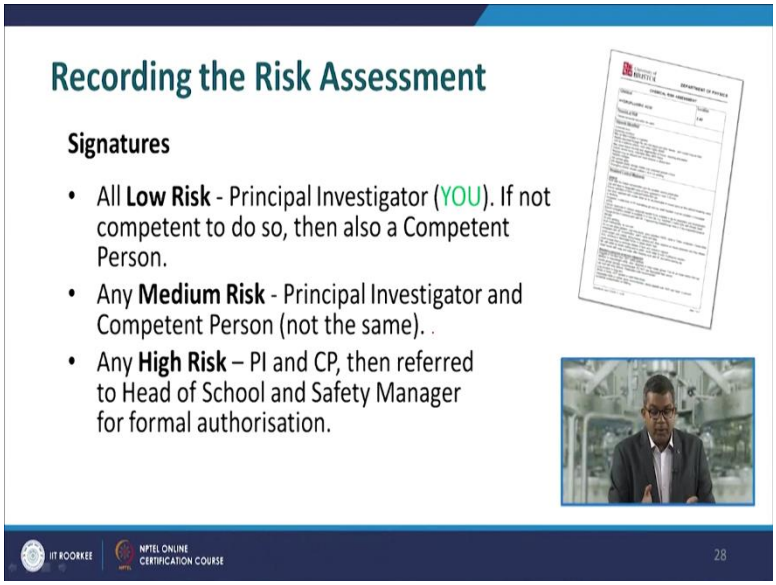

So all low risk, the principal investigator obviously it is you while as an engineer, if not the competent to do so, then also the competent person who will sign it. Then the medium risk, the principal investigator and competent person not the same, maybe some other different person they will sign it. Any risk like principal investigator, the competent person then referred head of any kind of may be head of the school, safety manager or it is related to the plant for the formal authorization. So this is only a legal requirement if 5 or employees they are working within the plant then you need to go for this kind of risk assessment.

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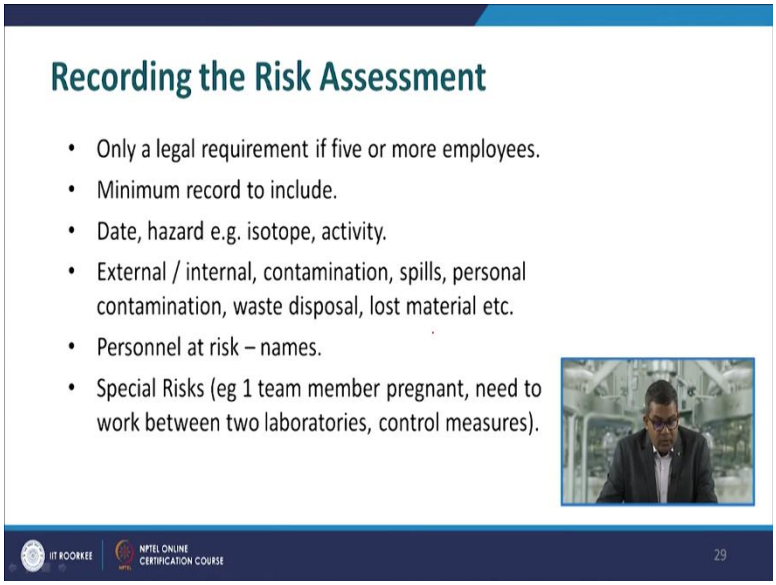

The minimum record to include the date, hazard, maybe isotope activities, etc. The external internal, contamination, spill, personal contamination, waste disposal, lost material, etc. Sometimes you may experience if you are passing through any plant, sometimes you may experience any off smell then you record this so that the person who is in charge of that particular arena may find that what is the reason for off smell.

Then you record that personnel at risk with the name because sometimes the insurance company may require this. Then you go for the special risk that is one team member is pregnant, need to work between two laboratories, control measures, etc. So you need to identify for those persons those may have some special risk and then you give proper attention to those special risk involved persons.

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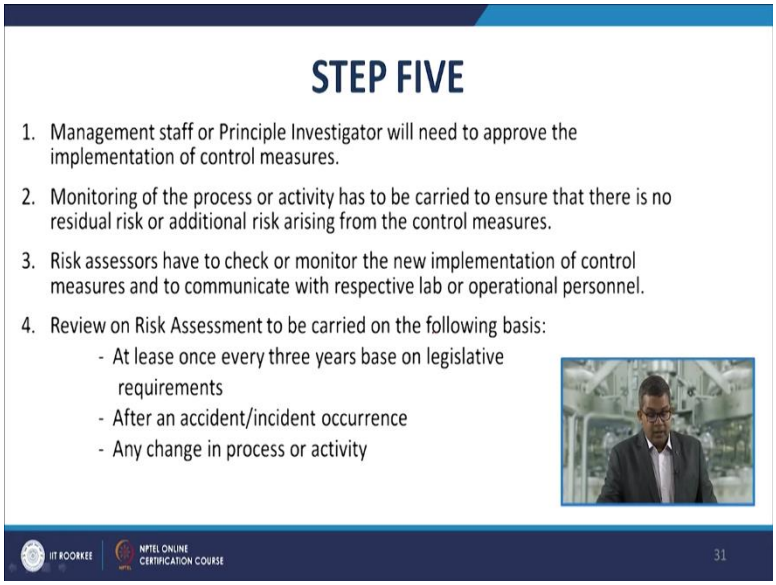

The last steps says to review the assessment, now this involves various points like management staff or principal investigator they will need to approve the implementation of various control measures based on the discussion. Then the monitoring of the process or activity has to be carried out to ensure that there is no residual risk or additional risk arising from the control measures.

The risk assessors have to check or monitor the new implementation of control measures and to communicate with respective lab or operational person whether they are working in the plant. The review on the risk assessment to be carried out on the various bases, one of the basis is that at least once every 3 years based on legislative requirement, sometimes after an accident or incident occurrence, any change in the process or activity this we had discussion previously.

So in this particular module we had a broad discussion about the risk assessment protocol, we have discussed about the different steps involved in detail. We have discussed about how we can develop the chart or table for likelihood of any incident, we have discussed about that who is the responsible person for what.

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Now if you wish to have further look, then we have enlisted different references for further reading further analysis, thank you very much.