Chemical Process Safety
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Lecture 37: Hazard and Hazard Identification: Introduction

Welcome to this particular module which is related to the Process Hazard and Identification. In the previous modules we have studied about the concept of Hazard, Risk and there are different methodologies through which we can identify the process Hazard which is available at the workplace. Now, in this particular module we are going to study with the various definitions related to this hazard identification.

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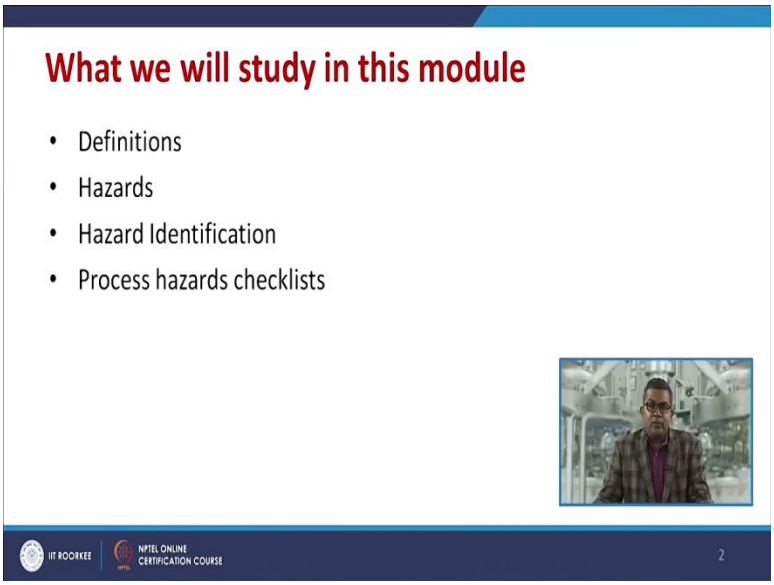

What is the hazard at workplace? How we can identify the specific hazard present at workplace through a systematic methods? And we will study about the concept of Process Hazard checklist, because checklist is extremely important while calculating the assessment or we are performing the assessment of Hazard present at workplace.

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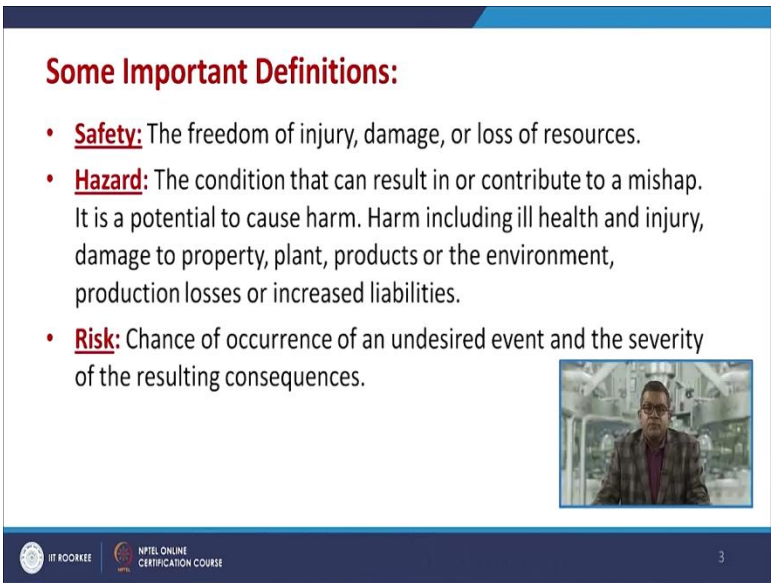

So, let us discuss about some important definitions. Now, first thing is that what is safety? Because ultimate aim is to have a process safe. The safety is the freedom of injury, damage or loss of resources. Another is the hazard, although we have gone through the hazard definition in the previous modules, but here is the more specific definition of hazard - The condition that can result in or contribute to a mishap.

Now, it is the potential to cause harm, harm including ill health, injury or even fatality or damage to the property, plant, product or the environment. Sometimes it may lead to the production loss or increased liability. So, ultimately it will return, it will turn into the economic loss, whether we consider all the aspect or an event.

Now risk, risk is the probability or a chance or occurrence of undesired event and the severity of resulting consequences. Now, remember which we talked earlier that hazard is present everywhere, even the wall may collapse, even the roof may collapse, even the chair on which you are sitting and risk is the probability whether it will collapse or not. So in a simplified manner you can analyze the hazard and risk.

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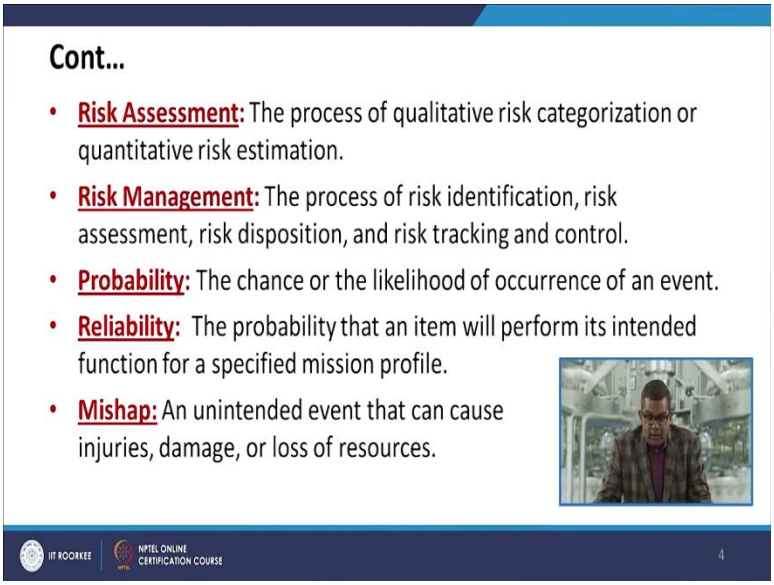

Now, once we analyze this hazard and risk, there is a concept of Risk Assessment. That is the process of Qualitative (analysis) risk categorization or Quantitative risk estimation. So that we can analyze that what is the economic loss and what is the impact of that particular risk to the plant and the environment associated. Now, Risk Management that is the process of risk identification, risk assessment, risk disposition and risk tracking and control, the probability that is the chance or the likelihood of occurrence of an event or a particular event.

The reliability that is the probability that an item will perform its intended function for a specified mission or profile, so reliability may be attributed to the the different safety devices, different process conditions etc. Mishap that is unintended event that can cause injuries, damage or loss of resources.

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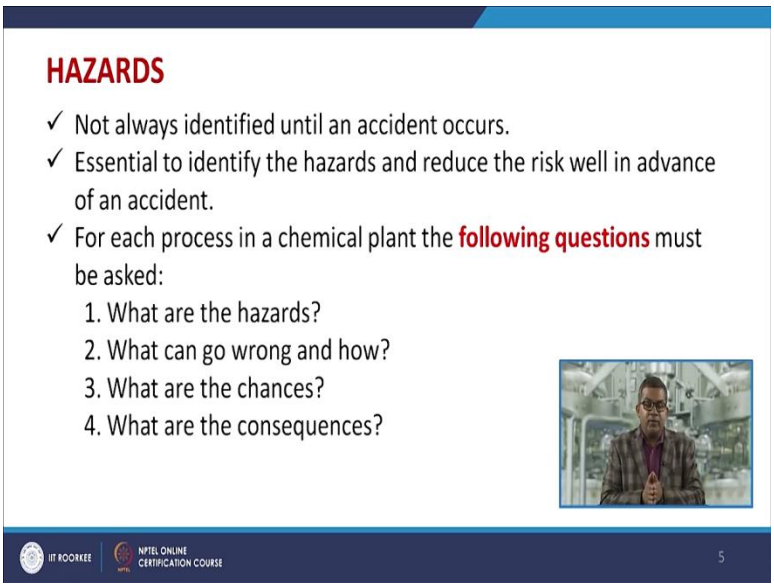

So once we have gone through or we are acclimatized to all these definitions, let us have the look about the hazard. This is not always identified until an accident occurs. So obviously when the roof collapse, so you would not be able to identify the hazard unless it collapse. So essential to identify the hazard and reduce the risk well in advance of an accident, that is the prima facie requirement so that we can minimize the losses, you can minimize the loss in production and you can minimize the economic aspect.

So, for each process in chemical plant you need to frame several set of questions and you must have answer for all those questions. Now these sample set of questions are enlisted, that is what are the hazards? What are the hazards present at your workplace? How you can identify those hazards? Once the hazards are present then what can go wrong and how and what are the chances that means you are calculating the risk and what are the consequences? Again, I am giving back to the another example that if you are working in the plant or if you are working in a particular room, maybe a chance of that the fan may collapse.

So it can go wrong because sometimes the pin which is holding that particular fan may may corroded, maybe bended, anything else. So, what are the chances, it may fall down, it may fall down on your head or it may fall down to an empty place. Then what are the consequences, the

consequences means you may get injury or not. So you have to you have to frame different set of questions and you must give the answer of those questions.

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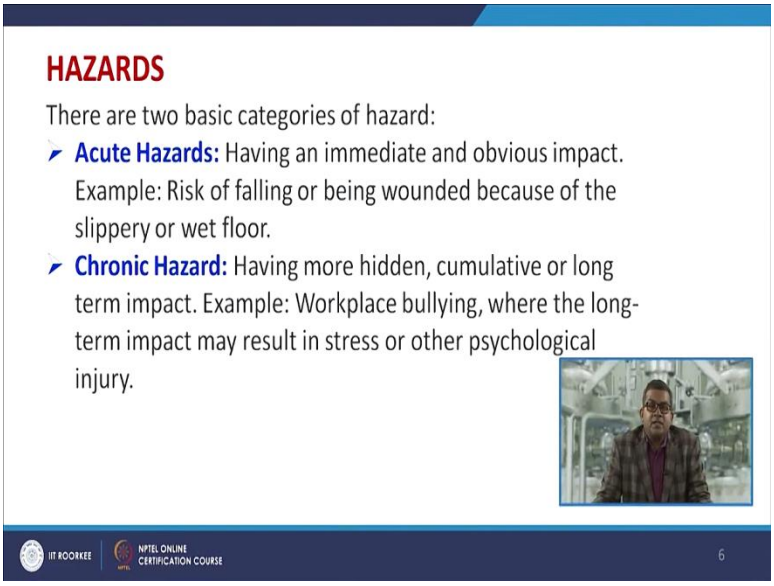

Now, while categorizing the hazard, there are two (diff) type of basic category of hazard. One is the Acute hazards; they are having an immediate and obvious impact that is for example risk of falling or being wounded because of the slippery or wet floor that is acute hazard. There may be chronic hazards having more hidden, cumulative or long-term impacts. For example workplace bullying where the long-term impact result in the stress or other psychological injuries.

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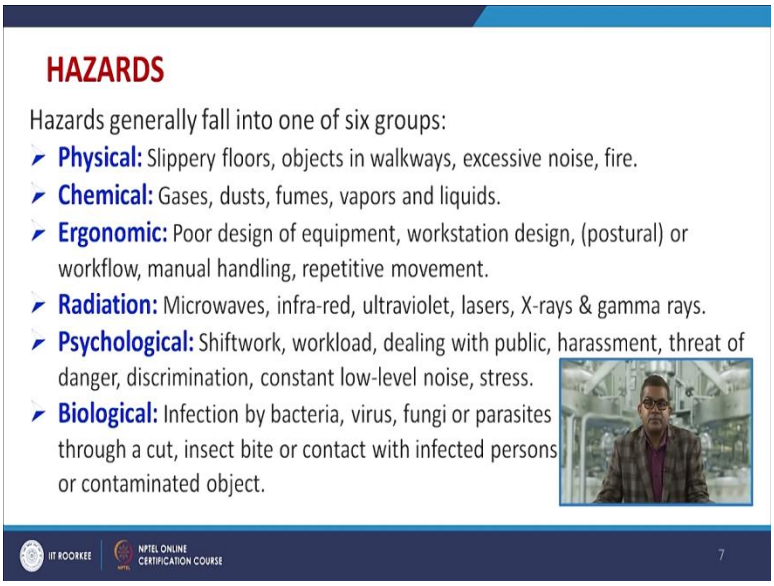

So, hazard generally fall into following six groups, so we have enlisted all those six groups. One is the physical hazard that may be the slippery floor, object in the walkways, excessive noise, fire etc. There may be certain chemical hazards that is gases, dust, fumes, vapors and liquid. There may be some ergonomic hazards that may be attributed to the poor design of equipment, workstation design sometimes postural or work floor problems, manual handling, repetitive movement. Some hazards are attributed to the radiation that may be attributed to the microwave, infrared, ultraviolet, laser, X-ray, gamma rays etc. sometimes while characterizing the various chemical samples you may encounter these type of radioactive hazards.

And Psychological hazards maybe the shift work, stress, workload stress, dealing with the public stress, harassment, threat of danger, discrimination. Sometimes constant low level noise, extreme stress etc. There may be certain Biological hazards that may be the infection by a bacteria, virus, fungi, parasites, through a cut, insect bite, or a contact with infected person or contaminated object. Sometimes you may encounter with the contagious diseases etc.

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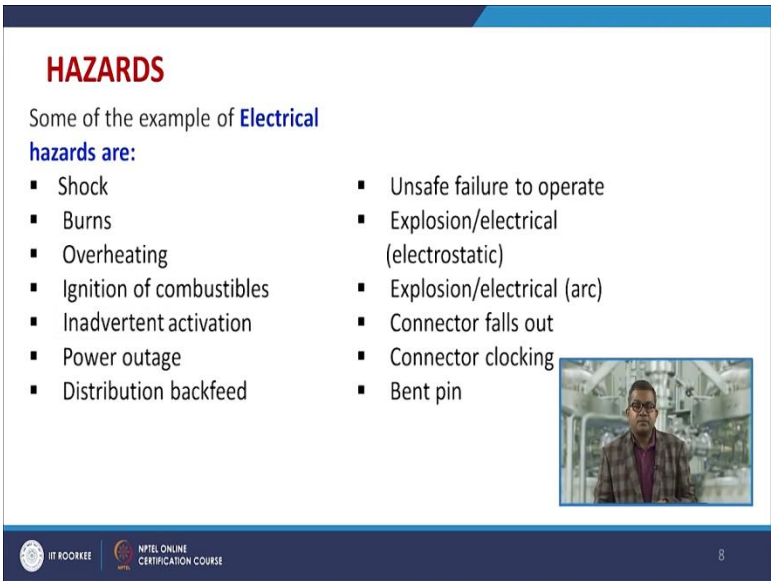

Now, let us have some example of various hazards, so in the first aspect we are going to discuss the some of the electrical hazards. So, they are attributed like shock, burns, overheating, ignition of sometimes combustible, inadvertent activation, sometimes power outage, distribution of backfeed etc. Sometimes it may be attributed for unsafe failure to operate, sometimes it may lead to the explosion electrical, sometimes electrostatic charges built up etc. sometimes explosion of electrical arc etc. So these are the certain hazards attributed to the electrical one.

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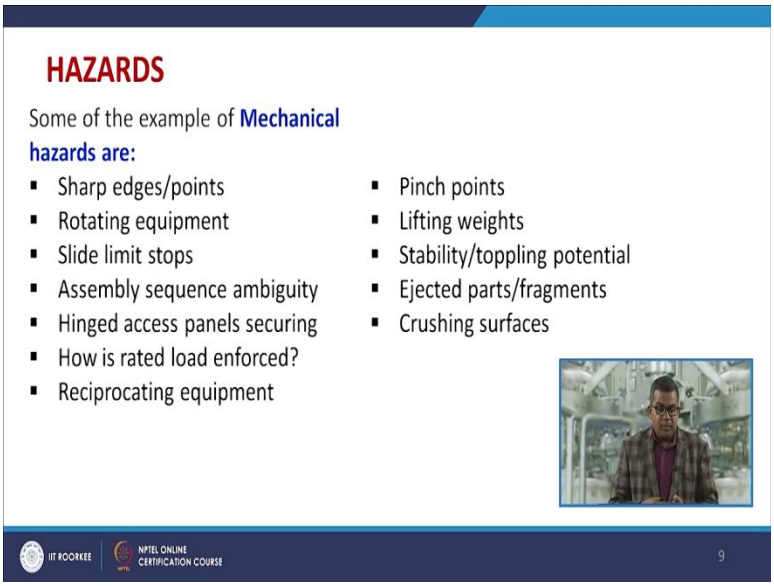

Let us have a look of some Mechanical Hazards like sharp edge points maybe pinch points, rotating equipment. Sometimes it may be attributed to the lifting weights, slide limit stops, assembly sequencing, hinged access panel, how is the rated load enforced that is again a big question, then reciprocating equipment etc.

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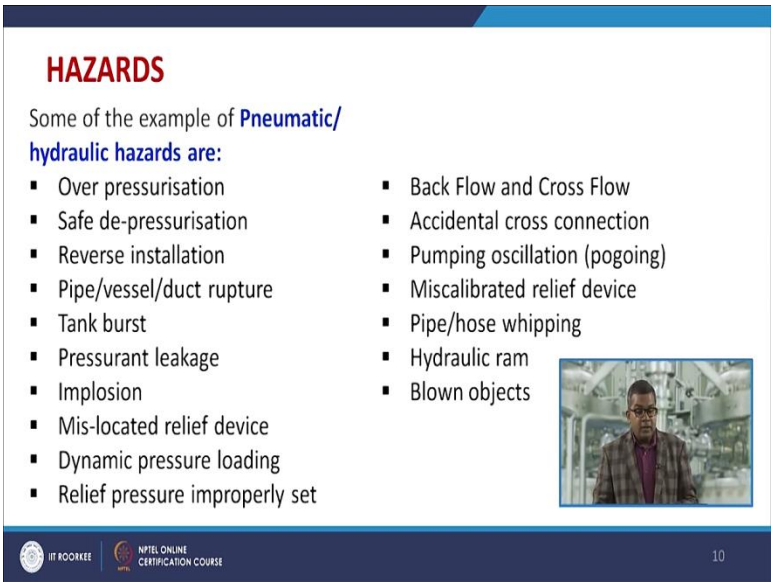

There are certain examples of Pneumatic Hydraulic hazards like over pressurization, safe de-pressurization, reverse installation, pipe vessel duct rupture, sometimes tank may burst because of the overpressure. Then sometimes the pressurant leakage, sometimes implosion, mis-located relief device that is why the location of relief devices are extremely important, the proper location of relief devices are extremely important. Sometimes there may be chances of dynamic pressure loading, the relief pressure may sometimes improperly set and it may be catastrophic. Then back flow and across flow impact, accidental cross connection and so there are so many Pneumatic Hydraulic hazards.

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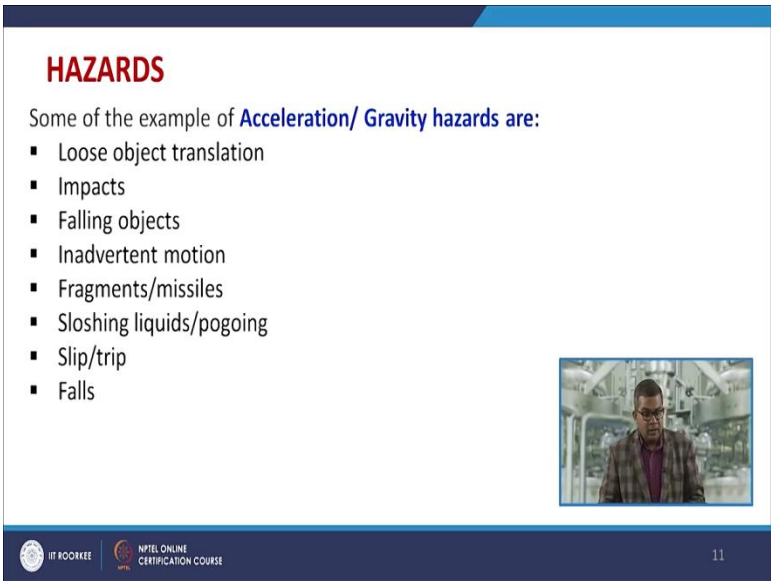

Now sometimes hazards maybe attributed to Acceleration Gravity hazards like loose object translation, sometimes due to impact sometimes the falling objects may lead. Sometimes inadvertent motion and fragmentation etc, so these are the hazards related to the Acceleration.

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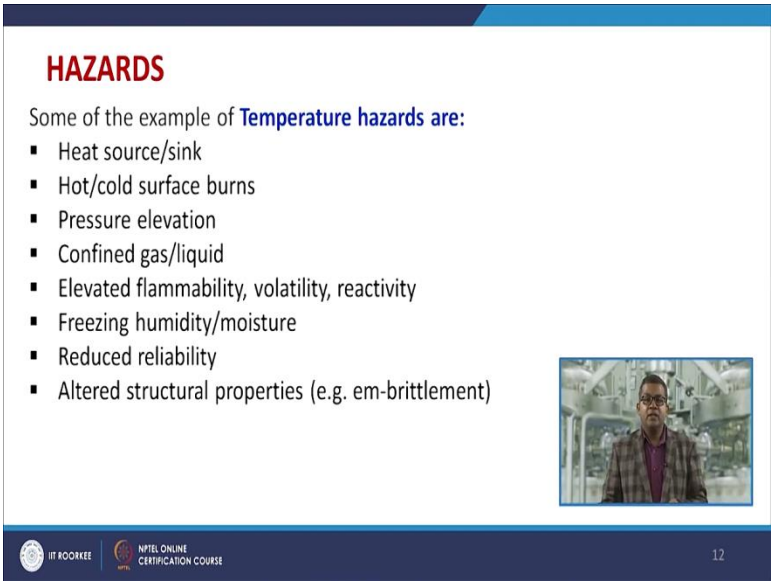

Then sometimes there may be certain examples of temperature related hazards that is the failure of heat source or sink, sometimes hot and cold surface burns, pressure elevation that may attributed to the temperature effect. Sometimes the vaporization of confined gas and liquid may lead in the pressure enhancement, elevated flammability and velocity reactivity etc may cause the Temperature hazard etc, sometimes freezing humidity, moisture etc. So these are the couple of examples related to the Temperature hazards.

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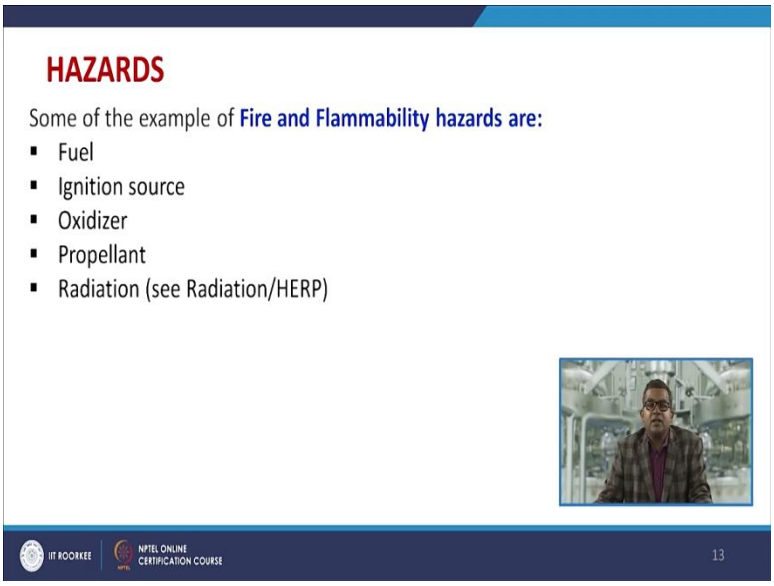

Now, we may look into the some Fire and the Flammability hazards like hazards attributed to fuel, it may be one of the best examples that sometimes it is said do not play with petrol, do not play with the diesel or any kind of thing because it may be extremely dangerous. Ignition source sometimes it may lead to the certain oxidizers, there are certain propellants, radiation etc. So, these are the certain things which are related to the Fire and Flammability Hazards.

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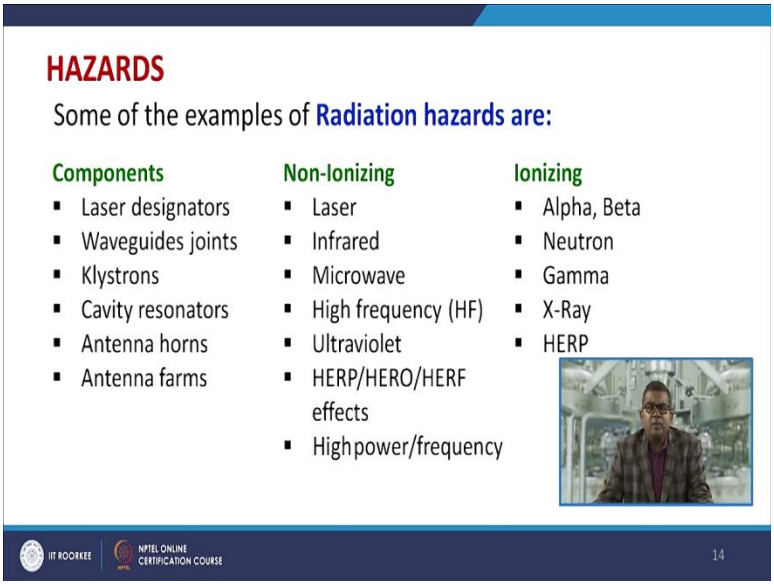

There are certain examples related to the Radiation hazards. There are certain components like laser, waveguide joints, different type of klystrons, then cavity resonators, antenna horns,

antenna farms etc. Because in past there are certain accidents they are attributed to these lasers. Sometimes they are categorized in terms of Non-Ionizing and Ionizing one.

Non-Ionizing they are like laser, infrared, microwave, high frequency ultraviolet and Ionizing one alpha, beta, neutron, gamma, x-ray etc. So specifically when you are using these types of radiative assisted reactions or sometimes you are performing any kind of characterization streams like UV spectro-photometry or laser guided spectro-photometry then definitely you have to look into these type of hazards.

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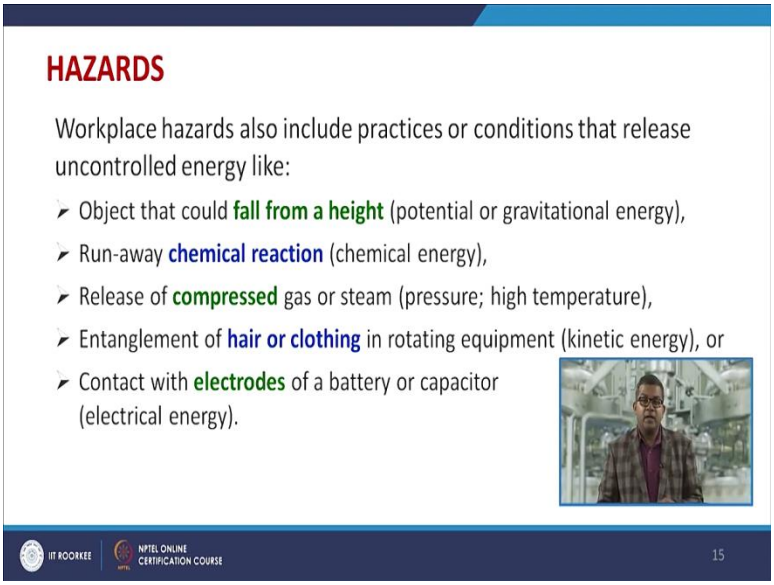

So, Workplace hazard also include the practices or conditions that release uncontrolled energy like object that would fall from height that is potential or gravitational energy. Run-away chemical reactions attributed to the Chemical energy, release of compressed gas or steam, pressure, high temperature. Entanglement of hair or clothing in rotating equipment like kinetic energy or sometimes contact with electrodes of battery or capacitor that is the electrical energy.

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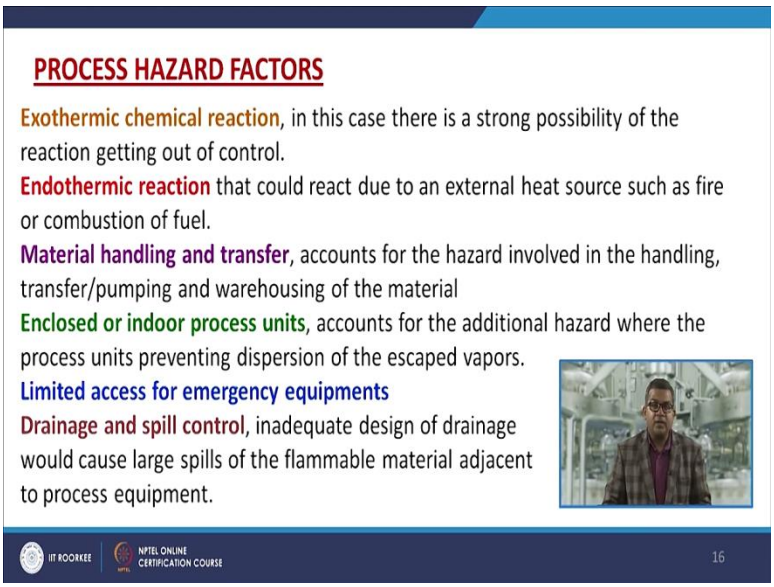

Now, let us have a look about the Process Hazard factors. There are so many factors involved in the Process hazard; one is one or the you can say that foremost is Exothermic chemical reaction, because the continuous release of the heat from the reactions. So in this case there is strong possibility of reaction getting out of control that is sometimes attributed to the thermal run-away reaction.

There may there are certain reactions those involve the Endothermicity that is clubbed under the head of Endothermic reactions. So that could react due to an external heat source such as fire or combustion or a fuel. That external heat source may be of any type of heat transfer mode. Next is the Material handling and transfer, this accounts for the hazard involving the handling, transfer, pumping, warehousing of the material.

Other is the enclosed or indoor process units, this accounts for the additional hazard where the process unit preventing dispersion of the escaped vapors. Now sometimes you may have a limited access for emergency equipment, this is again one of the factor because sometimes these these emergency equipments may lead to the safer operation but you do not have any access to approach of those emergency equipments and so this may be a process hazard factor.

Then drainage and spill, sometimes the inadequate design of drainage could cause a large spill of flammable material adjacent to process equipment not only the flammable material sometimes the toxic material may also gone through that drainage so better house-keeping is very essential and if you are not keeping a better house-keeping then it means that it is contributing to the process hazard factor.

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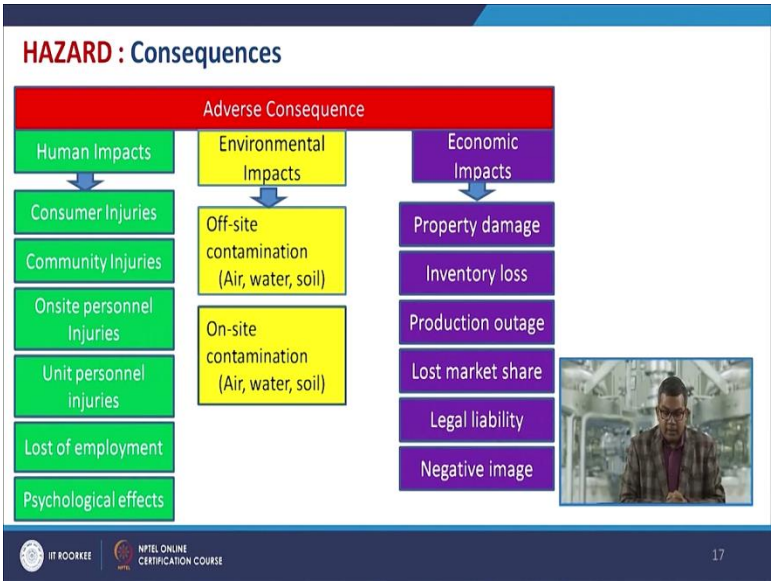

Now, her there are various adverse consequences are listed and they are divided into three different aspects like Human impact, Environmental impact and Economic impact. So Human impact is listed the consumer injuries, the community injuries, sometimes the toxic or flammable material may escape to the atmosphere and it may have a severe impact to the person those were living in the vicinity of that particular plant.

Sometimes on-site personnel injury, sometimes unit personnel injury, sometimes it may lead to the loss of employment because of the permanent disability etc. There may be certain psychological effect because sometimes the accident or hazard may have impact on their subconscious mind. So these are several human impacts.

Now, next is the environmental impact, now there may be chances of off-site (contain) contamination, maybe attributed to the air, water and soil. Then on-site contamination where it is again attributed to the air, water and soil, that means that they may have the adverse impact on environment whether it is on-site or off-site. Then there are certain economic impacts like property damage, fire may lead to the property damage.

Then inventory losses, there are several incidence where there is a huge impact on inventory losses so this may create the (environment) sorry economic impact. Then production outage, the

reason is that whenever you lose your machinery, you lose the inventory, you lose the property then definitely there will be a production outage. Then lost market share because when you are out of production then definitely your product will not come out to the market, then you will lose your market share.

The legal liability, the legal liability is attributed to equally attributed to the human impact as well as the environmental impact because something if it releases to the atmosphere, worker or any nearby person will get contaminated, then definitely you need to pay the legal compensation or legal impact.

Then in the negative image, the negative image is again very important because when you (are) you fail in your goal or you fail to provide the safer environment or fail to provide the safe product to the market then definitely you may enjoy the negative image in the society as well as your consumer as well as the workers.

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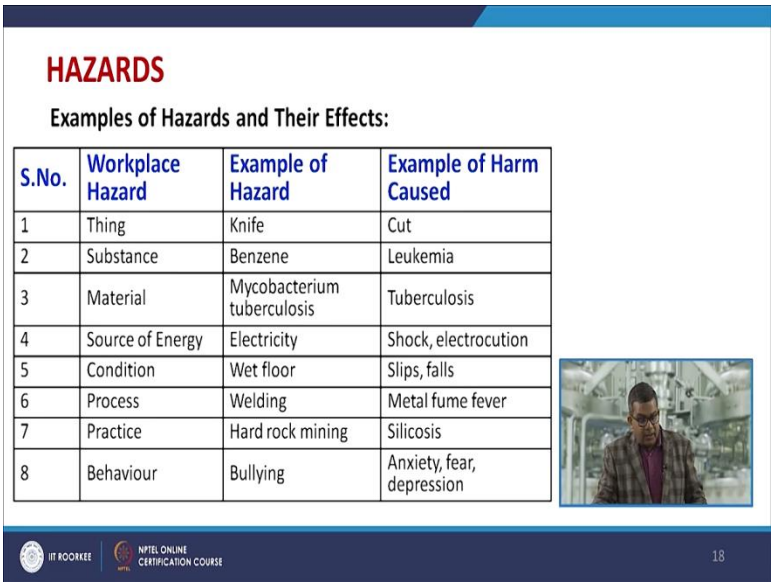

Now, there are several examples of hazards and their effect, it is again listed in terms of three aspect such as workplace hazard, example of hazard and example of harm caused. Like things, knife cut it may lead to the cut, if you have a substance like benzene then it may produce the leukemia or it may be create the carcinoma. Then material, there may be some mycobacterium tuberculosis then it may lead to the health hazard. Source of energy, sometimes electricity it may

have electrical shock and sometime it may lead to death and the condition sometimes the workplace conditions are not up to the mark.

One example is that wet floor, then you may slip or fall down. There may be a process like welding, then metal fume fever and sometimes it the spark may create the flammability aspect. Then again the practice sometimes the hard rock mining in that may create the problem of silicosis, then behavioral problem like bullying, example the anxiety, fear, depression. So these are the certain examples of hazard and their effects.

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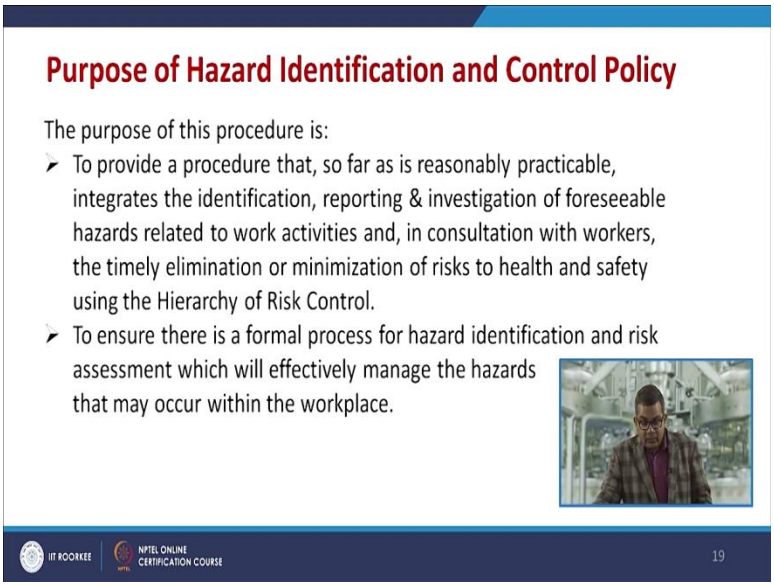

Now, let us have a look that what is the purpose of Hazard Identification and Control policy. In the previous slides, we had the discussion that what kind of different hazards present at your workplace and what is the impact to the society. So, the purpose of this particular procedure, because there are so many variables in workplace and in and around, on-site or off-site. Then we have to go for systematic process hazard identification and we must have a systematic control policy.

So, the purpose of this procedure is to provide the procedure that so far as is reasonable, practicable, integrates different type of identification, reporting and investigation of foreseeable hazard related to the work activities and in consideration with the workers, the timely elimination or minimization of risk to health and safety using the hierarchy of risk control. So you must

adopt the proper identification and control policy. Another objective or purpose is to ensure there is a formal process of hazard identification and risk assessment which will effectively manage the hazard that occur within the workplace.

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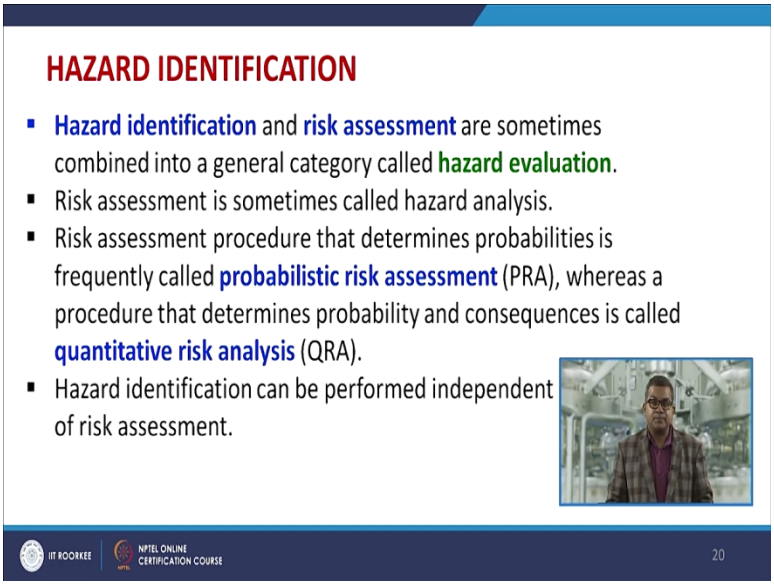

Now, let us discuss about the Hazard Identification Protocol. Now hazard identification and risk assessment are something combined into a general category that is called the hazard evaluation. Now, risk assessment is sometimes called the hazard analysis, and this risk assessment procedure that determines the probability which is frequently called the Probabilistic Risk Assessment PRA. Whereas a procedure that determines the probability and consequences is called the Quantitative Risk Analysis. So, Hazard identification can be performed independent of Risk Assessment. So these two things are altogether independent.

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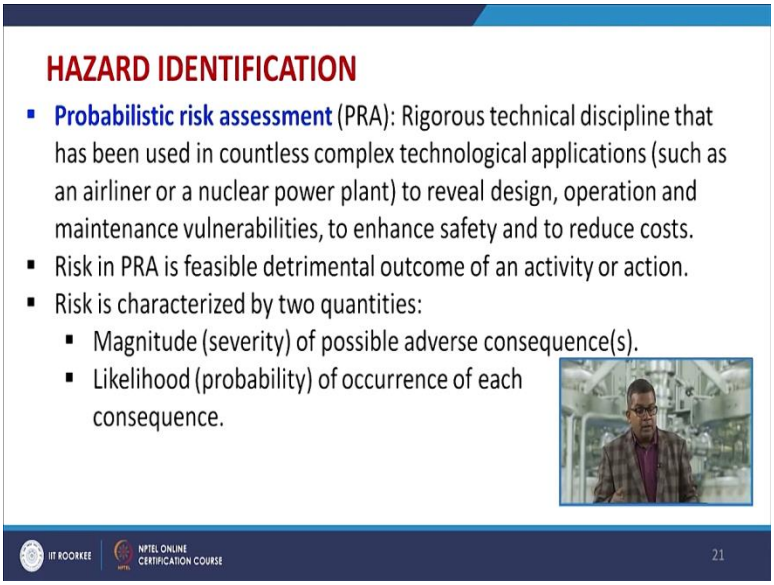

Now, let us have a look of the Probabilistic Risk Assessment that is PRA. So this requires a rigorous technical discipline, now the rigorous technical discipline that has been used in the countless complex technological applications such as airline industry or nuclear power plant because they are having string hazards.

Now this technological application to reveal design, operation and maintenance aspect, this will lead to the safety and reduce the cost. So risk in PRA is feasible detrimental outcome of an activity or action. Now the risk is characterized by two quantities that is the magnitude that is the severity of the possible adverse consequences and second is the likelihood that is the probability of occurrence of each consequences.

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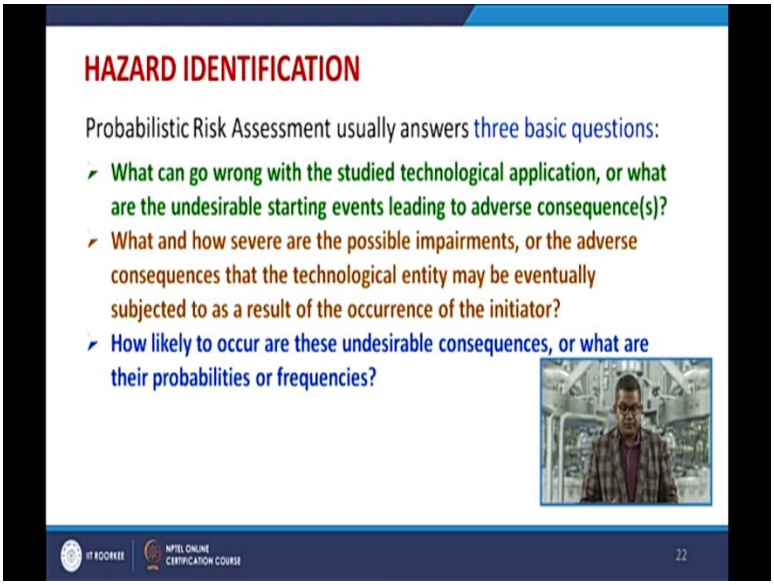

So the Probabilistic Risk Assessment usually answers three basic questions. One is the, what can go wrong with the studied technological application or what are the undesirable starting event leading to adverse consequences. Second is that what and how severe are the consequences, impairments or the adverse consequences that the technological entity may be eventually subjected to as a result of occurrence of the initiative. And third and the last basic question is that how likely to occur these undesirable consequences or what are their probabilities or frequencies. So you must answer all three basic questions in order to get the proper risk assessment.

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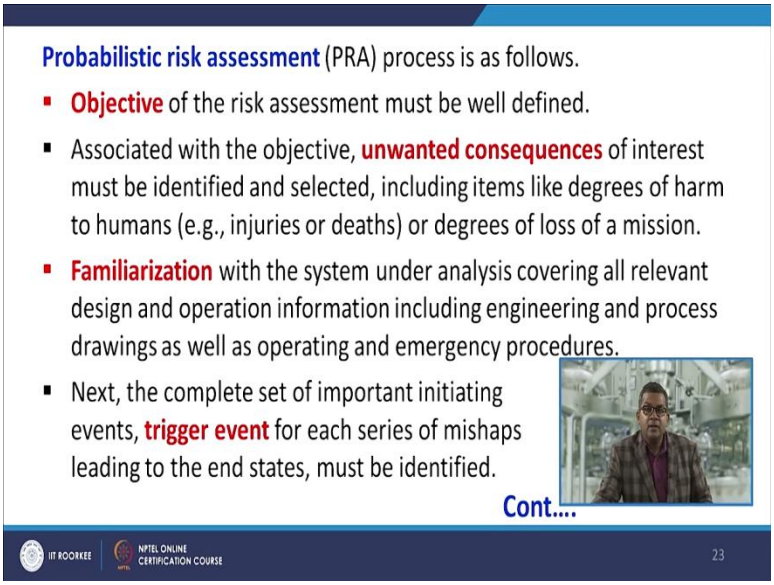

So this, now question arises how can we formulize this process? So the PRA process is usually as follows, first is the objective of risk assessment must be well defined, we must well define that what is the objective of that particular risk assessment. Now associated with the objective there may be certain unwanted consequences. So unwanted consequences of interest must be identified and selected including items like degrees of harm to human that may be injuries, sometimes illness, sometimes to the fatality or degrees of losses of a mission.

Then second is the familiarization with the system under analysis covering all relevant design and operation and formation including the engineering and process drawing as well as the operating and emergency procedures. Now, next to complete the set of important initiation event that is the triggering of event or trigger event. For each series of mishaps leading to the end state that must be identified.

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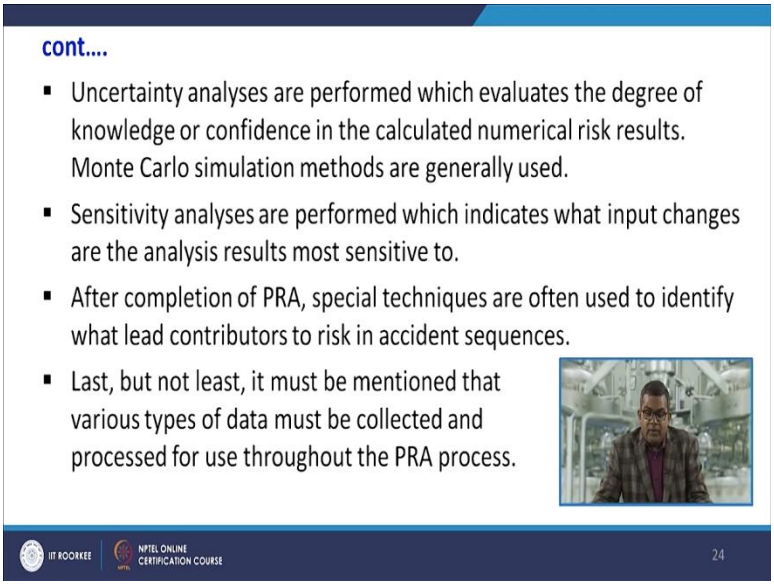

There may be you need to perform certain uncertainty analyses, so these uncertainty analyses are performed which then evaluates the degree, which evaluates the degree of knowledge or confidence in the calculated numerical risk result. Sometimes Monte Carlo simulations are used for this particular purpose. Now (sensivity) sensitivity analyses are performed which indicates with that input changes are the analysis more sensitive to.

So after completion of this PRA, special techniques are often used to identify what let what lead contributed to in that particular accident consequences. Last but not least it must be mentioned that various type of data must be collected and processed for the use throughout the PRA process.

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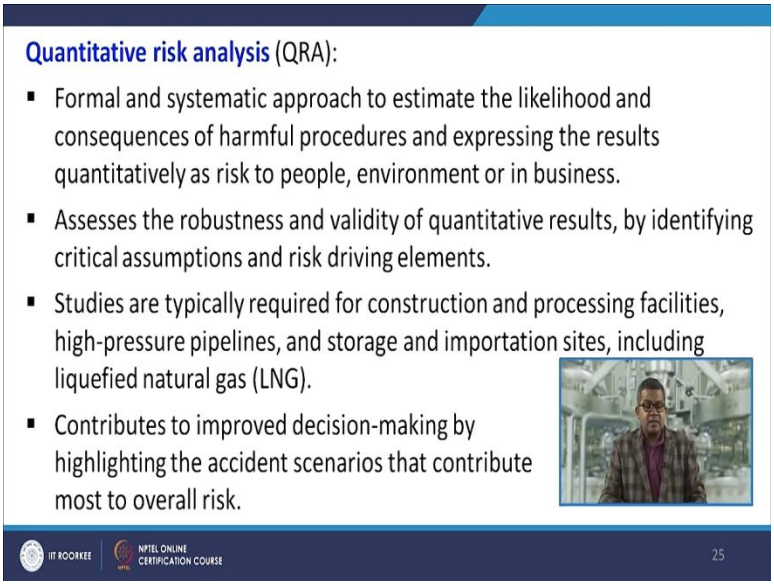

Now next is the quantitative risk analysis that is the second part the formal and systematic approach to estimate the likelihood and consequences of the harmful procedures and expressing the results quantitatively as to risk to people, environment or in business. So this is the basic aspect of this QRA. This assesses the robustness and validity of quantitative results by identifying critical assumptions and risk driving elements.

Now usually studies are typically required for the construction and processing facilities, high-pressure pipelines and storage facilities at important sites including LPG, LNG, etc. Now, this contributes to improved decision making by highlighting the accident scenarios that contributes most to overall risk.

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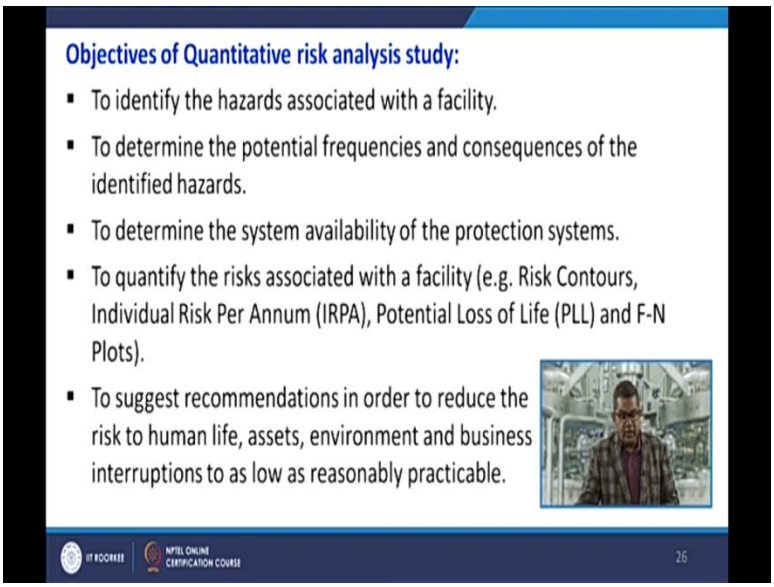

Now, this the objective of Quantitative Risk Analysis study is to identify the hazard associated with facility, to determine the potential frequencies and consequences of the identified hazard. To determine the system availability of the protection system, to quantify the risk associated with a facility that is the Risk Contours, Individual Risk per annum, potential loss of life (PLL) and maybe by F-N plots. Now to suggest the recommendation, in order to reduce the risk of to human life, assets, environment or business interruptions to as low as reasonably practicable.

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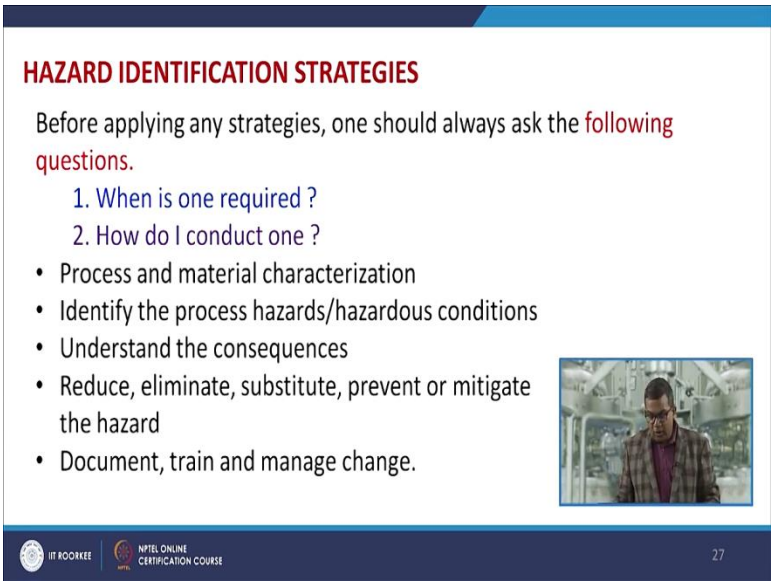

So, let us adopt certain strategy for Hazard Identification, so before applying any strategy one should ask the different questions, that is when is one required and how do I conduct one? The process material characterization must be performed, identify the process hazards and hazardous conditions, must understand the consequences and the extreme aspect, reduce, eliminate substitute, prevent, or mitigate the hazard. Proper documentation, training and managerial change must be performed.

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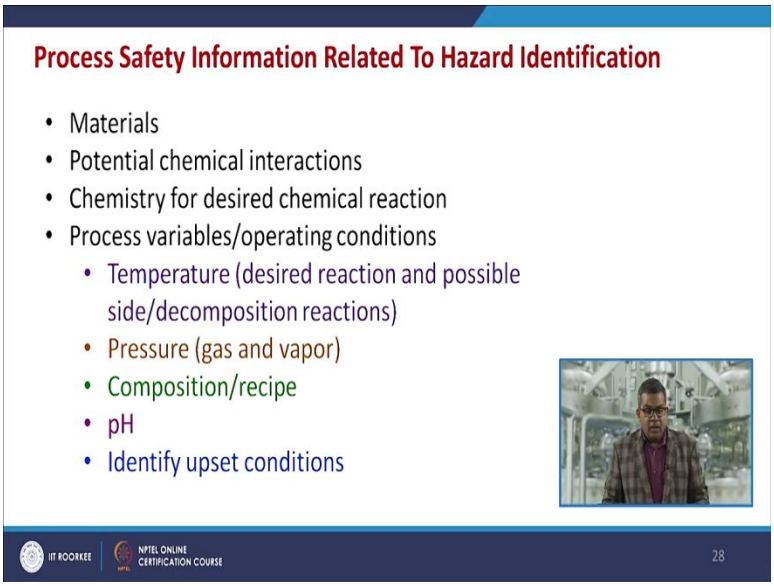

Now there are certain information required for the Process Safety related information pertaining to the hazard identification. You must be much aware about the materials, those who are present at the workplace, potential chemical interaction or probable chemical reactions that may occur in the due course of time. You must know the chemistry of the that desired chemical reaction so you must aware about the conversion factor, you must aware about the yield, you must about, you must know about the production of any side product, waste product, byproduct etc.

You must be much aware about the process variable and operating conditions like temperature, desired reaction and possibility of any side or decomposition reactions or decomposition products etc, pressure with respect to the gas gaseous and the vapor conditions. You must have a composition of all material in question, you must have a composition of all product in question, and you must have the recipe at your fingertips, what is the pH of your system.

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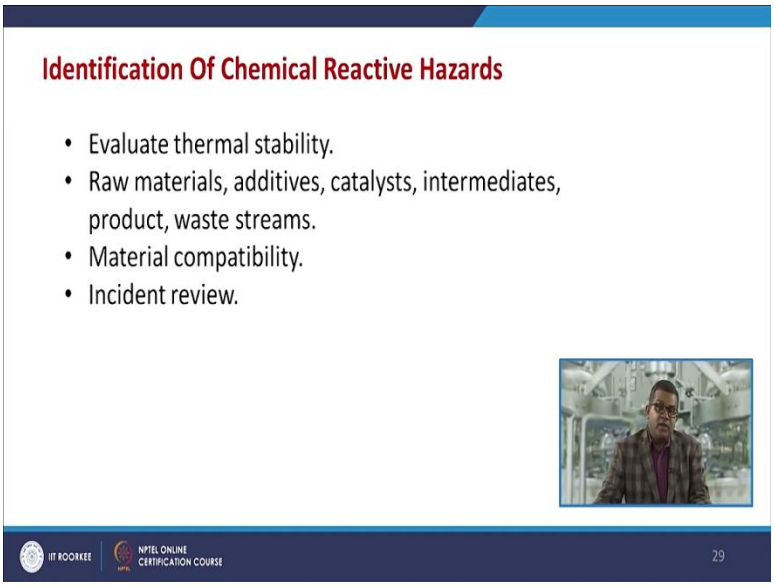

You must identify any kind of upset condition present in the workplace. You must know the or you must evaluate the thermal stability of your process, you must know that what kind of the raw materials present at your workplace, what are the different additives required, what is the purity etc.

You must know the catalyst available on site, what are the intermediates, intermediate products, what are the waste streams and as a far as possible you must know the MSDS of all those

materials in question. So once you know that you have a knowledge about the MSDS then obviously you will be aware about the material compatibility with other things. You must have an incident review or you must be aware or you must learn about the incident reviews.

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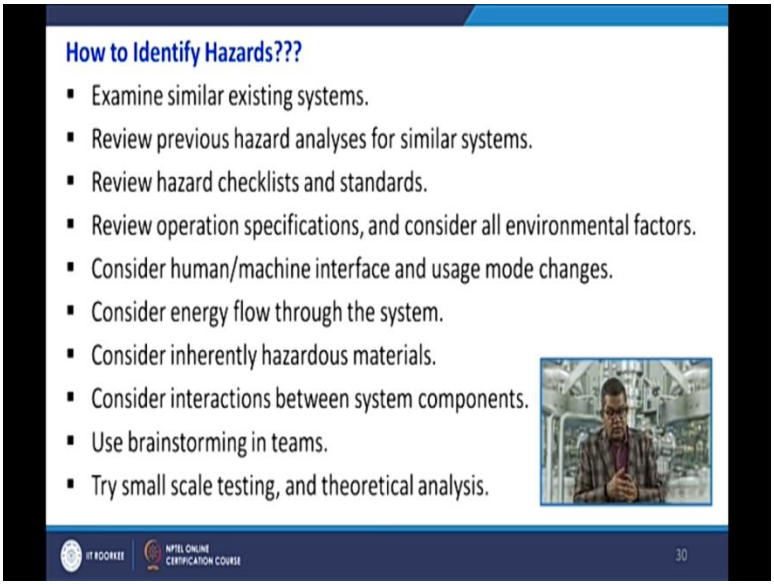

Now, once you have collected all these things, then question arises how to identify the hazards? So, there are few things enlisted in this particular aspect that is you examine the similar existing systems so you must have a review with you, review the previous hazard analysis for similar systems. You must have a review of hazard, process hazard checklist and standards applicable to global scenario and applicable to your country in question. You must have a review of operation specifications and consider all kind of environmental factors. You must consider the human machine interface and usage mode changes.

Then consider, you must consider the energy flow through the system, you must consider the inherent hazardous materials obviously you may get the information through the MSDS. Then consider the interaction between the system components and use and always use the brainstorming in teams, because sometimes you may find couple of people who are well versed in such type of system. They may give the proper information and they may give the useful information. Now try to get the small scale testing theoretical analysis.

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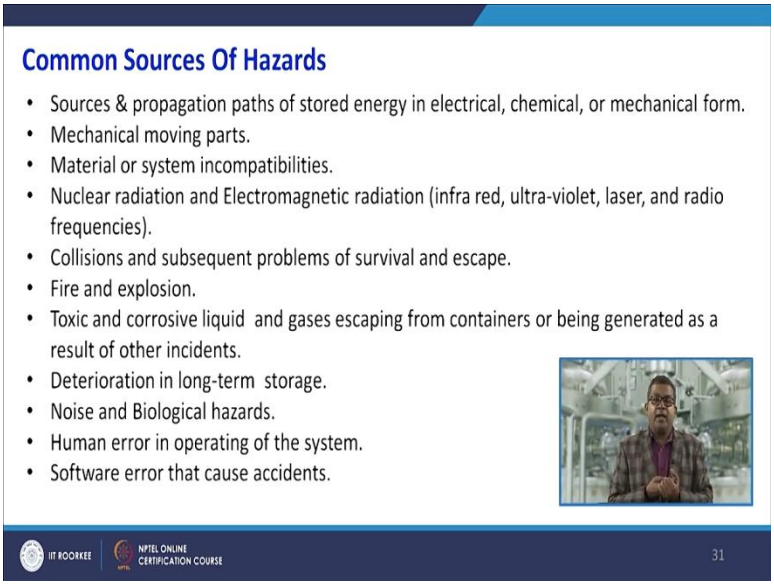

Now once you have gone through all these things you must identify the common sources of hazards like sources and propagation path of stored energy in electrical, chemical or mechanical form which we have already discussed. Sometimes mechanical moving parts may give a proper information, the material and system incompatibilities, the useful information you may have from MSDS. The nuclear radiation and the electromagnetic radiation that is infrared, ultraviolet, laser frequencies, etc. The collision or subsequent problems of survival and escape, we must have a fire and explosion data.

The toxic and corrosive liquid and gases escaping from containers or being generated as a result of other incidents, you must know the deterioration in long term storage; you must have knowledge about the noise and the biological hazards. Sometimes human error may play very vital role so you must aware about those kind of human error in operating of the system. Sometimes software errors they may cause severe accidents so you must aware to all those kind of common sources of hazards.

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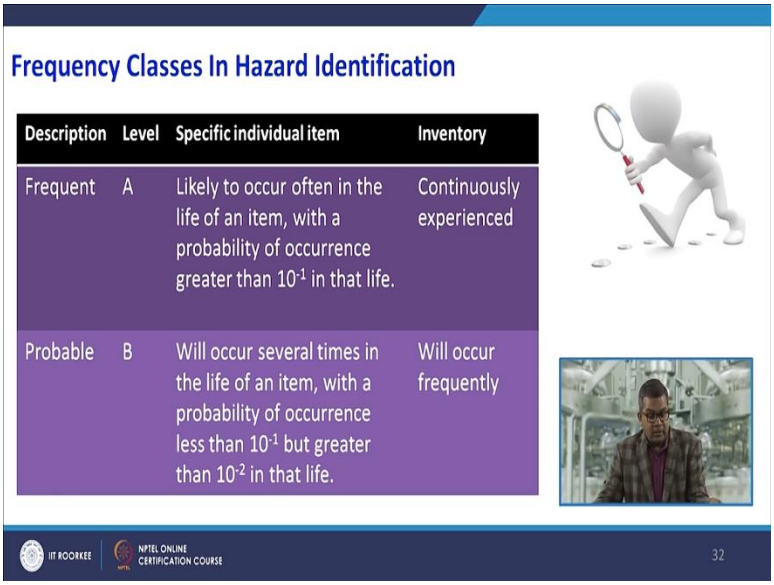

Now, there are frequency classes in hazard identification, there are several frequent sometimes with respect to the different levels so like frequent a level A, the specific individual item likely to occur in the life of an item with a probability of occurrence greater than 10 to the power minus 1 in that life and inventory sometimes continuously experienced. Similarly, probable that is B will occur several times in the life of an item with a probability of occurrence that is less than 10 to the power minus 1 but greater than the power 10 to the power minus 2 in life, that will occur frequently so that is the thing.

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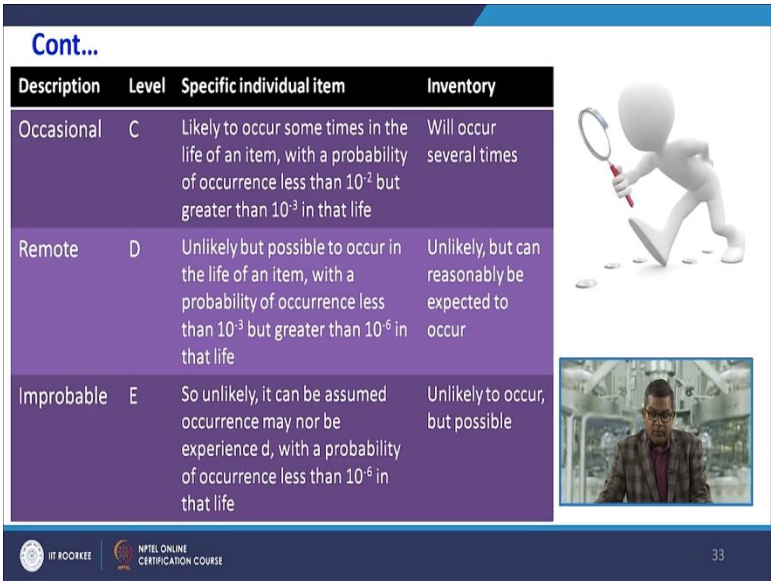

Occasional that is likely to occur sometimes in the life of an item with the probability of occurrence less that 10 to the power minus 2 but greater that 10 to the power minus 3 in that particular life. So the chance is that may that will occur several times. The remote that is D, the unlikely to possible to occur in the life with the probability of occurrence less than 10 to the power minus 3 but greater than 10 to the power minus 6 in that life.

So unlikely but can reasonably expected to occur. Then improbable, that is E, so unlikely, it may be assumed occurrence, may not be experienced but with the probability of occurrence less that 10 to the power minus 6 in that life, that is unlikely to occur but there is a possibility.

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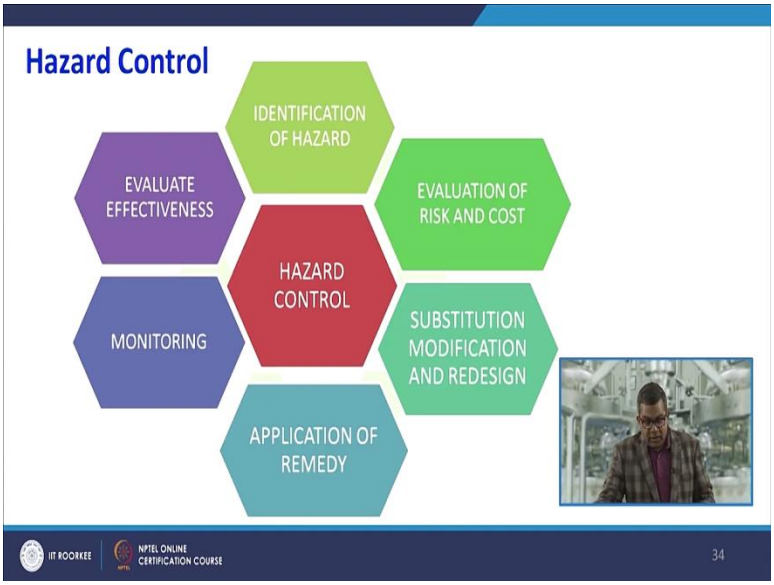

So, question arise that how we can control the hazard? Now the hazard you can control through the through various methodology. First thing is that you must identify the hazard, then you go for evaluation of risk and cost, go for the substitution, modification and sometimes it may happen that you may go for the redesigning of that process, go for the application of remedy, have a continuous monitory and then you evaluate the effectiveness of that particular hazard control methodology. So this is the basic objective and the basic methodology of hazard control.

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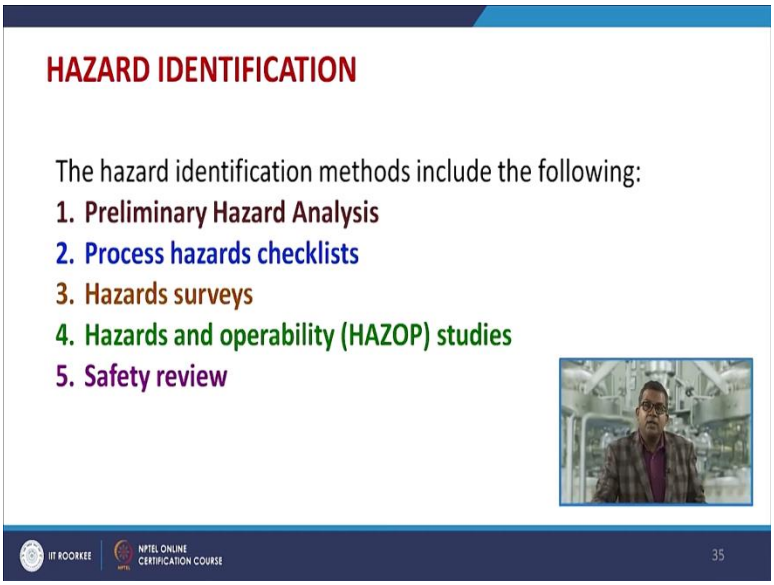

So in this particular module we have discussed about the basic definitions of the hazard identification because ultimately (we) our main motive is to go for development of Process hazard checklist, we have discussed different hazard control methodologies, different process of hazard identification etc. In the subsequent modules we are going to discuss that how to evaluate the process hazard checklist. Thank you very much!