Chemical Process Safety
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Lecture 10 - Industrial Hygiene: Regulations & Identification

Welcome to this Industrial Hygiene and Identification module. In this particular module, we will discuss the various aspect of industrial hygiene process involved in any chemical process industry, how we can identify it and what is the gravity of that particular hazard present at your workplace. And once you analyze the gravity of that particular hazard, then how do we can control those particular hazards at workplace?

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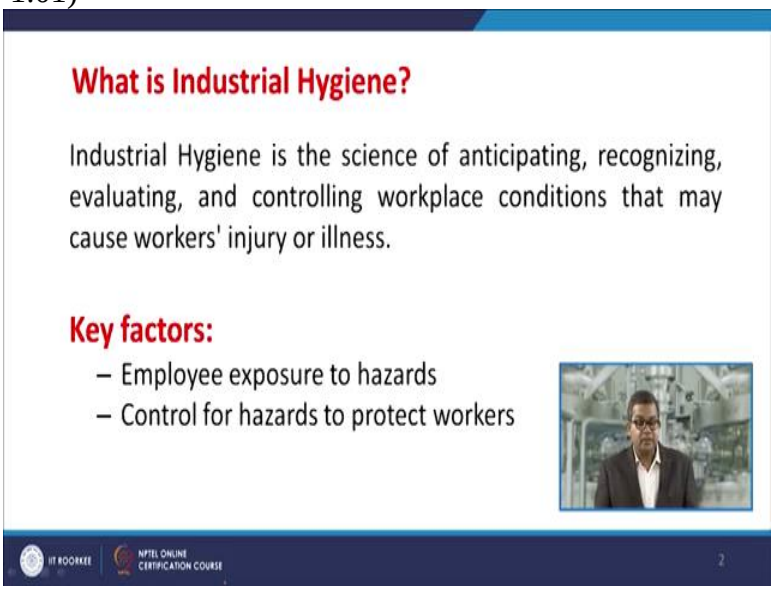

So, first question arises that what is industrial hygiene? Now, basically in a systematic manner, industrial hygiene is the science of anticipating of any kind of hazard present at workplace, maybe in the liquid form, maybe in the solid form or maybe in the gaseous form. Then recognize it based on your technical competency, technical knowledge, you must recognize. Suppose you are working in kitchen, then you must recognize that one big hazard LPG is present at workplace. So, you must be in a position to recognize it, then based on your technical knowledge and based on the malfunctioning of the system, you must evaluate that how hazardous that particular system is. Now, because this is the ultimate objective of this particular chapter, that you need to evaluate the gravity of that particular hazard.

Now based on this particular knowledge that you have anticipated the hazard present at your workplace, then you recognize this properly, and when you evaluated it properly, you designed or you adopt the control measures to the workplace. So in a nutshell, the industrial hygiene is the science of anticipating, recognizing, evaluating and controlling workplace condition that may cause workers' injury or illness. Now remember, whenever any worker got injured or illness or sometimes the fatality, then the industry or process industry may need to pay the compensation or sometimes it may loss in terms of men, men hour or men days.

So, there are two key factors in the industrial hygiene, one is that employees' exposure to hazard, because sometimes the employee exposure may lead to the exposure to the atmosphere and this is extremely dangerous scenario. So employees' exposure to the hazardous, suppose I am working at this particular place with a toxic substance or a (flame) flammable vapors, then what is my contamination or what is my exposure to that particular workplace? Suppose I am working over here, the concentration may be on the higher side compared to the person who is sitting at the corner of that particular room. So, what is the employee exposure to that particular hazard, then how we can control that particular hazard to protect the workplace?

So, these are the two key factors or in just you can say these two major things we are going to study in this particular chapter.

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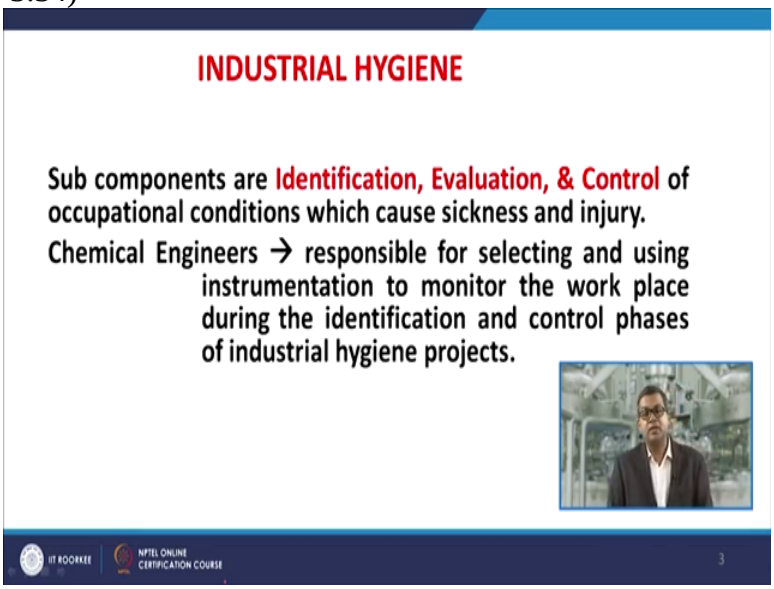

Now, as far as when we go ahead with the industrial hygiene, there are three subcomponents or you can say the major components: identification, evaluation and control, you must identify the hazard substances at your workplace, you must evaluate that what is the exposure and based on the exposure because unnecessary if you are adopting the control measures, then ultimately your economy will be hampered.

So, as far as the engineering perspective is concerned or a chemical engineering part is concerned the chemical engineers, they are responsible for selecting and using instrumentation to monitor the workplace during the identification, you need to go ahead with the proper type of sensors and control phases of industrial hygiene projects. So, this is the role and responsibility of the chemical engineers when they are dealing with the industrial hygiene projects.

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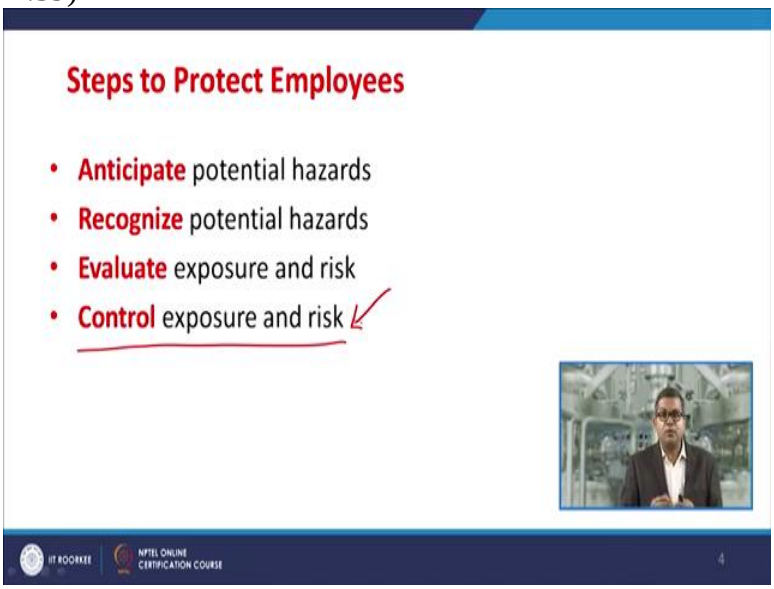

Now, this entire thing divided into four steps: One is that anticipate the potential hazard based on your knowledge of hazard, based on your competency, based on the research risk assessment ability. You anticipate that what kind of potential hazard present at your workplace, may be in all three phases, may be present in any one phase, then you recognize the potential hazard that is purely based on your technical knowledge and competency.

If you are not aware that the peculiar smell belongs to LPG, then you wont be able to recognize it. Then you need to evaluate the exposure and the risk, that how much quantity is being involved

in due course of time or if there is a continuous evaluation, then what need to do? So based on this particular aspect, you need to adopt the proper control measures so that you can avoid the exposure as well as you may create the barrier between the worker and the exposure source and you minimize the risk. So, these four, so do not forget these four steps.

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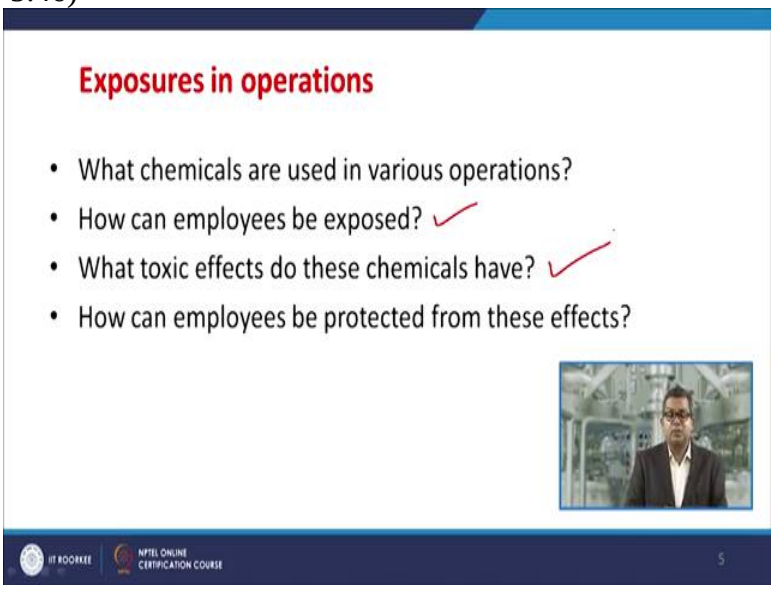

Now, as far as the exposure in operations are concerned, you must know that what chemicals are used in various operations. See in this particular aspect, your technical competency plays a vital role, because suppose there are four colorless liquids at your workplace, one belongs to water, another belongs to benzene, another belongs to say hexane and another belongs to say NaCl, then which one is hazardous and up to what gravity? Sometimes, NaOH is having the normality of say one normal, H_2SO_4 is highly concentrated. So, you need to aware that what kind of different chemicals are present in your workplace or in the different operation. Second thing in this aspect is that you must know that which one is hazardous and how.

So, based on this particular knowledge, you can go ahead with the second aspect that how can employees be exposed? See, you cannot say precisely that water is…water will become the fatal or water may cause occupational injury or occupational illness, but sometimes HCl vapor may cause the occupational illness or occupational injury. Sometimes the hexane vapors may cause the occupational illness or injury and simultaneously that hexane vapor may lead to the formation of inflammable vapor.

So, how can employees be exposed? Sometimes suppose the working temperature of normal hexane is say 60-65 degrees Celsius, then in cases all of sudden the temperature rises up to 90 degree or 100 degrees Celsius, then definitely the vapors will form and the employees those who are working at the periphery then definitely they may get exposed. So, you need to know that how your employees or how your worker may get exposed to that particular substance.

What toxic effects do these chemicals have? So, for this particular information, you must refer to some reliable sources that what kind of toxic effect and where they can impact to your body system, how can they enter into the biological system and what kind of effects, sometimes they may create irritation, sometimes skin dryness, sometimes they may become, they may react the water inside the body and may create a future problem etc.

So, you must know that what toxic effect to do these chemicals have. That means, you must have proper information to (hand) know this. How can employees be protected from these effects? You need to know that if in case of any exposure, in case of any evaluation, then how you can protect your employees from these toxic effects? You either you need to create a barrier between the worker and the exposure or you must develop certain scenario through which those toxicants or those flammable vapors are not evolved at your workplace.

So, this is purely an engineering perspective, so you must know these particular aspect. Now before we go ahead, we must know what is the history of industrial hygiene. Remember industrial hygiene not only deals in a positive manner to protect your workers to workplace, but simultaneously, it creates a problem, in (the) past people used , people use this particular knowledge to kill their enemies. So, the history of industrial hygiene is very interesting.

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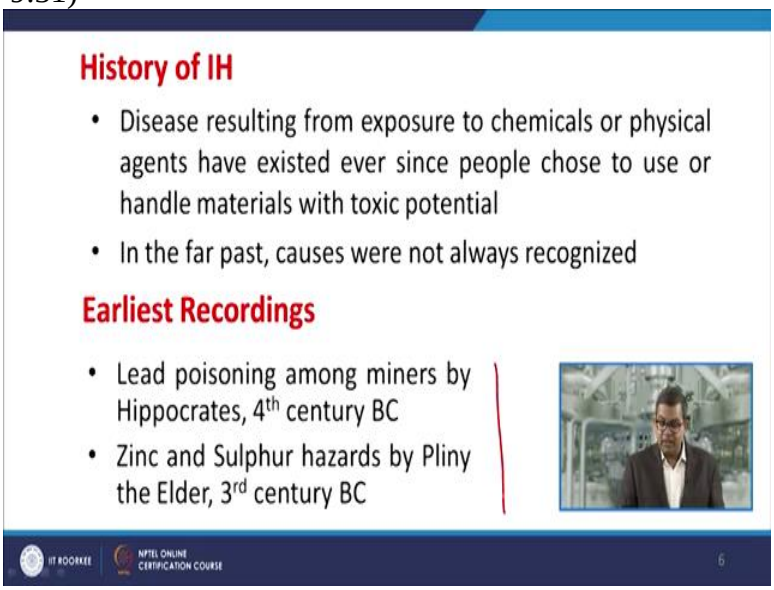

Disease resulting from exposure of chemical or physical agents have existed ever since people choose to use or handle material with the toxic potential. In the far past, causes were not always recognized. So, the earliest recording is that lead poisoning among miners by Hippocrates in 4th century it was the first recorded that people got exposed to the lead in the miner or children. Then zinc or sulfur hazards by Pliny the Elder in 3rd century BC. So, these are the earlier recording.

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Now, we are not going into the history because up to say Pliny or Hypocrites up to Napoleon Bonaparte, because based on the body structure and based on your geographical conditions, the

toxicant may enter in your body system and may create a problem. So, what we are going to cover and what is the industrial hygiene coverage is like toxicology, occupational health standards. We are going to study airborne hazards, we must know that indoor air quality and see nowadays people are very much aware about the particulate matters and that is why the air purifiers are common in every household.

There are certain skin disorders, noise exposures, various type of radiation, various type of thermal stresses etc. Now, before we discuss all these things, we must know that where they can impact. All these toxic substance can impact although in the previous modules we have studied, in the toxicological studies, they may create the problem of in the human anatomy, they may create a problem of biohazards, various kind of chemicals involved in this thing and so and so on. So, various coverage it is enlisted over here.

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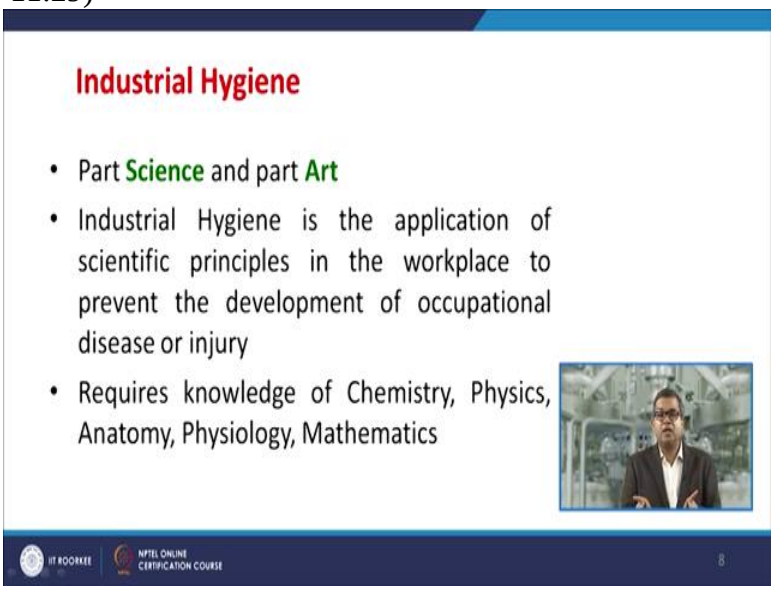

Now, industrial hygiene is a part of science and part of art, why we are saying this? Because science, it tells you that this particular component is toxic to human being, this particular substance is hazardous to human being or environment. Now part of art why we are saying, that suppose if we must know that, what, how much quantity is harmful for human being. Now remember, when we are talking about the human being that means we need to cover the entire population. Entire population may make our, may have children with a different age group,

middle aged person with a different age group and elder person and the effect of those toxicant or flammable vapor may not be common to all.

So, in case if you wish to control the effect of toxicant and if you wish to control the effect of flammable vapor, you need to analyze the things in a different perspective based on age, based on environment, based on geographical condition. And whenever you know all these things, then you need to apply the appropriate technique available as on date or you must evolve certain other technique which may be useful for the area in question. So, industrial hygiene is the application of scientific principle in the workplace to prevent the development of any kind of occupational disease or injury.

So that is why because there are so many factors involved, so many parameters involved, that is why it is called, that is this industrial hygiene is an art because this not only covers the identification, this not only covers the evaluation, but also it covers the control and not only the available control measures, but also you may need to design your own control measures. So, this requires the knowledge of chemistry, physics, anatomy, mathematics etc.

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Now, before we proceed further, there are certain governmental regulations, so we must know the abbreviations because we will use these abbreviations in due course of time. So there are six standard regulations or protocols available globally, OSHA, Occupational Safety and Health

Administration and NIOSH the National Institute of Occupational Safety and Health, ACGIH American Conference of Governmental Industrial Hygienist, SDWA, the Safe Drinking Water Act, TSCA that is a Toxic Substance and Control Act, FMSHA that is Federal Mine Safety and Health Act.

So, these are the governing bodies, those who are responsible for designing the various control methods and suggesting the things that which is the toxic, which is a flammable, which is undesirable for human being.

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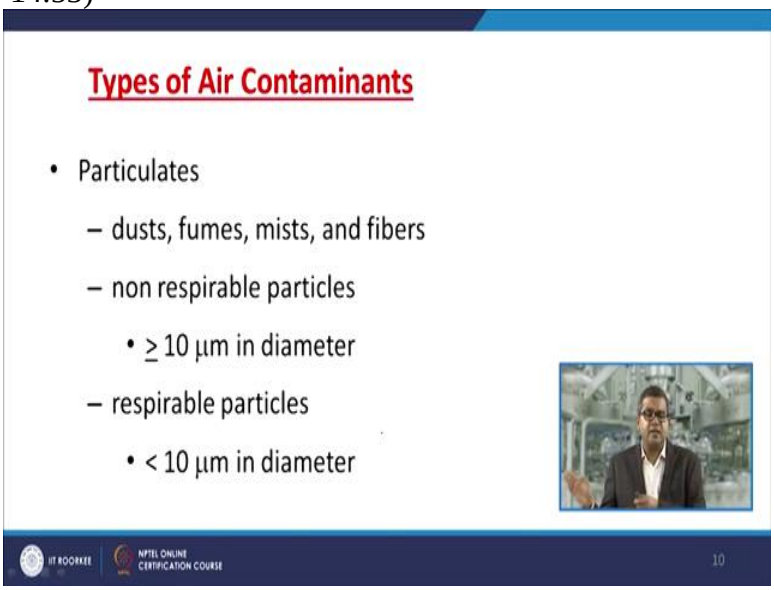

Now, before because basically almost 50 to 60 percent coverage of industrial hygiene is based on air contaminants, so we must know that what kind of air contaminants and different type of things like Particulates, dust, fumes, mist and fibers, non respirable particles that is greater than or equal to 10 micrometer in diameter, respirable particles those who are less than 10 micrometer in diameter, you must know because based on this type of information you can design or you can use the proper control techniques.

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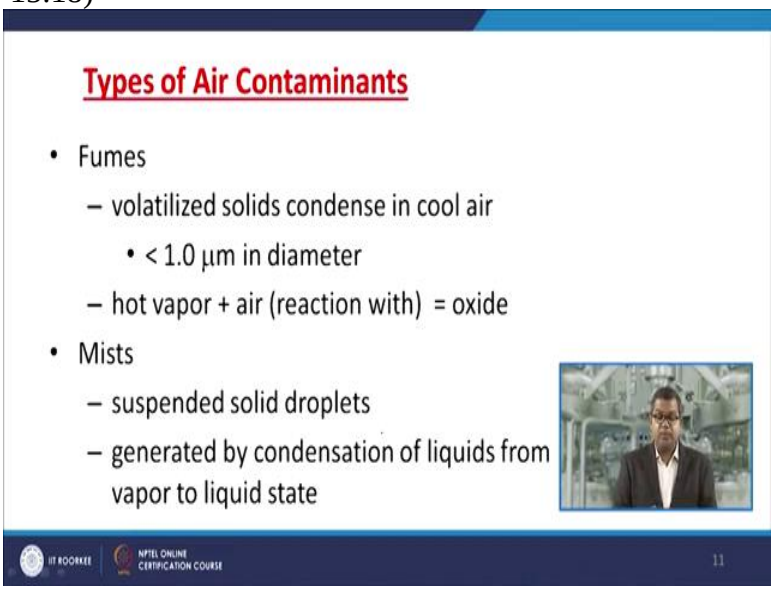

Certain fumes, they are volatilized solid condensed in cool air, less than 1 micrometer in diameter, hot vapor or air they may form certain oxide dioxins etc. This is again create a problem for the human being or the person those who are living nearby; mist, suspended solid droplets, they are generated by the condensation of liquid from vapor to liquid state.

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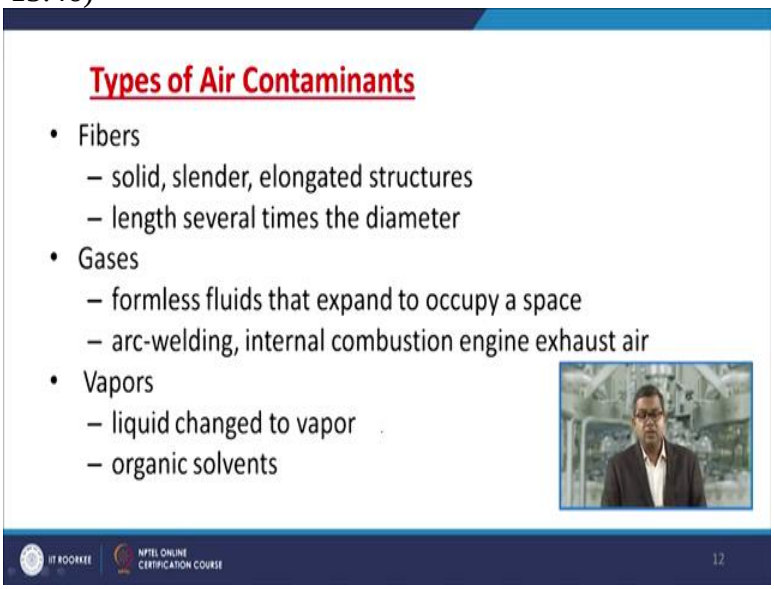

There are certain type of fibers, in the previous module, I told you that the asbestos fiber is banned in Indian context. So, fibers they may be solids, cylinders, elongated structures etc. They may get deposited into a body system, length may be several times in the diameter. There are certain gases, formless fluids that expand to occupy a space; arc-welding, internal combustion

engine exhaust air etc. There are so many things. Vapors, liquid changes to, change to vapors, organic solvents, etc.

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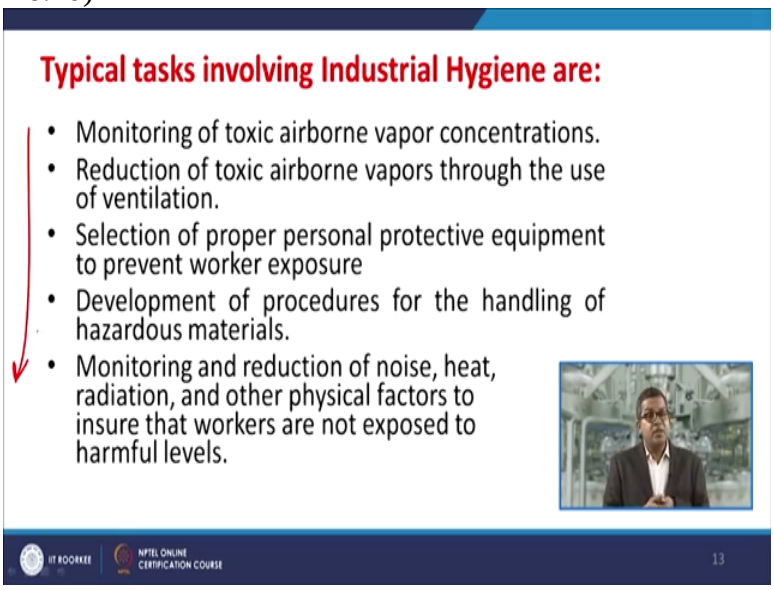

Now, in industrial hygiene we need to perform several task and those, the example are enlisted in this particular slide. We must monitor the toxic airborne vapor concentration available or present at the work place because (the) this toxic airborne vapor may escape to atmosphere, create the problem of, for nearby people like in Bhopal gas tragedy. We must monitor that they should not cross the threshold limit values. So, in case if they cross then you need to adopt the proper control measures and you have to ensure that your workers are not overexposed.

So, reduction of toxic airborne vapors through the use of ventilation, ventilation is one of the tool to control the toxic vapors at workplace, so you need to know that what is my threshold limit and by the applicable technique you must need to, to reduce the toxic airborne concentration within workplace. You need to select the proper personal protective equipment to prevent the worker exposure. That means, whenever you are using the personal protective equipment, then you (need) you are creating a barrier between the toxic evaluation and your human being, sometimes mask, sometimes goggles, sometimes cap, gloves, full body suits etc. You may sometimes…you may require to develop the procedures for handling of hazardous materials.

Suppose you are handling any scenario where you are practically unaware of any kind of toxic release or sometimes by any chance by a chemical reaction, any kind of byproduct or unwanted product being generated in due course of time, then you need to develop the procedure for protection of your workers or environment and you have to take the decision. Sometimes you may need to take this decision spontaneously; you need to continuously monitor and reduction of noise, heat, radiation and other physical factor to ensure that workers are not exposed to harmful level. So, these are the typical task you must know that how to get your environment protected.

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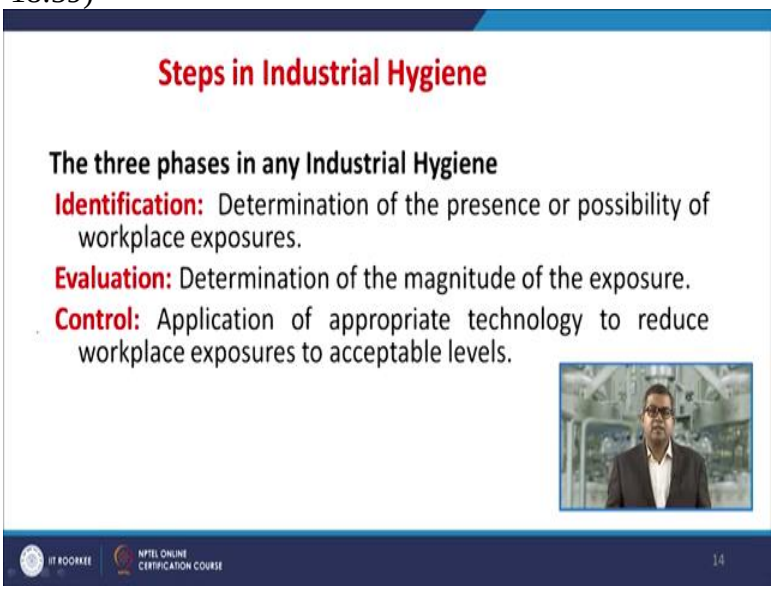

Now, there are three basic steps in industrial hygiene: Identification that is a determination of the presence or possibility of workplace exposure. I am giving you another example that I am working at say pool of hexane, then I must know that hexane is not only flammable in nature, but also it creates a health problem. So, we need to identify that hexane is present at workplace, then evaluation that determination of the magnitude of the exposure. Now, if hexane is….evaluating at a continuous manner and sometimes because of change in temperature, because of the change in temperature, the vapors may generate in manifolds.

So, you must know that what is the magnitude of the exposure because this governs the control aspect. If it is within the acceptable limit then there is no need to adopt any kind of control methodology. Now, if it is, if my workers or if the worker at workplace they are overexposed, then definitely you need to adopt a proper control methodology. Now, these control

methodologies are of two types, one is the inherent control methodology, so suppose back to the example of hexane, if the working temperature is around 60 to 70 degrees Celsius, then of course the generation of the vapors will be supposed X and suppose if temperature rises up to 90 degrees Celsius, then sometimes the magnitude of vapors may be say 2 X, 3 X etc.

So, one thing is that if you are unable to avoid this particular change in the temperature then definitely you need certain personal protective equipment and you need to adopt the methodology through which this hexane cannot catch, cannot form the (flammable) flammable mixture, and if it is formed then it cannot catch the fire, that is the first thing. Second thing is that by any means, your workers cannot inhale this type of hazardous flammable vapor to their body system. So, you must provide the barrier in between and sometimes another control methodology is that if you by any means, if you are in a position to control the temperature and pressure then try to reduce it.

So, these two factors are involved, one is the inherent and other one is that the external. Now, we start with the identification step, this identification step requires a thorough study of the chemical process, what the process going on? What are the different processes? What are the different equipment available at the workplace, how these equipment are hazardous? How these chemicals are hazardous? Sometimes you are, suppose you are producing ammonia by nitrogen and hydrogen right. So, nitrogen may require certain attention because sometimes it is available in the liquid form. Hydrogen because it is highly inflammable, hydrogen may require certain special attention and ammonia of course, it requires the special attention.

So, you must know that this is an exothermic process and you need to give the due care to nitrogen, hydrogen and ammonia, all three, not to ammonia because sometimes you may say okay, I am working in ammonia plant, that means I need to pay special attention to ammonia, but it is not. You have to pay the proper attention to this. So, you must be aware about the plant layout, you must aware about the different chemicals, different processes within the plant periphery.

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Then you must know about the operating conditions, operating conditions cover, cover up with the pressure, temperature, different type of zones. So, you must know that in case of any imbalance in temperature or pressure what problem may arises, because risk is everywhere, hazard is everywhere. So, you must know that what is my operating condition and what kind of precautions we need to take care. Then we must know about the operating procedures, operating manuals so that we should not cross the boundaries, we are practically aware that the operating procedure says that you must, if you are working with the hexane, then at 1 atmospheric pressure you have to maintain the temperature 60 to 70 degrees Celsius.

So, you do not forget, because in history there are so many accidents took place when people forget these operating procedures. One is the Seveso, another one is the flixborough, when they forget or they violated the protocol. So, you must aware about the operating procedures and operating conditions.

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Now these particular things, all these things; operating condition, operating protocol and chemical processes, they require the various kind of sources through which you can gather the information. Now these resources includes the process design description, different type of designs are available, what is the plant layout etc. You must know the operating instructions, what the operating instructions is being given by the equipment supplier and what kind of things you need to handle. Do not forget to take the safety review, the reason is that if there are N number of plants working in globe, then definitely you must know that what kind of malfunctioning and what kind of problems may occur during the smooth functioning of those plants.

So, every time they usually all these plants, they usually maintain the log book and they usually publish the different type of safety reviews. So, you must be acquainted with all kinds of safety reviews. Sometimes equipment vendor they supply the proper information for the safe handling, even in our domestic affairs. When we purchase any equipment then the equipment vendor or equipment supplier, they usually supply a proper instruction manual.

So, you need to follow those instruction manual and sometimes because of the compulsion of your process, you may need to violate all those things, do not forget to consult the equipment vendor. You must know that in which form the chemical supplier they used to supply the information and especially safety related information. So, this is again the source of

identification because if you are borrowing or if you are purchasing H_2SO_4 from vendor, then they used to supply the information that what is the concentration, what are the other ingredient, what are the other components present in that and at what percentage they are present in H_2SO_4. Now this provides a very crucial information because if suppose you are having the 70 percent pure H_2SO_4, that means 30 percent are the allied component and if you are using in a particular reactor, sometimes those allied chemicals may create a problem and may give rise to the thermal runaway reaction or a chemical runaway reaction.

So, you must adhere or you must know that what is the information being provided by the chemical supplier. Similarly those chemical suppliers, they provide the some safety precautions and in the scenarios in which you may encounter, in case of spillover, in case of transportation etc. So, you must know those particular information, we will discuss this particular thing in the next lecture when we will discuss the Material Safety Data Sheet. You must gather the information from operating persons because these are the person those who are directly in touch with that particular process.

So, suppose any malfunctioning is there or suppose there is any contamination or adulteration in the chemicals, so they can provide the proper information and a regular use, because they are the regular user of that particular equipment. So they provide the proper information and sometimes they may give you a valid suggestion to improvise the process. So, do not forget to take the information from the operating person.

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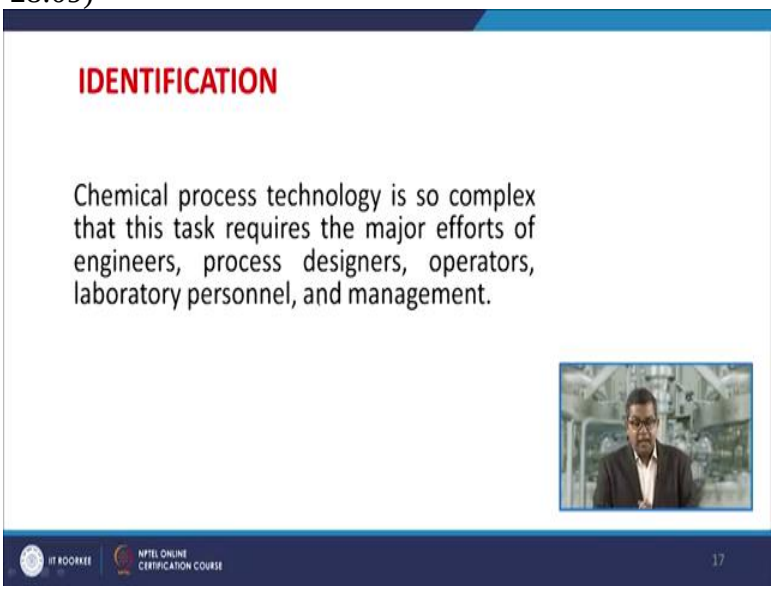

Now chemical process technology is so complex that this task requires major efforts of engineers, process designers, operators, laboratory persons, management etc. Remember the cup of tea, so we must take the help of all these person to improvise the process. And (when) whenever there is a lack in the synergy or coordination among all these resource person, then the accident took place.

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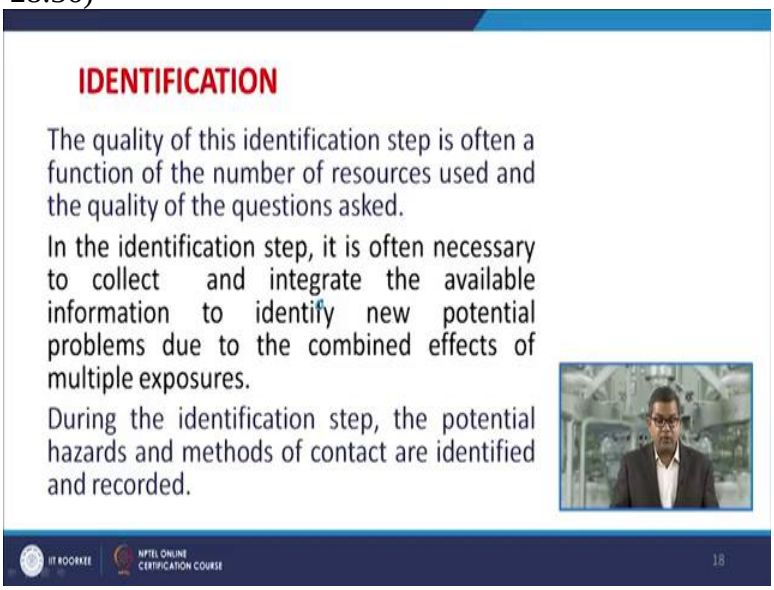

Now quality of this identification step is often a function of a number of resources used and the quality of the question asked. So, you must ensure that you ask N number of question, you use N number of resources, only then the quality will be improvised. So, in the identification step it is

often necessary to collect and integrate the available proper information or useful information to identify new potential problem due to the combined effect of multiple exposures.

So, you cannot eliminate or you should not omit any kind of useful information, unuseful information or unnecessary information may create the confusion. So, you ensure that as an engineer your responsibility is to collect the relevant information, go for all the all kinds of reviews, ask N number of questions and integrate those information for the benefit of the system. During the identification step the potential hazard and method of contact usually they are identified and recorded.

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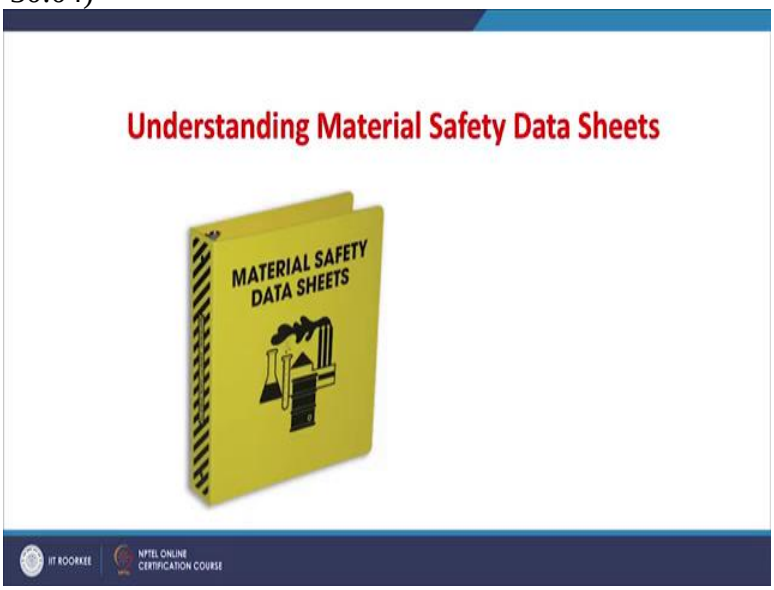

Now before we go into detail, we will discuss that how we can have the prima facie information for a particular chemical. Now, in this aspect the Material Safety Data Sheets, they play a very vital role. This gives you the entire information about the particular chemical which is being used at workplace and it is essential for every manufacturer or every producer of those chemical to give the Material Safety Data Sheet.

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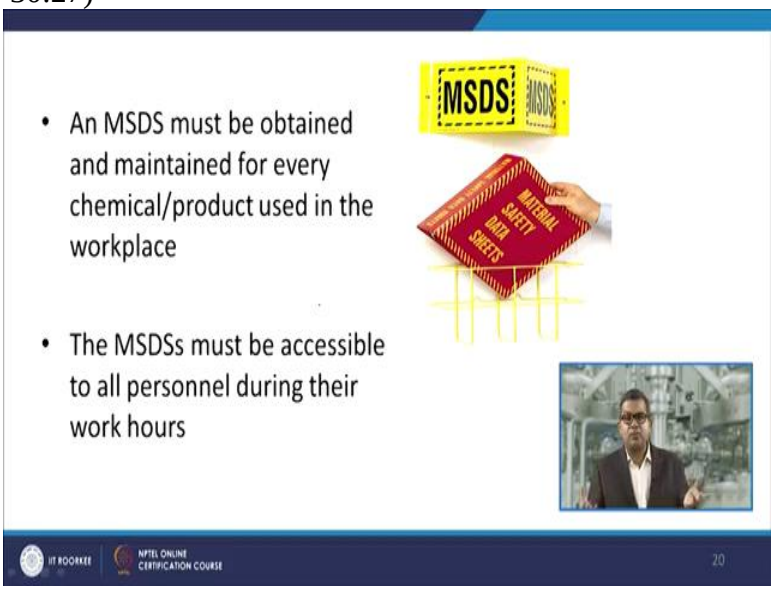

Usually the MSDS must be obtained and maintained for every chemical product used at workplace. Now, these MSDS must be accessible for all personnel during their working hours so that in case of any problem, in case of any doubt or confusion in the working system, then they must get the information, appropriate information from those documents.

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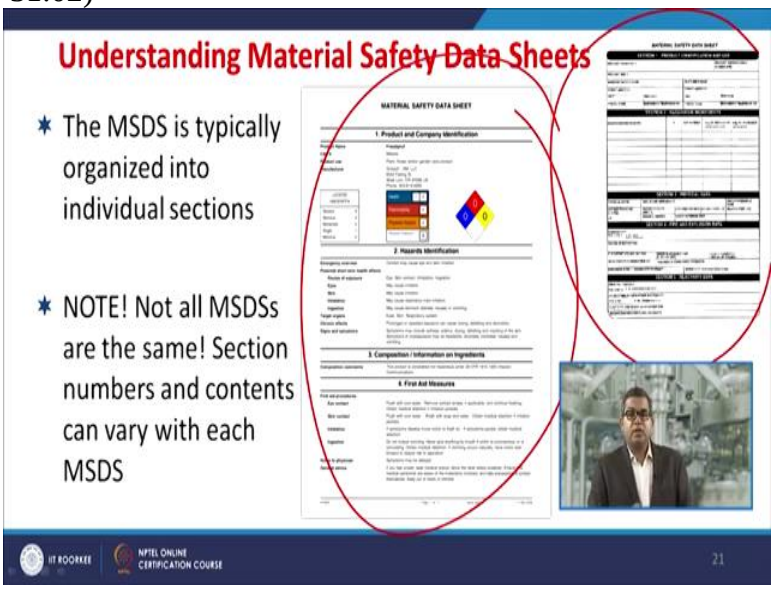

Now the MSDS is typically organized into various sections and every section deals with the useful information. Remember, not all MSDS are same, section number and contents can vary with each MSDS, this is the sample MSDS and in subsequent lecture, I will go into detail that what is the significance of each and every section in the MSDS.

So, in this particular lecture, in this particular module, we have discussed about the 3 integral aspect of (chemi) industrial hygiene; identification, evaluation and control methodology. And theoretically, now in subsequent lectures, we will go ahead with the identification aspects, how we can get information that this particular component or this particular process is hazardous, how it is having the major gravity and how we can control it.

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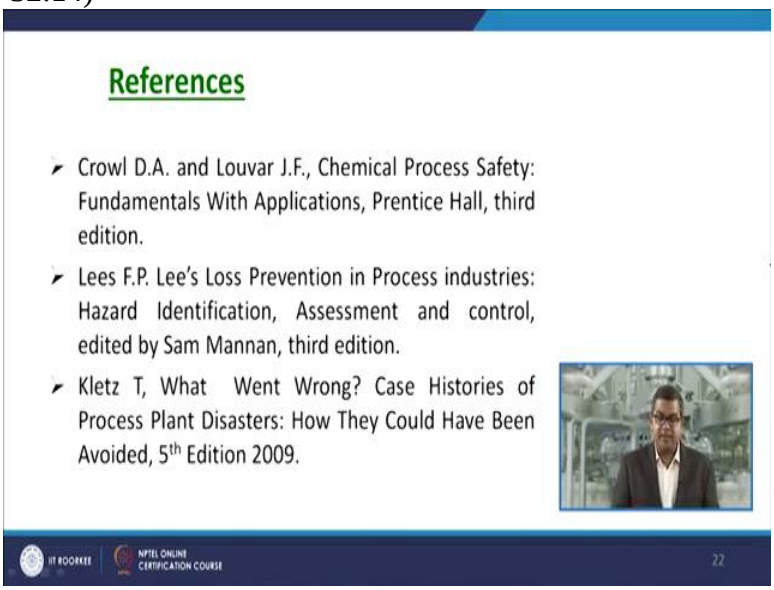

There are several references enlisted which can be utilized for the identification step by this way. Thank you.