Health, Safety and Environmental Management in Petroleum and offshore Engineering

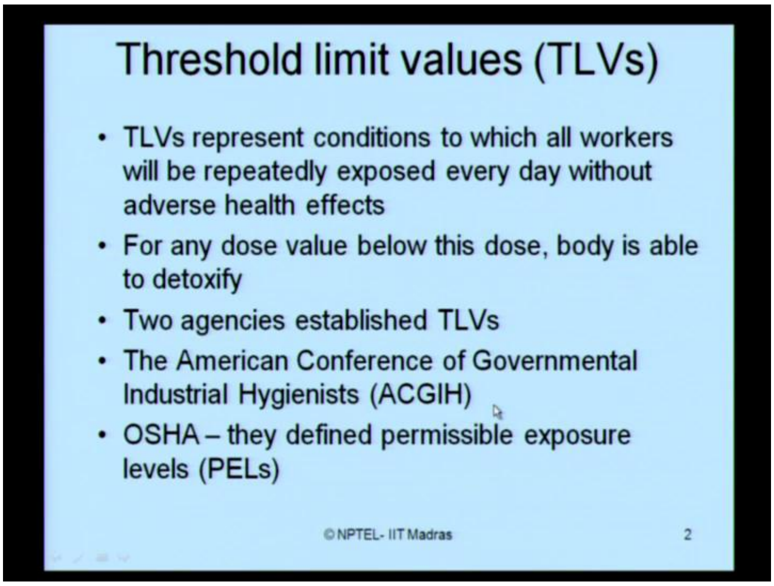
Prof. Dr. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module No. # 03

Lecture No. # 02

Toxic release and Dispersion modeling

(Refer Slide Time: 00:31)



We have been discussing about the toxic release and dispersion modeling. We already discussed about the different kinds of dosage, and the respective response of human being's to these dosages. Therefore, we define these dosages of toxic chemicals as ED, LD and TD; we will slightly look at them more in detail now.

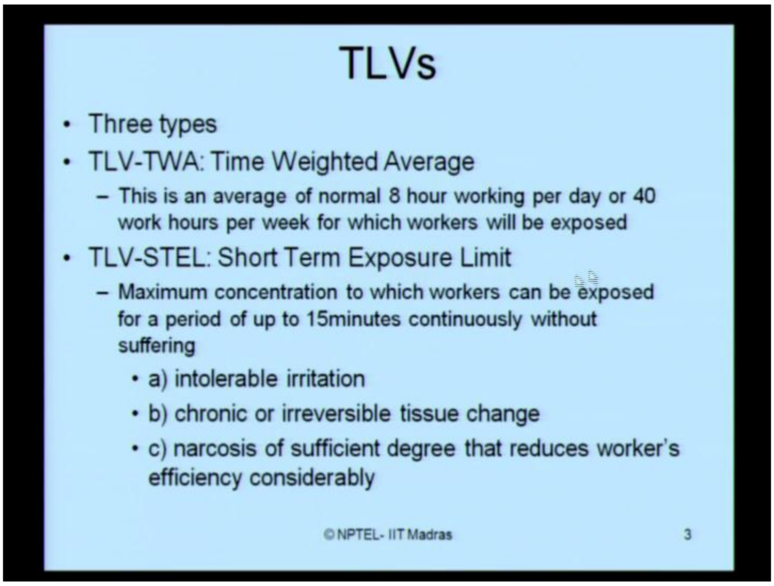
As we said these dosage should have an acceptable upper limit; we call this limit as threshold limit values expressed as TLVs in the literature. The TLVs represent conditions to which all employees will be repeatedly exposed every day without adverse health effects. Now you can either appreciate ladies and gentlemen, the effect of the chemical or the physical agent on human body is now directly brought into a threshold limit value by the industrial standards saying that the upper limit of these values or threshold limits of these values are those, where the employees on board even though they will be repeatedly exposed everyday should not cause any adverse health effects on them.

Remember that I am putting a word here adverse. So, there will be certainly certain health effects, which will come into play when you are exposed to these kind of dosages. There is absolutely no doubt on that, now we can recollect that oil and gas industry has a basic level of risk acceptance. But what we are saying here is that threshold value, so that that beyond which there will be adverse effect, so that should be avoided.

For any dosage value below this TLV human body is able to detoxify. There is not going to be any irreversible damage on its health. You will be able to detoxify and control the effect of that dose on this response. There are two agencies internationally recognized who have established the TLV values. Again you may say TLV is a subjective issue, because you are talking about on subjective characteristic of human health saying that adverse effect. So, which effect is adverse for example, eye irritation to me is adverse, loss of eye is an adverse effect for another person. So, there is a subjectivity here therefore, international agencies established already the TLVs for oil and gas industries.

The American conference of governmental industrial hygienists ACGIH and OSHA, I have defined the acceptable level of TLVs OSHA has slightly defined in different way they call this by a name of permissible exposure levels PELs. Both of them are actually addressing the same content of acceptable upper limit of the chemical dose or the physical agent which can cause effect on human body. There should be no adverse effect when they are continuously exposed, but ACGIH directly gives you TLVs for different chemical dosage whereas, OSHA gives you PELs that is a difference.

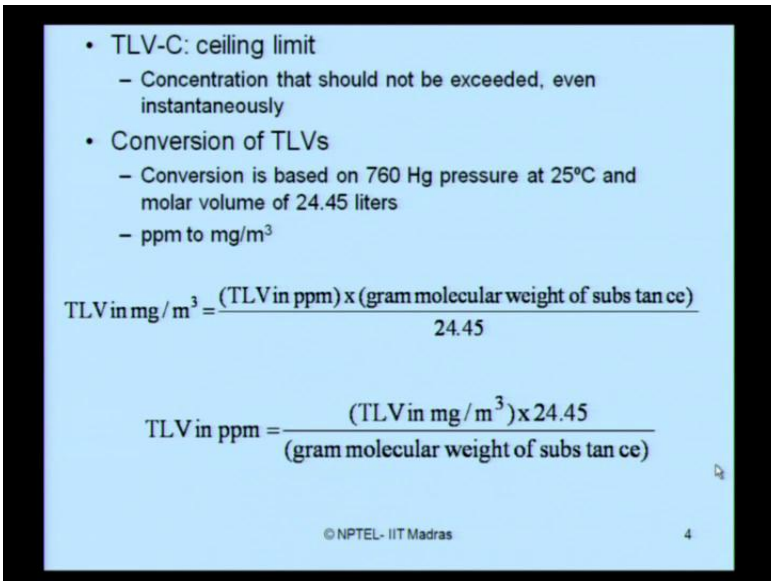
(Refer Slide Time: 03:35)



Let us talk about threshold limit values which are defined by the industry international standards. There are three types of TLVs - one is what we call as TLV time weighted average. This is an average of normal 8 hour working per day or 40 hours working per week for which workers will be exposed. So, basically TLVs is a dose, it is a dosage limit; this is an average of normal 8 hours you consider or 40 hours a week it means five days a week only a person is working, Saturday and Sunday is non-working day for him. And an average, I take 40 hours of working per week for which the worker will be exposed to a specific kind of dose and that dose is what I call as TLV time weighted average.

Now, there is another TLV called STEL which is short term exposure limit. This is a maximum concentration to which an employee can be exposed up to a maximum period of 15 minutes only continuously. If you exposed in beyond this there will be desirous effects, but even if we expose within fifteen minutes he should not develop intolerable irritation. You should not develop a chronic irreversible tissue change or narcosis of sufficient degree that reduces worker's efficiency considerably. These should not occur even if he is exposed continuously up to 15 minutes. So, if you look at that kind of upper limit of dosage which I call as a maximum concentration, I call them as short term exposure limit. The term here refers to short term, because you are specifying the duration is very, very small compare to a normal working hours of a person on board.

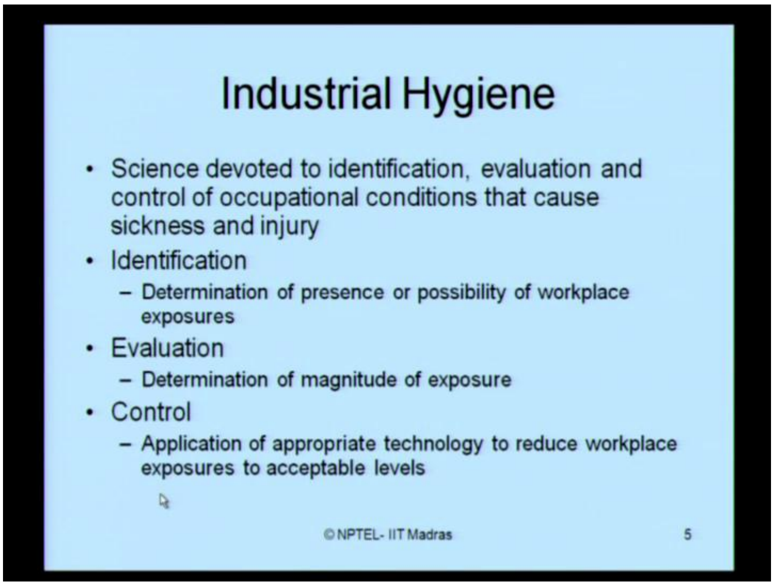
(Refer Slide Time: 05:35)



You also have what is called TLV-C, which is a ceiling limit. It is that concentration which we never should be exceeded at all even instantaneously. Even for a very, very brief time this kind of concentration of that chemical exposure should not be exceeded by chance even - that is an upper limit basically. So, threshold limit values are always a ceiling limits there're some acceptable levels as we saw in the previous slide, so TLV, STEL and etcetera.

Now you can also convert TLV to ppm (parts per million). So, the conversion actually is based on 760 mercury pressure at 25 degree celsius and a molar volume of 24.45 liters what we call as ppm to mg per cubic meter. So, if you want TLV in the value of mg per cubic meter, if you know the TLV in parts per million, then multiply that with the gram molecular weight of the substance, which causes the toxicity and divide that by the molar volume of 24.45. On the other hand, if you have TLV in mg per cubic meter use the same equation in the reverse order to find TLV in parts per million. So, TLV can be expressed either in milligram per cubic meter or in parts per million using this two standard equations, which is now shown to you.

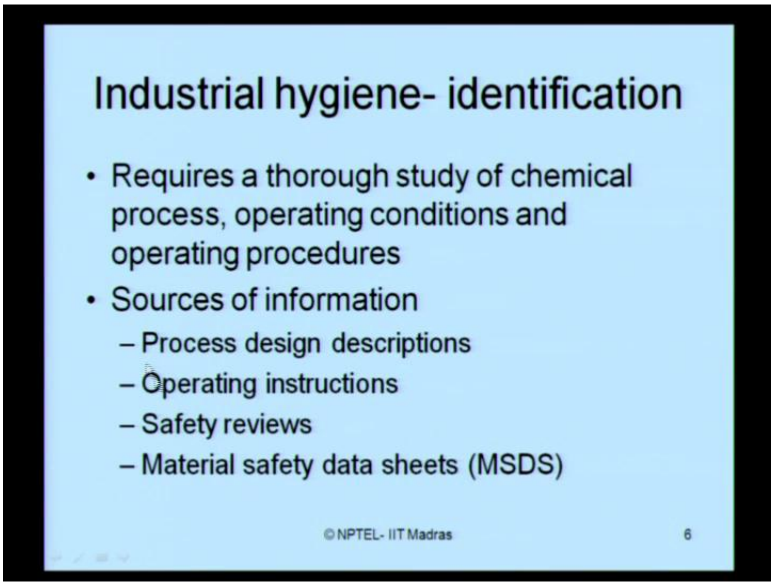
(Refer Slide Time: 07:07)



When we talk about safety, we spoke about acceptable level of risk, we spoke about toxicology, we spoke about toxic agents, it can be physical or chemical, we talk about the response to this dose on human body, then we defined LD, ED and TD. Then we spoke about the TLVs - the upper limits the threshold values of these chemical doses, all put together now we speak in general about what we called as industrial hygiene. It is actually the science devoted to identification, evaluation and control of occupational conditions that cause sickness and injury.

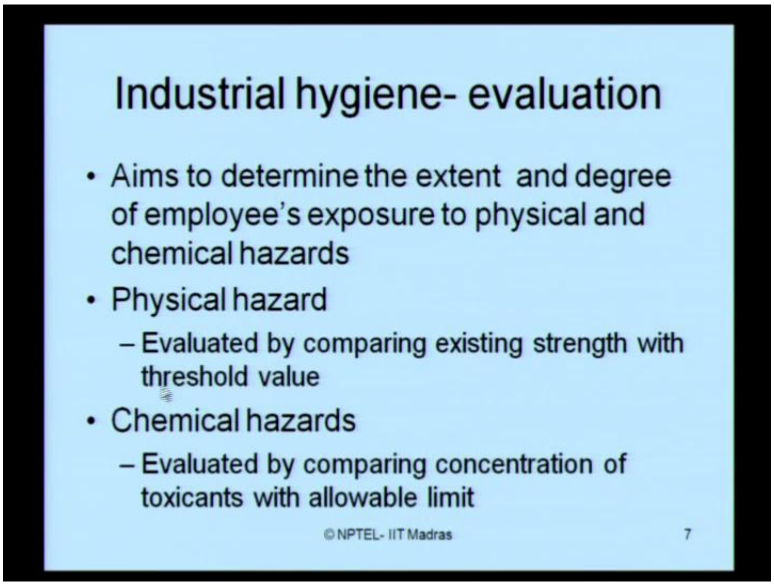
Identification actually is determination of presence or possibility of work place exposures. You are trying to determine the presence or possibility of any exposure to that kind of toxic chemicals. Evaluation is to determine the magnitude of exposure and of course, the control is application of appropriate technology to reduce the workplace exposure within acceptable levels.

(Refer Slide Time: 08:23)



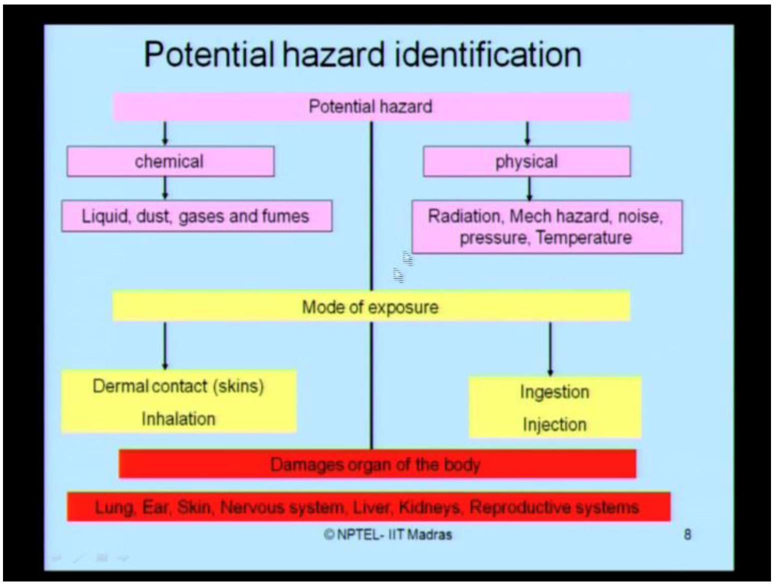
When you talk about identification, it requires a thorough study of chemical process, operating conditions and operating procedures. The sources of information to identify them are the following you can have a very detailed process and design descriptions. You can look at the operating instructions of the process industry, you can look at the safety reviews and methodologies what the industry follow, and you can also look at material safety data sheet to know about the toxic nature of the inventory being stocked in the plant during operation which we call as MSDS. So, based upon these available sources of information, you can always identify the chemical process thoroughly and there operating condition and operating procedures.

(Refer Slide Time: 09:18)



If we look at the evaluation, basically the aim is to determine the extent and degree of employee exposure to physical and chemical hazards. So, the objective is to determine the extent and degree of exposure to a human body or the employee on board to any physical or chemical hazards. Now what do you understand by a physical hazard? Physical hazard actually is evaluated by comparing the existing strength with the threshold value; whereas, chemical hazards or evaluated by comparing the concentration of toxicants with allowable limits. So, chemical hazards deal with the chemical concentration of toxicants, physical hazards deal with the comparing existing strength with any threshold value.

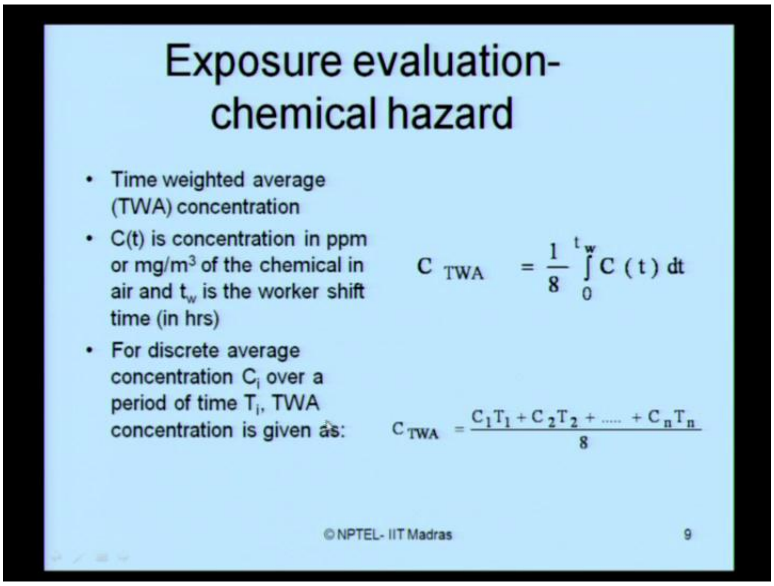
(Refer Slide Time: 10:04)



Now, we look at the potential hazard identification chart, potential hazards can be broadly classified into two parts. One is what we called as a chemical hazard, other is what we called as physical hazard. Look at the chemical hazard, it can come from liquid dust, gases and fumes; whereas, physical hazards can be caused by a radiation, mechanical hazards, noise, pressure, temperature. Now when you are exposed to both of these kinds of hazardous situation the mode of exposure can also be through dermal contact inhalation may be through skins or may inhalation because a chemical hazardous situation can arise, it can enter the human body like liquid, dust, gases, fumes etcetera either by a dermal contact through skin or by inhalation. Whereas, the physical agents can enter to human body through ingestion and injection. Ladies and gentlemen, you will easily recognized that these are the four terms by which we said their toxicant can enter human body.

Now, I am categorizing these two based upon the two types of chemical or the potential hazard situation in an industry. So, totally ultimately both of them can damage organs of the body like lung, ears, skin, nervous system, liver, kidneys, reproductive system etcetera. So, that is the ultimate damage or the effect of these kind of exposure been given. The mode can be either through skin or dermal contact, through inhalation, through injection or through injection and the agent can be either physical or chemical.

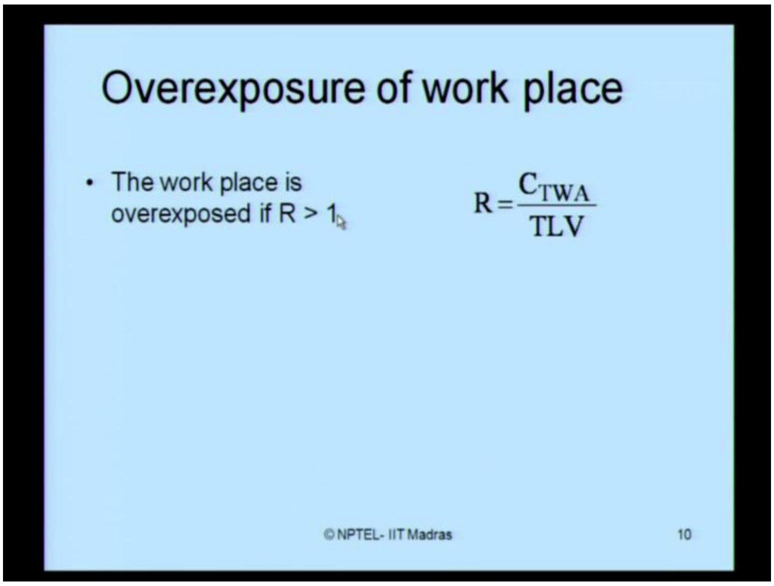
(Refer Slide Time: 11:50)



When you talk about the evaluation to these exposures, let us first concentrate on the chemical hazard. Physical hazard, we will look at later. We will first talk about the chemical hazard; I want to basically evaluate the exposure modeling for these kind of chemical hazards.

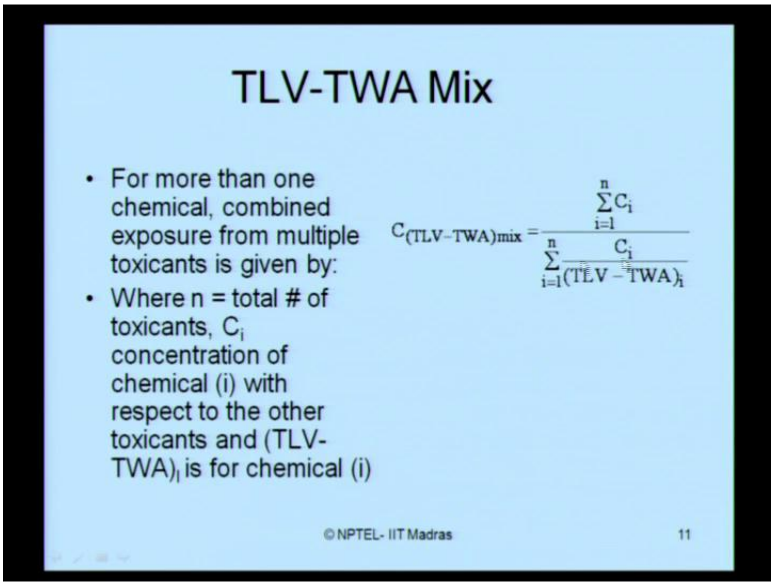
Now, I look at what we call time weighted average concentration, what we address as TWA. TWA concentration is given by a simple equation integral zero t w C of t, where c of t is a concentration in parts per million or in milligram per cubic meter of the chemical in air, and t w is a worker shift in hours, and you can always see and guess why there is a denominator of 8 here. Because I am dividing that concentration for a normal working hours of 8 hours a day or 8 hours a shift. If you want to use a discrete average concentration technique for example, you have different concentration exposed for different time for example, the concentration C 1 is for T 1, and concentration C 2 is exposed on for time T 2 etcetera,. Simply you can always find a discrete average concentration C i over a period of time T i, we will given by this simple equation.

(Refer Slide Time: 13:18)



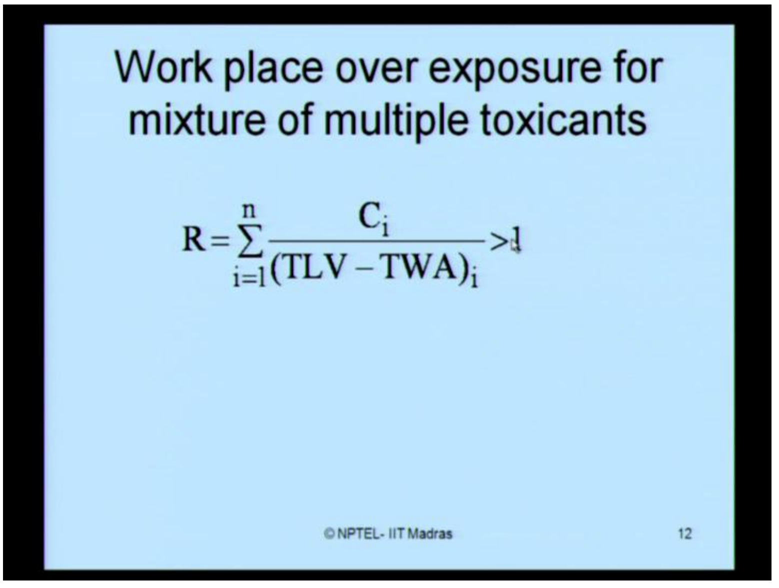
You have something called over exposure of this chemical concentration in a work place. The work place is considered to be over exposed if r is greater than one now what is r r is given by a simple equation as C T by W A by TLV; TLV is a threshold limit value and C W A is what we computed from the last slide. The ratio of these two will give me a number by value of R and if the value of R is greater than one, then I can call that the work place is over exposed and it is not a very good successful place.

(Refer Slide Time: 13:57)



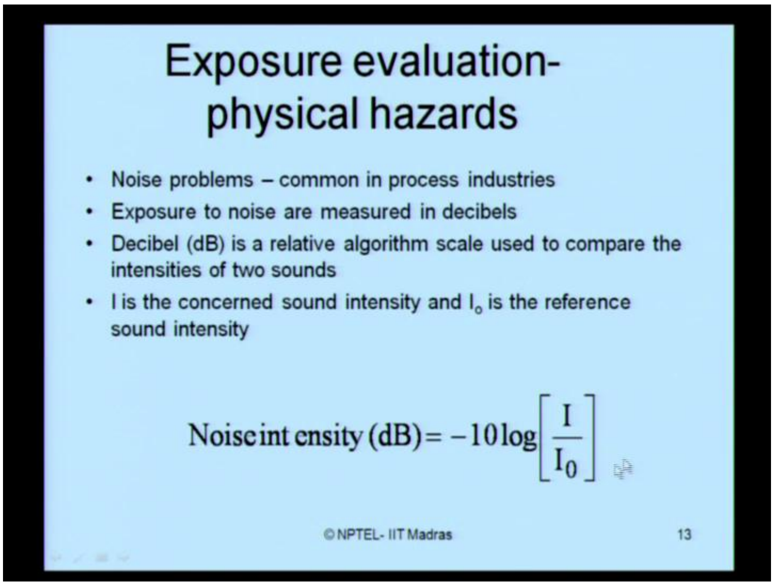
Sometimes TLV-TWA mixture is also available in literature. For example, if you have more than one chemical, then they are combined exposure from multiple toxicants is given by these equations, because TLV is a specific value expressed in milligram per cubic meter or ppm corresponds to a specific chemical. But you have a combination on different chemical then we use what we called as TLV-TWA mix and that concentration is given by a simple equation as shown here, where in this equation n which is an upper limit of this in summation is a total number of toxicants you are considering for which the human beings or the worker is being exposed, and C i is the concentration of chemical of i with respect to the other toxicants.

(Refer Slide Time: 14:52)



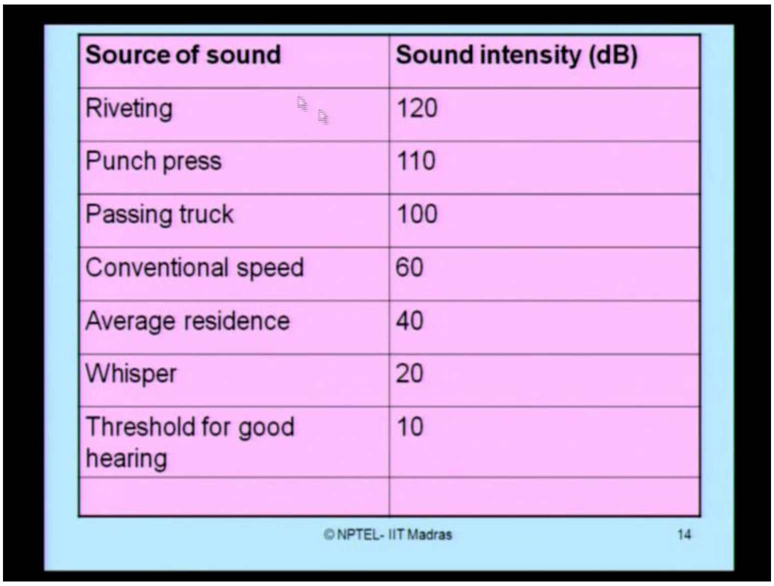
Now, in this case, if you have got a multiple toxicant then the overexposure index is given by the simple equation and that ratio crosses one or exceeds one then I can call that the work place is exposed is over exposed.

(Refer Slide Time: 15:08)



If you look at the physical hazards then if you concentrate on evaluating the exposure limits of the physical hazards, let say look at the noise problem. The noise problem is a very common phenomena in any process industry. Generally, exposure to noise are measured in decibels. Decibel is a relative algorithm scale used to compare intensities of two sound levels. It is given by a simple equation as shown here, where I is the concerned sound intensity which you want to check whether it is within acceptable limits or not and I 0 is a reference sound intensity. Now, you may ask me sir where this I 0, the reference sound intensity is available that is available in the next slide for you.

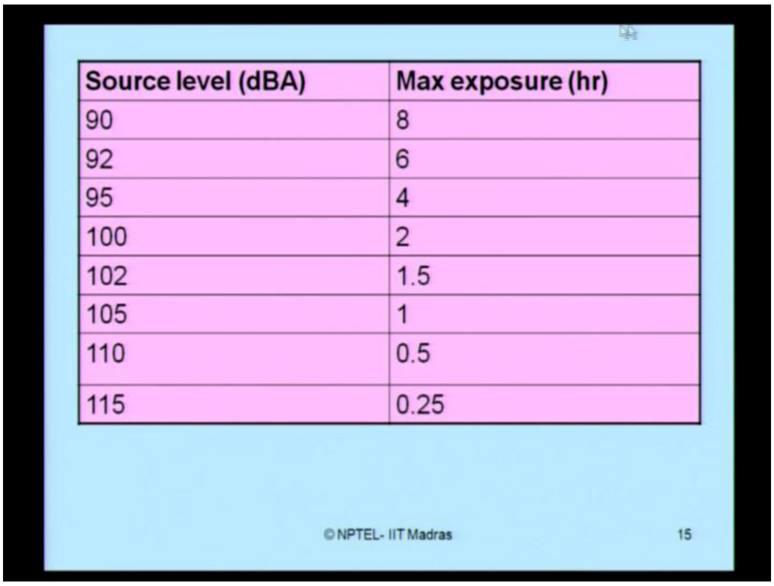
(Refer Slide Time: 15:57)



Source of sound	Sound intensity (dB)
Riveting	120
Punch press	110
Passing truck	100
Conventional speed	60
Average residence	40
Whisper	20
Threshold for good hearing	10

These are all the reference sound intensity available; for example, if you are doing an operation of riveting, then 120 decibel level is the sound intensity; if you are doing a punch press operation is 110 and so on and so forth.

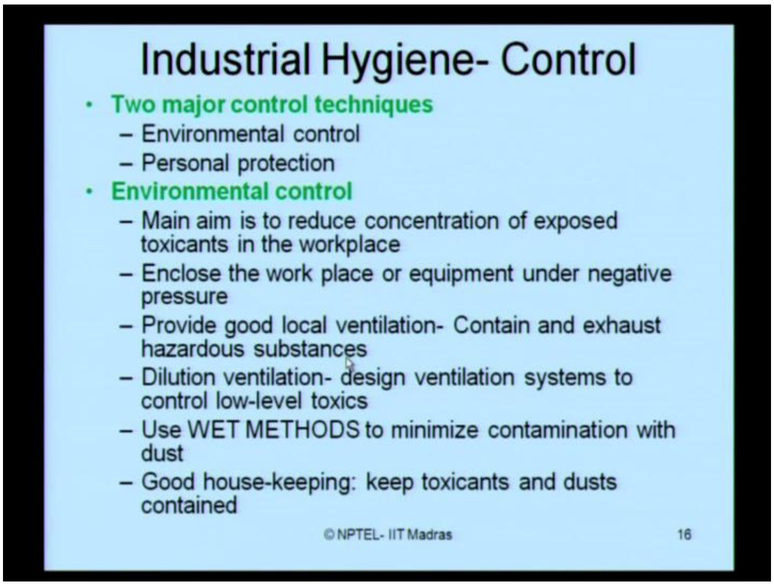
(Refer Slide Time: 16:11)



Source level (dBA)	Max exposure (hr)
90	8
92	6
95	4
100	2
102	1.5
105	1
110	0.5
115	0.25

Now, for a given decibel level of sound or noise which is a physical hazard, you are permitted to have a maximum exposure of so many hours if this is being allowed. This is based upon industrial standard specified by many organizations, which I am presenting to you for a direct reference. So, if your process industry has a reference sound level, for example, let say 100 then the maximum exposure limit to which a worker can be exposed to this kind of sound level should not be more than two hours. So, these all are industrial standards which are related to physical hazards that can be causing damage or irreversible damage to human health on a plant.

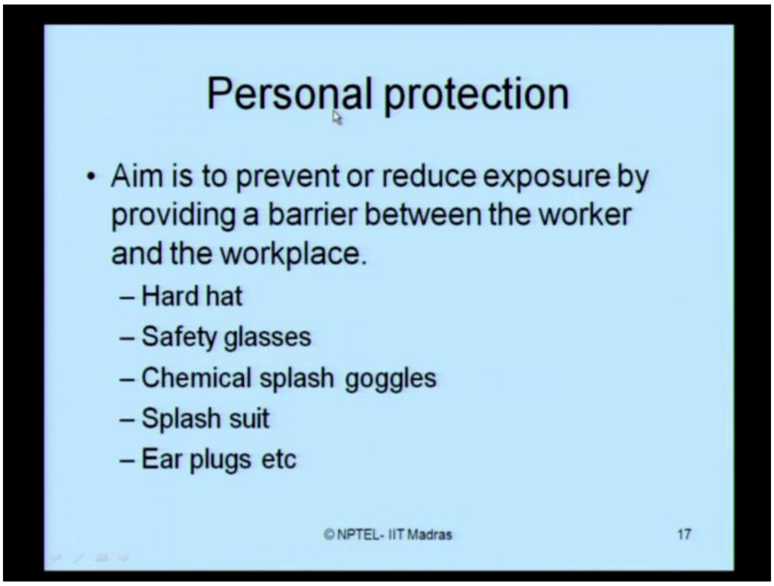
(Refer Slide Time: 16:58)



When we talk about control, there are two major control techniques that can be employed in industrial hygiene. One is what we called as environmental control; other is what we called as personal protection. The main objective of environmental control is to reduce concentration of exposed toxicants in the workplace. The rules are like this enclose the workplace or the equipment under negative pressure, provide a good local ventilation, so that you can contain or and exhaust hazardous substances. The other alternative control you can do is create what we called as dilution ventilation.

What does it mean? Design the ventilation systems to control low-level toxics. So, you can use what we call as wet method to minimize contamination with the dust for example, you must have seen it is a very common practice where when the shaft floor is generating lot of dust, they try to keep the floor basically wet. This is one of the simple techniques by which you can control the contamination or the physical hazard created by dust. The third, the final one could be what I call as a good housekeeping. Keep the toxicants and dust in a contained environment may be you keep them closed or keep them in a vessel or a containment which is under constant monitoring and control. So that they do not cause a physical hazard for a people working on board.

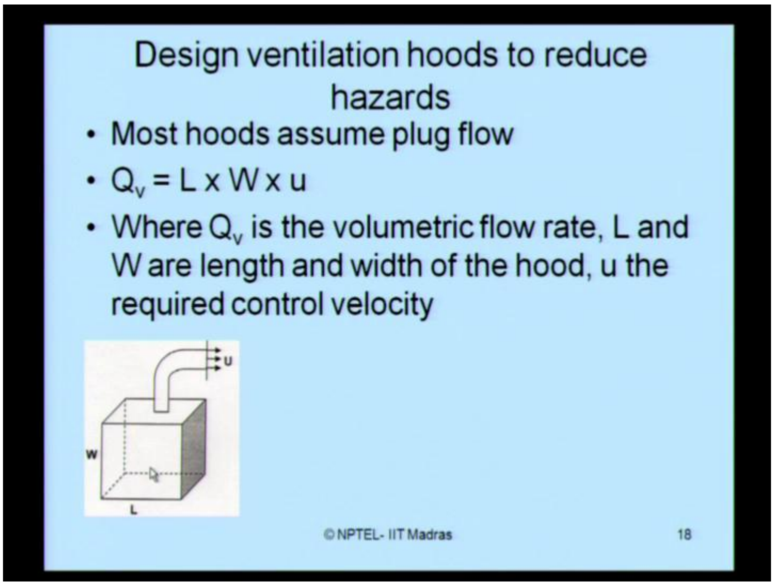
(Refer Slide Time: 18:36)



If we look at the personal protection, basically this aims to prevent or reduce exposure by providing a barrier between the worker and the workplace. There are simple techniques which are insisted upon on personal protection of worker on board, where a helmet or a hard hat always wear safety glasses try to wear chemical splash goggles if you are working on chemical exposure industry. Wear a splash suit if you are working on fire explosion hazard industries; wear ear plug if you are working on the industry where the noise level is relatively high.

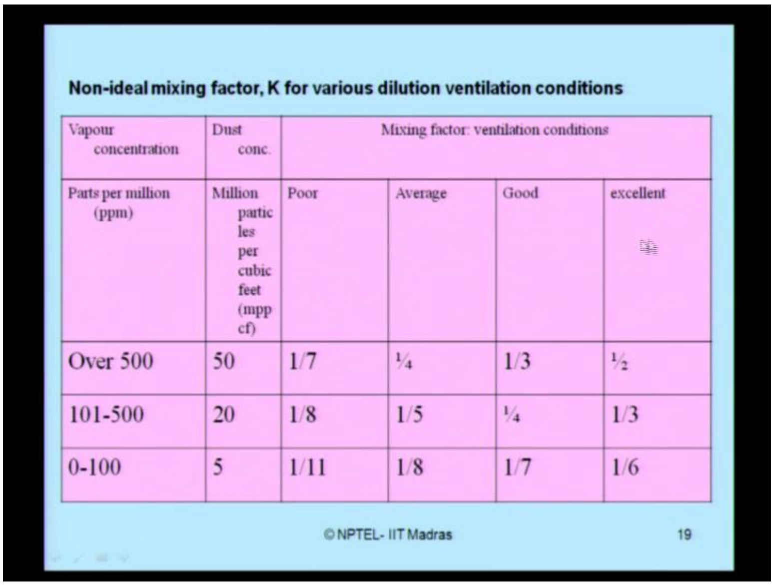
Generally, ladies and gentlemen when we talk about health safety people generally insist on essentially personal protection. People have been overall thinking so far that by personal protection ensuring, let say by wearing a helmet, wearing a safety glass during welding, or wearing a splash goggles etcetera one will be safe in his working environment. HSE deals much more than what we talk about personal protection. We have been so far discussing full two modules of lectures where we have given you a very fairly a broad idea about HSE therefore, personal protection is only a very small component of health safety related to wearing a hat or wearing a helmet or glasses etcetera.

(Refer Slide Time: 20:03)



Now, to contain the dust or the physical agent being hazardous for a person working on a workplace, you can always design a ventilation hood to reduce these kinds of hazards. Let us see, what is that ventilation hood, which you can design. Basically there is a containment area where dimensions given are L and W. You have an exposure or an let say an exit which comes from this container volume. Generally most of the hoods assume what I called as a plug flow. If you want to design this then in that case my equation where I will find a volumetric flow rate is given by a product of L, W and u; where L and W are the length and the width of the hood what you are designing and whereas u is the required control velocity which you must employ, so that the container inside this should be evacuated quickly without creating any potential hazard.

(Refer Slide Time: 21:05)



Non-ideal mixing factor, K for various dilution ventilation conditions

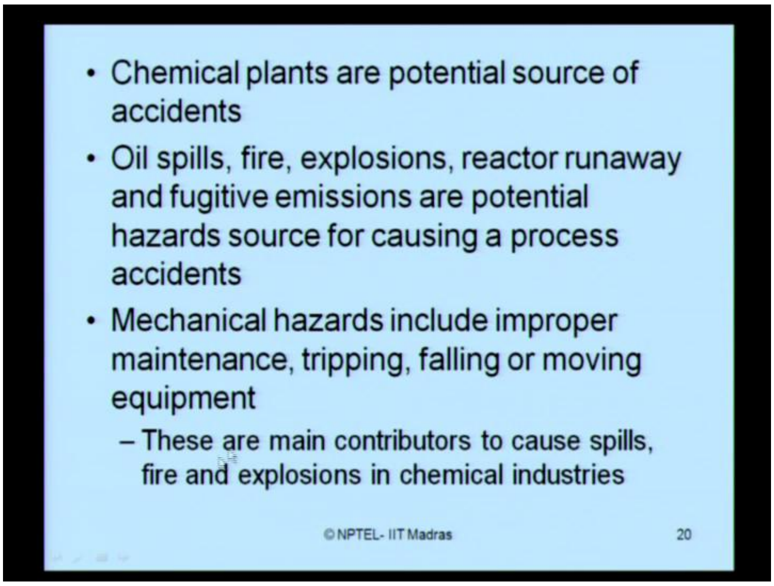
Vapour concentration	Dust conc.	Mixing factor: ventilation conditions			
Parts per million (ppm)	Million particles per cubic feet (mppcf)	Poor	Average	Good	excellent
Over 500	50	1/7	¼	1/3	½
101-500	20	1/8	1/5	¼	1/3
0-100	5	1/11	1/8	1/7	1/6

When we look at different physical agents which can cause or contaminate the environment, then we use a factor called non-ideal mixing factor K which can be used for the dilution ventilation conditions. Now the table goes like this, if you have a vapor concentration and dust concentration mixed together which is a non-ideal situation then the mixing factor for a proper ventilation condition is given by in four specific columns as poor, average, good and excellent.

Let us try to read this table slightly in a different way, before we read it let us try to understand how I am specifying my vapour concentration. My vapour concentration will be expressed in parts per million, whereas my dust concentration will be expressed in million particles per cubic feet (mppcf). Suppose, if a vapour concentration is about exceeding five hundred in a process industry and that mixes with the dust concentration of fifty and that ratio is one in seven then you will call that ventilation situation as poor.

If that mixture is happening as fifty-fifty, you can call the ventilation condition as excellent. Similarly, if your vapour concentration is varying from zero to hundred or basically less than hundred, and your dust concentration is about five million particles per cubic feet as shown here, then if the ratio of mixture or mixing factor is one in eleven, then the ventilation condition what you have in industry is chalked as poor. If that mixing ratio is one in six, then your ventilation condition in your arrangement in the process industry is considered to be excellent.

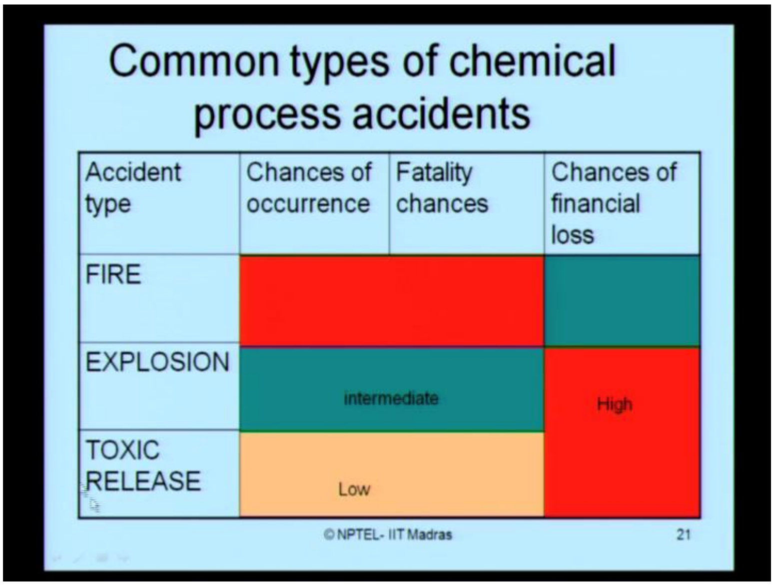
(Refer Slide Time: 23:11)



We all understand that any process industries to be very specific, any chemical plant are actually potential source of accidents. They have lot of hazardous situation because of the process by itself, because of the complex mechanical components present in the system. Further when address to oil and gas industry, we have many more hazardous situation which have potential source of accidents, for example, there can be oil spills, there can be fire, there can be explosions, there can be reactor runaway, there can be fugitive emissions, these are all considered as potential hazardous source for causing a process accident and most of them are common in case of like for example, oil spill, fire, explosion, fugitive emissions, these all are very common in case of oil and gas industry.

Look at the mechanical hazards, they include improper maintenance, tripping of valves, falling or moving equipments. Mainly the contributions come from these mechanical hazards which will result in oil spills, fire and explosions, and chemical industries. On the other hand, what do I want to say here is in case of improper maintenance, in case of frequent tripping of control valves, the mechanical hazards will lead to chemical accidents causing from chemical industries or process industries which can result in an oil spill, fire or explosion.

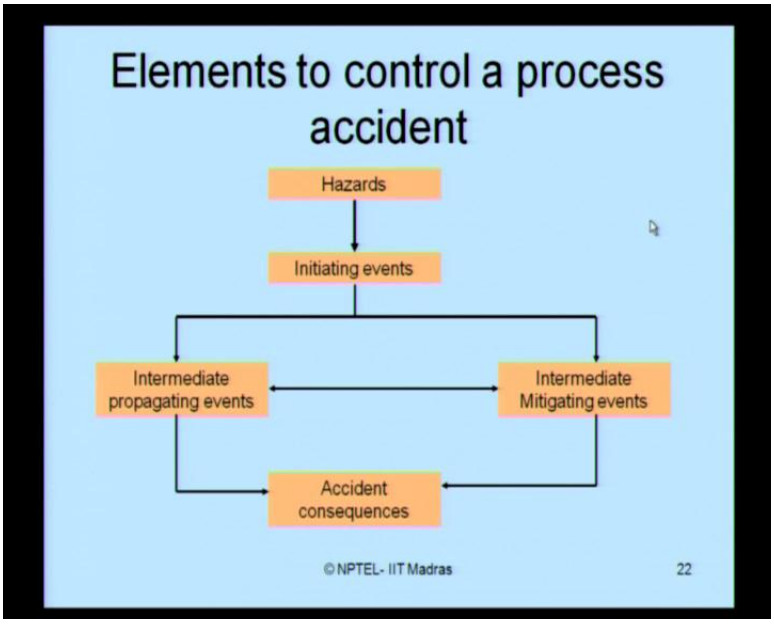
(Refer Slide Time: 24:50)



If you look at the common types of chemical process accidents, and try to chalk them in a different format of a matrix as shown here; if you look at three kinds of accident types fire, explosion, and toxic release. Look at the chances of their occurrence, the fatality chances, and chance of financial loss to the company. Remember ladies and gentlemen in the first module of the lecture, we have already discussed that risk is always financed as well. We should know if at all risk is occurring in the oil and gas industry, how to invest on controlling either the risk mitigating or let say maintaining a risk at acceptable level.

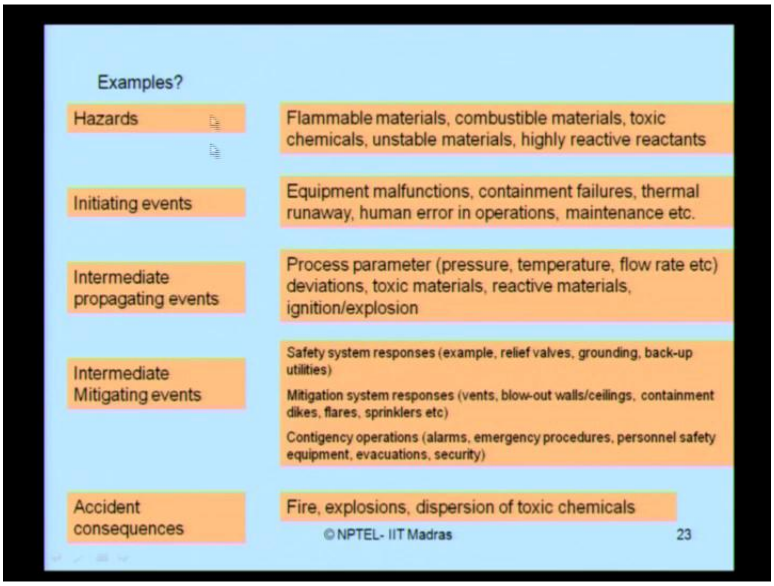
So, if you look at the accident types which are very common in chemical or in process industries, if you look at the fire if the chances of occurrence is very high, and there the fatality chance is very, very high. If you look at toxic release, the chances of occurrence of these accidents are low, and the fatality resulting from toxic release are relatively low, but the problem with this kind of release is the financial loss to the company is enormously high. So, this matrix will give you an idea what kind of accident creates an intermediate financial loss. Fire accidents are having fatality chances very high, but the financial loss incurred from fire loss fire accidents are relatively intermediate level compared to the that of financial loss occurred from what I called as a toxic release accidents.

(Refer Slide Time: 26:28)



Now, let us look at the elements to control a process accident. If we look at the hazards, there are some initiating events which can be divided as intermediate propagating events and intermediate mitigating events, both of them put together will result in what we call as accident consequences.

(Refer Slide Time: 26:52)

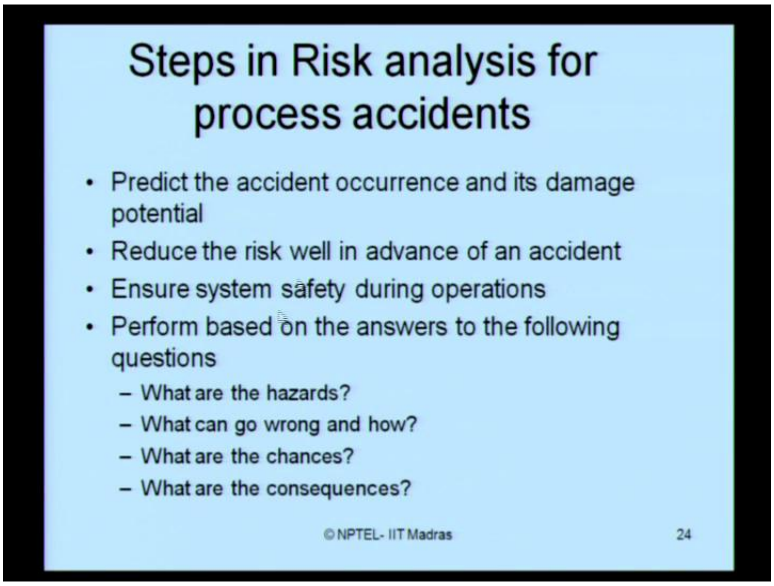


Then I have some examples, for an example, let’s us say hazards flammable materials, combustible materials, toxic chemicals, unstable materials, highly reactive reactants - we call them as hazards situations. If you look at initiating events present in any accident scenario that can arise from equipment malfunctioning, containment failures, thermal runaway, human error in operation and maintenance etcetera. If you look at some of the intermediate propagating events, then process parameters like pressure, temperature, flow rate can be attributed to this. If you have any deviations from the design intents, if you have any toxic materials, if you have reacting materials, if you have ignition and explosion scenarios, then they have all will result in what we call intermediate propagating events.

If you look at intermediate mitigating events, then in that case if you have any safety system responses similar to relief valves, grounding, back up utilities - they all will contribute to what we call as intermediate mitigating. If you have mitigation response system response like vents, blow outs, containment dikes, flares, sprinklers etcetera or if you have any contingency operation devices like alarms emergency procedures personnel safety equipments evacuation plans for emergency planning security etcetera, all of them put together will fall in intermediate mitigating events.

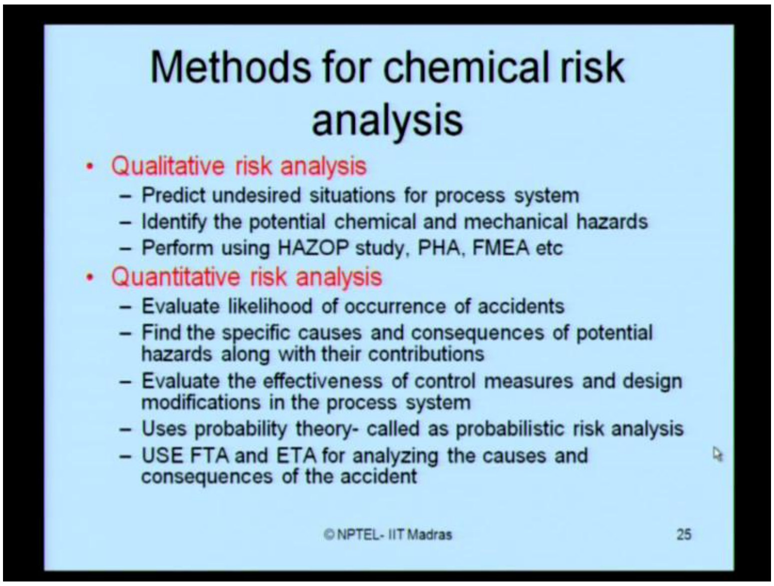
Ultimately the accident consequences can be result in fire, they can result in explosion. It can disperse of toxic chemicals; these are all basically the consequences from an accident. We all understand right from first module of lectures that hazard is a scenario accident is an realization or risk getting realized from on hazardous situations. So, a flammable material can become an explosion provided, the containment failure would have occurred or they may be human error in operation may be the pressure, temperature is not properly controlled may be it is a toxic chemical may be the safety system responses are not properly working no contingency operation are present in the plant. Ultimately this inventory which was hazardous in the beginning became an accident as an explosion or fire.

(Refer Slide Time: 29:39)



Now, when you look at the process industry, I want to do risk analysis for that what are the steps involved in doing risk analysis in a process accident. Firstly, predict the accident occurrence and its damage potential reduce the risk well in advance of an accident ensure system safety during operations, and of course, perform based on the answers to the following questions what are all the hazards present in the industry what can go wrong, and how what are the chances of that going wrong what are the consequences if that goes wrong. So, try to prepare a check list like based on these questions answering these questions and be prepared to control the scenario of accidents which will result in high risk. So, these are basically the following steps what I am going to do in case of risk analysis for a process accident.

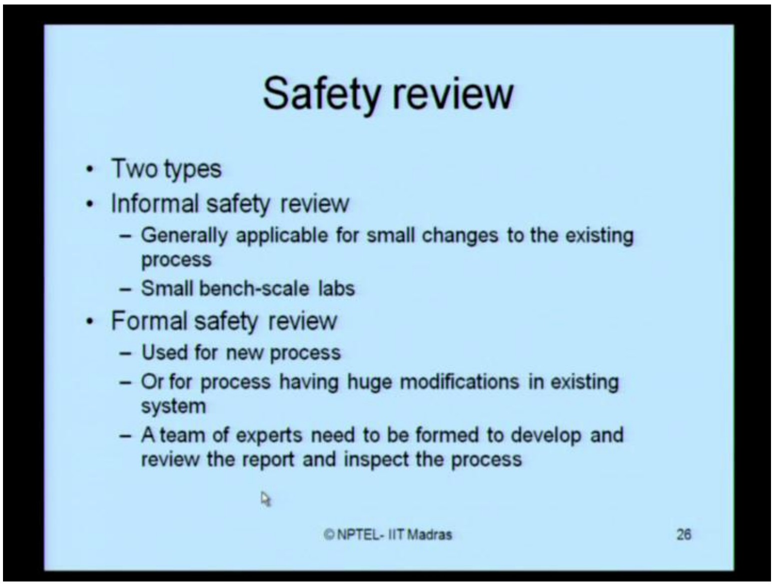
(Refer Slide Time: 30:41)



In particular, if we look at chemical hazard then I call this as chemical risk analysis what are the different methods by which I can do chemical risk analysis. The chemical risk analysis can be broadly at two levels qualitative risk analysis and quantitative risk analysis. If you look at the qualitative one, it predicts undesired situation for a process system, this identifies the potential chemical and mechanical hazards causing that undesired situation, then the methods or mathematical models available are HAZOP, PHA, and FMEA out of this three. We have already discussed HAZOP and FMEA in detail we will be also discussing probabilistic hazard analysis later.

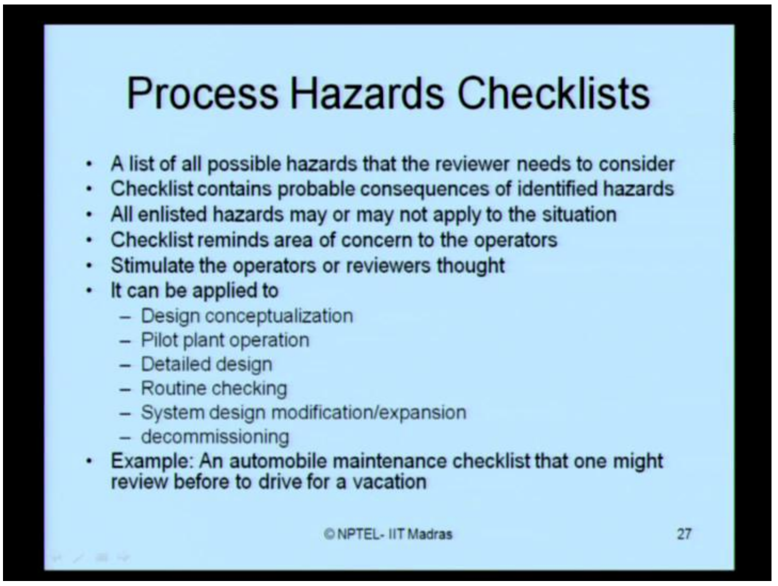
Look at the quantitative methods; this evaluates likelihood of occurrence of accidents. This finds a specific cause and the consequences of potential hazards along with their contributions evaluate the effectiveness of control measures and designed modifications - that is required in the process system. It uses overall probability theory therefore, it is called probabilistic risk analysis examples are fault tree analysis and even tree analysis which we will be discussing in subsequent lectures.

(Refer Slide Time: 32:09)



If you look at safety review, for example, I want to review the whole system of safety present in a process industry, how many types are there to review a safety system which is existing in my process industry or which is being proposed in a new designed plant. There are two types, how I can review my safety one is what I call informal safety review. It is generally applicable to small changes to the existing process small bench scale labs can only employ this kinds of safety review the formal safety review what we are discussing in detail in HSE is that it is generally used for new process or the process which is subjected to have huge modifications in existing system. This requires off course a team of experts to develop and review the report and inspect the process in detail.

(Refer Slide Time: 33:04)

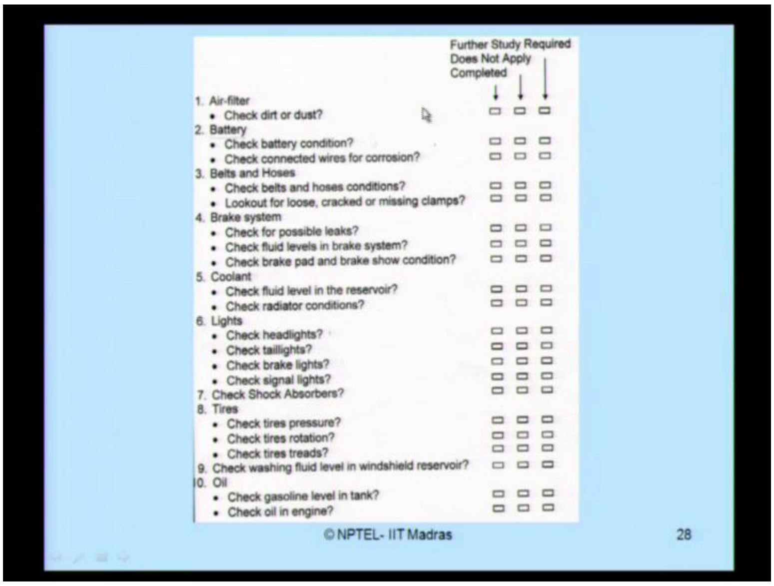


Now process hazards can also be done through a simple checklist. A checklist is basically a list of all potential hazards that a reviewer needs to consider when he analyzes the process for hazardous situations. The checklist generally contains probable consequences of identified hazards. All enlisted hazards may or may not apply to the situations which you are looking at the checklist is very common checklist reminds area of concern to the operators. So, that is an idea it gives a pre requisite thought for the team of experts actually to conduct hazardous analysis, because all those check points which has got to be checked for hazardous situation are available in a readymade list given it actually simulates operators or reviewers thought to look into all those parameters which have been identified in the check list.

It can be applied generally to designed conceptualization, pilot plant operations, detailed designed level, routine checking process, system designed and modification and of course, during decommissioning as well because decommissioning is also equally important, because there may be many hazardous situation while decommissioning which gets uncontrollable and results in serious accidents.

Now, let us look at a very small example of what I call as a checklist preparation for an automobile maintenance, for example, let us say you want to take your car for a longer drive during a vacation. I want to prepare on hazard checklist to have a safe journey back home what kind of checklist should I prepare, so that my automobile maintenance can be done properly before I take by car for a long drive on a vacation.

(Refer Slide Time: 34:57)

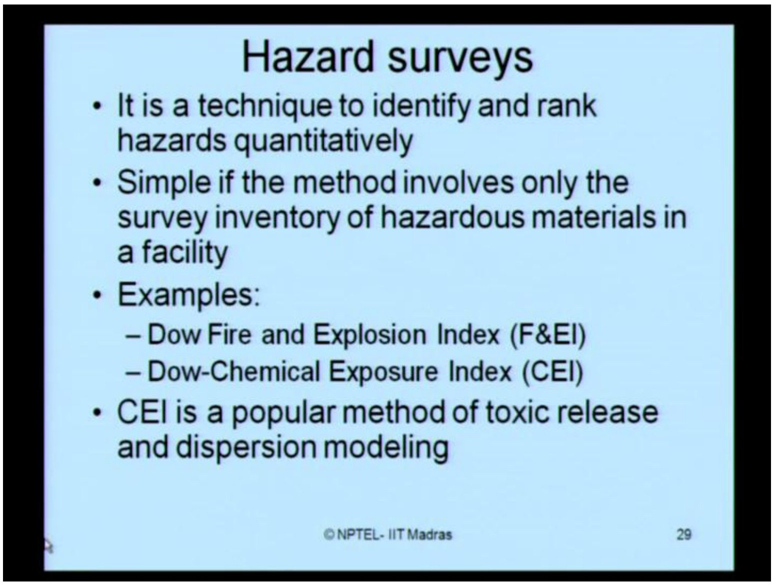


This is the very simple chart which shows me an hazardous checklist for an automobile. Check the air filter check the dirt or the dust, for example, if you have already completed that tick mark here if this does not apply to your mechanism of the automobiles, then tick here or if you want to really look at that in the detail then tick here.

So, look at the battery, check the battery condition, check the connected wires for corrosion. Check your safety belts and hoses look at the check belts and hoses condition, look out for the loose cracked and missing clamps in these, check for the breaking systems, check for the oil leak in the brake fluid, check the fluid level in the breaking system, check the brake pad for the ware and tare and brake show conditions of the lights in the rear and the tail lamps, look for the coolant level, check the fluid level in the reservoir of the cooler, check for the radiator conditions, check for of course the head lights, tail lights, break lights, signal lights indicators. Check for the shock absorbers, check for the tire pressure, rotation style, trades, check for the washing fluid level in windshield reservoir and of course, check for the oil the gasoline level in the tank, and check the oil in the engine.

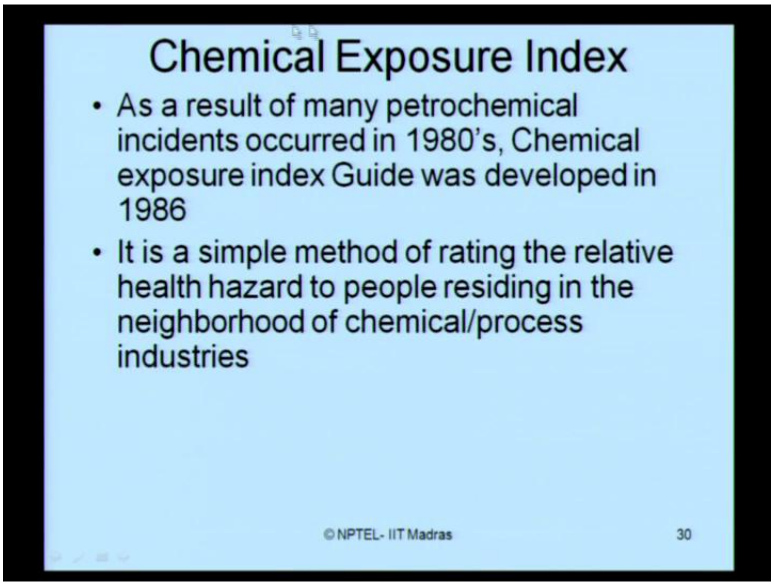
So, ladies and gentlemen such kind of checklist really helps a simple present to locate what kind of a readymade list can be prepared to do that. So, these checklists will give an idea to people that what kind of points or what are the points which are important one must look before taking the car for a longer drive. So, one can prepare a similar easier checklist for hazardous situation in any petroleum or offshore industry or an oil and gas sector, where I will prepare this physical hazardous checklist to know how can I basically by improve the safety standards by doing or by employing simple check measures.

(Refer Slide Time: 37:08)



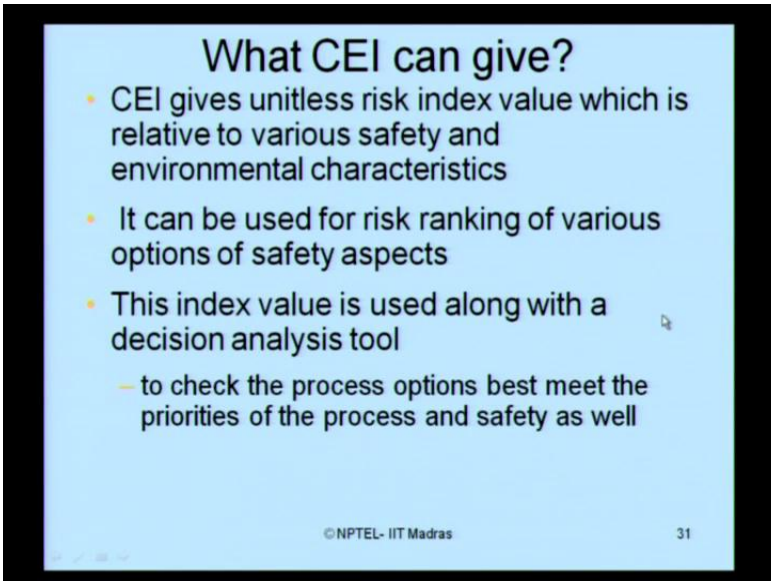
There is something called hazards surveys; we can also do hazards surveys. It is a technique to identify and rank hazards quantitatively. It is very simple with the method involves only the survey inventory of hazardous materials in a facility, for example, I can talk about what we call dow fire and explosion index and dow chemical exposure index. So, these are two kinds of very commonly employed hazardous surveys among these two chemical exposure index is a very popular method of toxic release model and dispersion modeling which we will discuss subsequently in detail in the coming lectures.

(Refer Slide Time: 37:50)



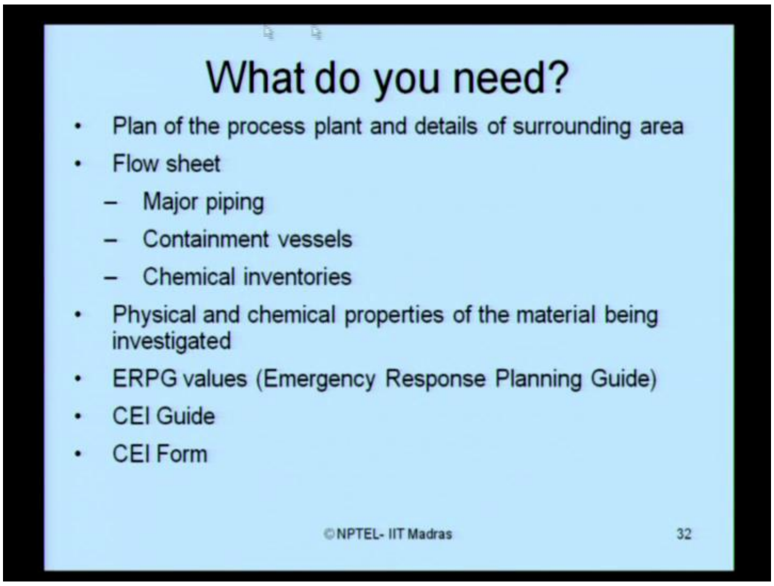
Now, let us briefly explain what is a chemical exposure index. Basically due to the incidents occurred in petrochemical industries in eighties, chemical exposure index guide was developed in the year 1986. It is a very simple method with this actually rates the relative health hazard to people residing in the neighborhood of chemical or a process industry. Basically what is the health hazard to people residing in the neighborhood of a process industry, when you are exposed to a specific chemical or a toxic level that is what chemical exposure index is.

(Refer Slide Time: 38:33)



What this chemical exposure index can give me. CEI actually gives unit less risk index value it gives me a number basically which is relative to various safety and environmental characteristics. We will explain that very clearly, it can be also used for risk ranking of various options of safety aspects. This index values is used along with the decision analysis tool; to check the process options best mate the priorities of the process and safety as well. For example, if you have got different priorities, different options in a process industry, to maintain safety standards and your safety is are of different priorities as well, chemical exposure index tool use along with decision analysis tool will be a helpful method will be very useful in actually prioritizing your safety options to make the process much safer.

(Refer Slide Time: 39:37)



To do a chemical exposure index analysis for dispersion or modeling of this kind, what data do you require first of all you are detailed to plan of the process plant, and details of the surrounding area is required. Then I must have a flow sheet which shows me the major piping or the pipelines present in the process system, I must have a clear understanding on the flow sheet showing where are the containment vessels which is holding the hazardous chemicals as inventories, and which are all the chemical inventories which are present in that whole industry, whole plant or subject onto consideration. The physical and chemical properties of the material being investigated should be known to me in advance then I must also have an access to what I call emergency response planning guide which is call as ERPG values. The emergency response planning guide will tell me different ERPG values for different kinds of chemical exposures.

Now, the questions comes what is an ERPG we will talk about that in the coming slide, once I have a detail plan of the process industry, once I have an idea about the flow sheet of the process, once I understand the chemical and physical properties of the material being investigated, once I have an excess to the ERPG values, then I also have a guidance from chemical exposure index then I will fill up the results in what I call as chemical exposure index form we will discuss this procedure in detail in the next lecture. Thank you.