HSE for Offshore and Petroleum Engineers: Practices
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Module - 03
Accident Modeling, Risk Assessment and Management
Lecture – 10
Chemical Risk Analysis

Friends, welcome to the tenth lecture in module three in H S E practices.

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In which, we are going to discuss about the chemical risk analysis. This is tenth lecture in module three in H S E practices; where in module three, we are talking about accident modeling, risk assessment and management. We already said in the last next lectures that, fire and explosion is one of the serious consequences, which can be either detonation more or in deflagration more, which can be harmful as it keeps on creating over pressure and a negative pressure, which can be dangerous for the object on which it is subjected to.

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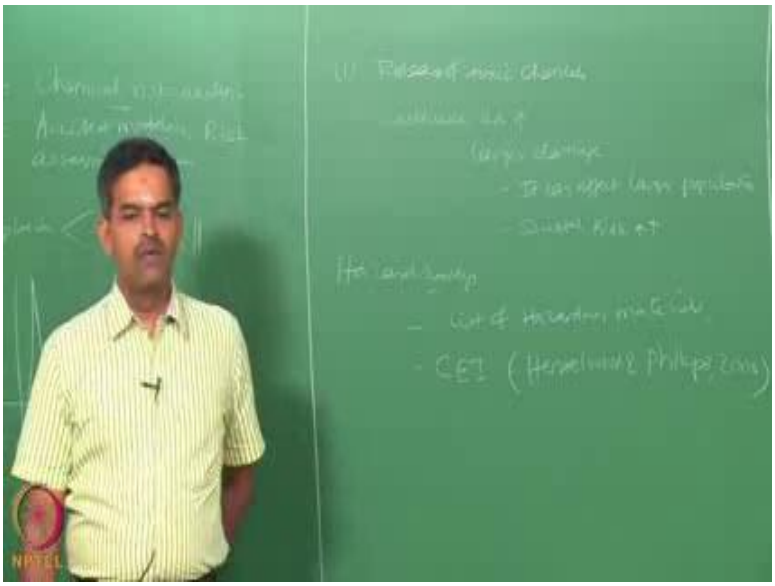

In addition to that, the next important consequence, which one can see is release of toxic chemicals. So, one can see here; even though they are accidental, the consequences are very severe, because they can cause larger damage. It means it can affect larger population. It means the societal risk is very high in terms of release of toxic chemicals. So, how do you mathematically model this and what will be the steps involved in mathematically modeling this. We already said in the last lecture that, hazard service are very interesting and very important, which can be giving useful information, which the method is very simple and involves only survey of inventory, which are hazardous materials in a given facility. So, once you have a list of materials, which are hazardous in a given inventory, then one can easily find out what would be the consequences if these materials are released in the atmosphere. So, chemical exposure index is one of the interesting tools, which is used to understand the consequence of release of toxic chemicals in atmosphere, which is given as we discussed in the last lecture Henselwood and Phillips 2006.

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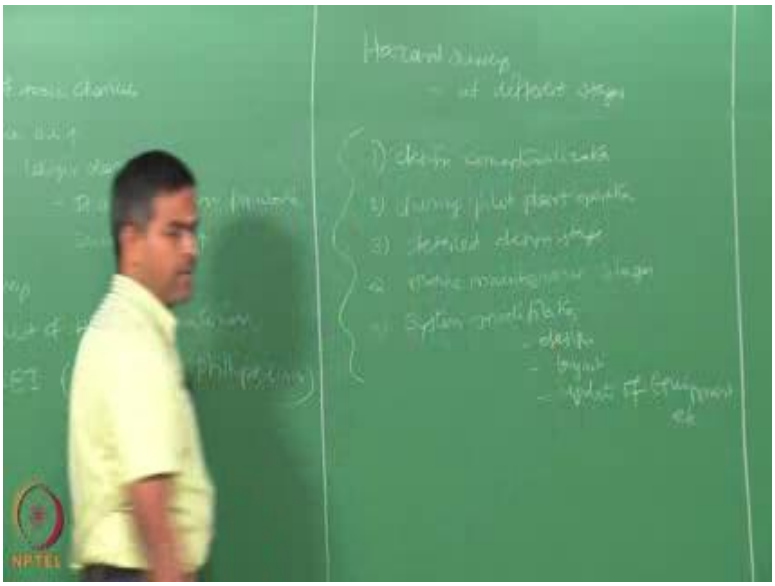

So, now, hazard surveys can be applied at different stages – hazard surveys, where chemical exposure index is also a path – can be applied at different stages. You can do it during design conceptualizations. You can also do it during pilot plant operation, what we call as trial run systems. You can also incorporate the effect of these consequences at the detailed design stage to make modifications in the process line and the equipment layout. You can also do this as a part of routine maintenance checks. You can also apply this in case you require any major system modification in terms of design layout. Let us say update of equipment, etcetera. In all stages, we can always apply hazard study.

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Interestingly, when we talk about release of toxic chemicals, it is evident that one must understand the chemical properties of these kinds of inventory. So, one can refer to chemical engineering handbook, which gives information on various chemicals in terms of the limiting oxidant concentration, in terms of the flammability limits, in terms of its permissible concentration stoichiometric relationship. And interestingly, it also gives me dosage with respect to E R P G. Now, what is this E R P G? E R P G stands for emergency planning and response guidelines. So, these are actually rules and regulations formed – published by American Industrial Hygienist Association – American Industrial Hygienists Association published certain rules and regulations, which can be used essentially for planning and response evacuation especially in the case of emergency. E R P G values actually estimates different concentration ranges, which one may get to exposed.

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E R P G actually are nothing but estimates of different concentration, where one might – one might experience or feel any adverse effects because of the (Refer Time: 07:34) when the chemicals are released. It is actually useful to identify the priority concerns in a process plant. It evaluates the adequacy of the containment. It also identifies the downwind areas, which will be effected in case the chemical is released. These guidelines are actually helpful in developing the emergency response layouts.

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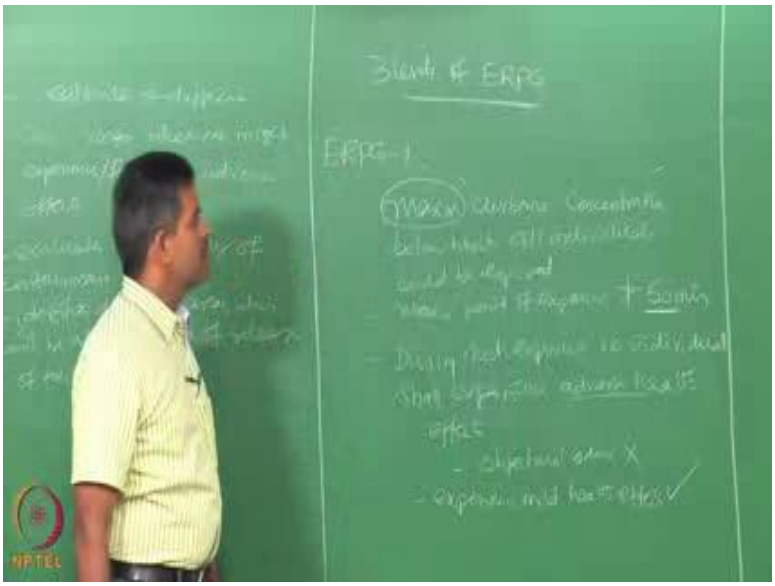

There are three levels of E P R G, which are called as let us say E R P G 1, 2 and 3. Let us discuss one by one very quickly. E R P G 1 is the maximum airborne concentration, below which all individuals could be exposed. The maximum period of exposure should not be more than 60 minutes, that is, 1 hour. Interestingly, during such exposure, no individual, who is exposed to this concentration, shall experience adverse health effects. They should not even experience objectionable odour. So, they do not experience any adverse health effects of course, they can experience – can experience mild health effects when they are exposed to this chemical for a period of 60 minutes. So, we have that kind of concentration, which is airborne concentration, whose limit is maximized in the upper most limits. Then, that is what we call as E R P G level 1.

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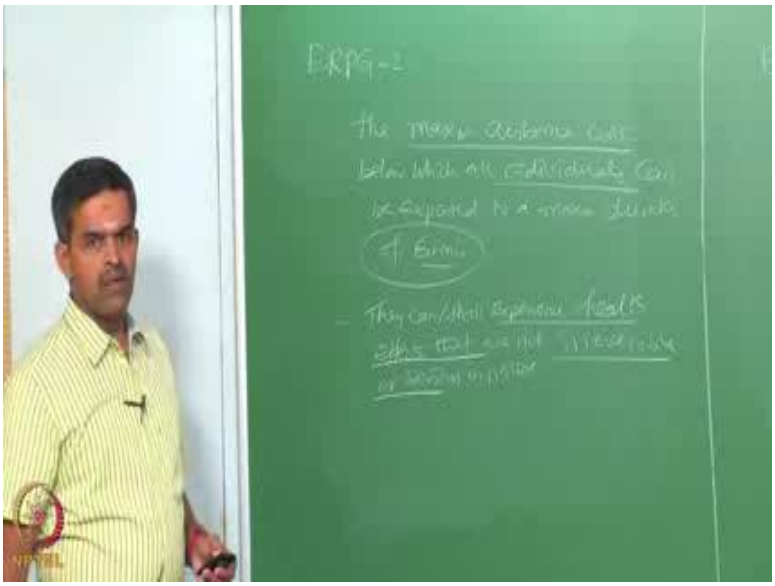

E R P G level 2 is again the maximum airborne concentration below which all individuals can be exposed to a maximum duration of 60 minutes. So, one may wonder what is the difference between the E R P G level 1 concentration and E R P G level 2 concentration, because in both the cases both have the maximum airborne concentration, which all individuals can be exposed to the maximum duration of 60 minutes. Now, the difference between the level 1 and the level 2 comes only from the consequences or the adverse effects caused by this concentration on the individual. So, in E P R G level 1, individual who are exposed to this concentration should not feel objectionable odour; they should not feel or experience any adverse health effects; whereas, concentration of E R P G 2 – they can or they shall experience health effects that are not irreversible or serious in nature. Unlike in E R P G level 1, even they should not be exposed to odour. In this case, this concentration will cause health effects – will cause health effects on people; but, those health effects caused by this concentration will not be irreversible or they are not very serious.

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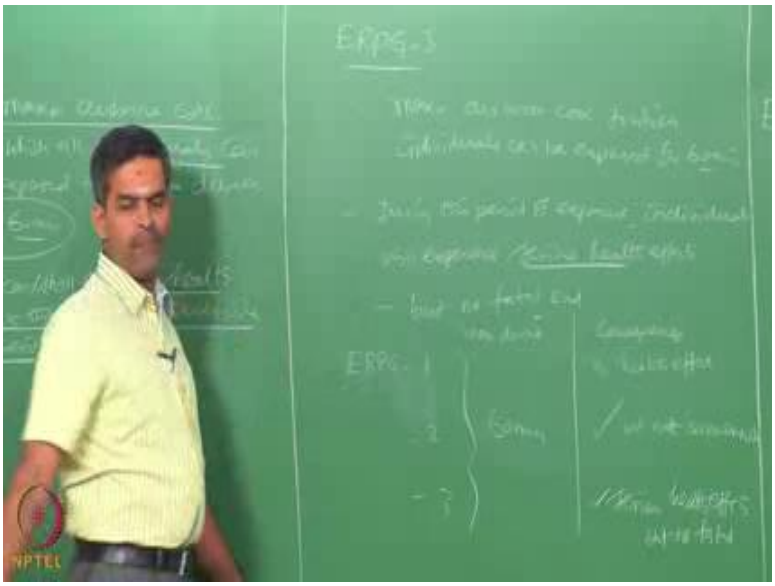

Let us talk about E R P G 3. This is the maximum airborne concentration below which all individuals could be exposed for a maximum period of 60 minutes. So, maximum airborne concentration to which individuals can be exposed for maximum of 60 minutes. Again the definition of exposure time remain same in all the three levels namely, E R P G 1, 2 and 3. Now, the difference as we expected should come from the consequences. Let us say during this period of exposure, individuals, who are exposed to this concentration will experience serious health effects, but no fatal. They will not die. But, they will experience serious health effects. So, now, can say here E R P G level 1, level 2, level 3, the maximum duration of concentration allowed is in all the cases 60 minutes. If you look at the consequences of the exposed person or the effects caused by the exposed concentration on the individual; so, no health effects; can say health effects will be there, but not irreversible. This will cause serious health effects. But, no fatal; person will not die. So, one can expect that the concentration, which is maximum airborne concentration under E R P G 3 for every chemical will be the maximum or highest compared to that of 2 with respect to that of 1. So, 1 is the mild concentration; 2 is the medium level concentration; and, 3 it can be the more intensified concentration. In all the three cases, they are airborne. In all the three cases, maximum exposure limit is only 60 minutes; they all classify or they are differed only by the consequences or adverse effects caused by them on the exposed individual. Having understood this, chemical exposure index actually derives the data or understanding from the basic level of explanation from E R P G.

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Let us talk about chemical risk analysis, what we call otherwise, chemical exposure index – C E I. Chemical exposure index is one of the simple methods of rating the relative health hazard caused by chemical release on individual or society. C E I actually gives unitless risk index value. So, C E I outputs risk index value, which is actually unitless. This is useful to relatively understand the safety and environmental characteristics of chemical release. This also is useful in developing preparedness of the industry to release of toxic chemicals. C E I index can also be useful in ranking various options of safety aspects.

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This is also useful to rank various options of safety aspects. This index is used along with a decision tool; C E I index is used along with the decision tool to check the process options – the process options or process layout with respect to improving its safety. Now, what do we need for carrying out C E I?

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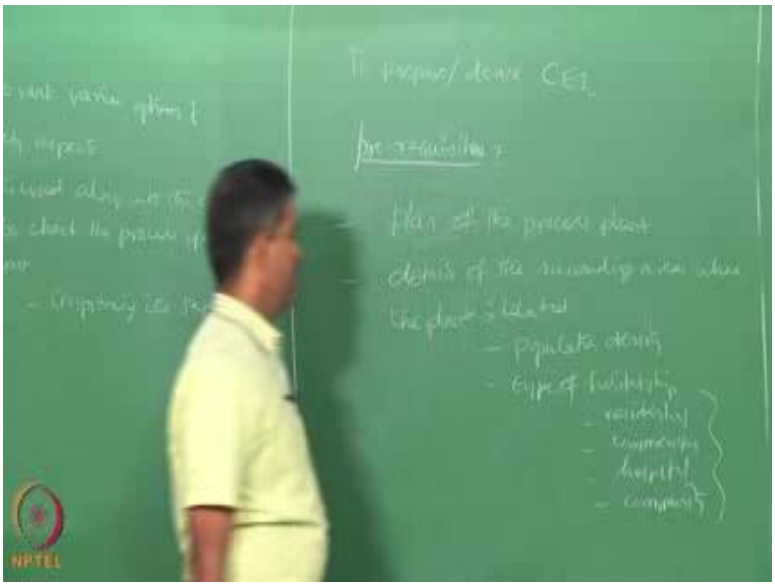

So, to prepare or to derive chemical exposure index, what are the pre–requisites? One you should have the plan of the process plant, that is, the layout. One should also have details about the surrounding areas, where the plant is located. The moment I say details, one should look for population density type of habitatship. I mean that is it residential, is it commercial, does it have a hospital, does it have a community leaving like schools, etcetera? All should be look at as additional data.

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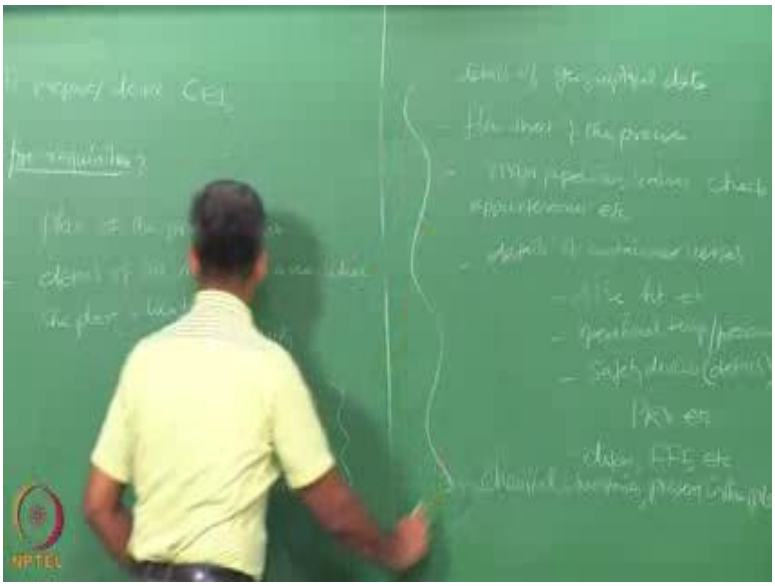

It should also have details about the geographical data. It should have details of the complete flow sheet of the process. It should have details about the major pipelines, presence of valves, check the appurtenances, etcetera. It should also have details about the containment vessels in terms of size, height, etcetera – operational temperature and pressure. Then, safety devices – details of the safety devices in terms of pressure relief valve, etcetera; dimensions about the dikes – containment dikes, fire fighting equipments, etcetera. It should also have details about the chemical inventories present in the plant. So, these are very important pre-requisites to prepare the chemical exposure index.

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Interestingly, if you look at the physical and chemical properties of the chemicals – chemical properties of the hazardous materials, which offshore industry deal with, which can be referred from the chemical engineering handbook. One can also find out different E R P G concentrations of such chemicals available from the literature. Let us quickly see the flow chart how the C E I can be estimated.

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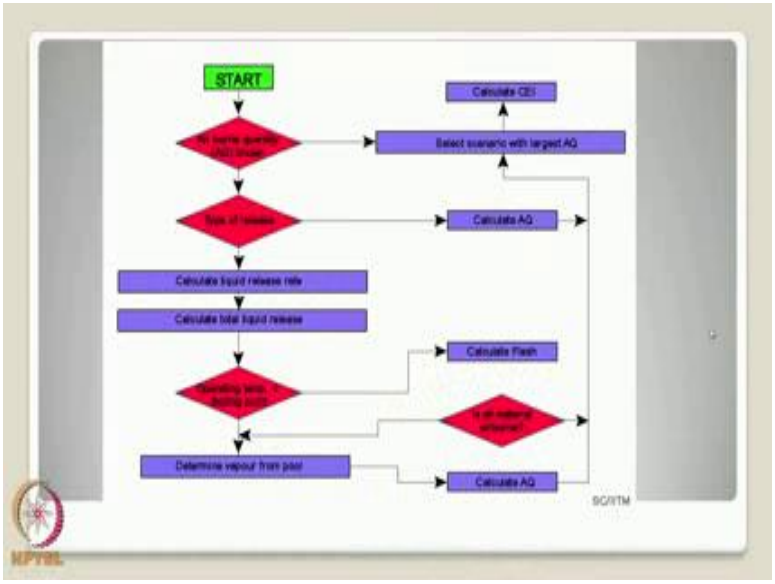

Kindly pay attention to the flow chart shown on the screen now. To start preparing the chemical exposure index, the first step is to compute the airborne quantity, because we

are talking about the chemicals dispersed in air or atmosphere. Let us try to compute A Q, which is called airborne quantity. If you know the airborne quantity, then select the scenario with a largest airborne quantity and calculate chemical exposure index directly. If you do not know the airborne quantity, you can estimate the airborne quantity. To know that, you must then identify the type of release; a type of release can be a liquid release, can be a vapour or a gaseous release. So, calculate the liquid release ratio, calculate the total liquid released from the section. And, for the given operating temperature and boiling point, estimate what is called the flash. Based upon the flash value, then estimate what is the vapour pool, which is being formed from the chemical. Then, based on this data, try to calculate the airborne quantity.

Sometimes what happens, depending upon the operating temperature and boiling point, you have to check whether all material remain airborne or some of them remain in the liquid form. If all of them remain airborne, calculate the largest scenario with airborne quantity and estimate the chemical exposure index. So, interestingly, friends, to estimate the chemical exposure index, one need to know how much is the quantity, which is airborne from the released chemical. So, one is interested to always compute the airborne quantity based on which chemical exposure index will be estimated. So, one is interested to compute the airborne quantity for a given chemical release. Once we are able to identify and compute the chemical exposure index, which I will explain by taking examples, then what actually we are looking at? Because we are now looking at risk estimate; but, chemical exposure index does not give me anything on the risk part at all; it is only an index, which is helpful in comparing the priority of risk given by or exposed by different chemicals on individual. But, I would like to know the risk estimate. So, as I know and as you will also agree, once a chemical or a toxic release happens in atmosphere or in the environment, it disperses.

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It affects a large sector of people, which we call; it may result in societal risk. So, now, to minimize the societal risk, which could occur or which could result from the hazardous chemical exposure, one need to place this people away from the target source of release. So, then in that case, what would be the hazard distance up to which the chemical released from the source will remain effective? So, hazard distance is that distance up to which the released chemical – the released chemical – I should say even toxic – the release toxic chemical has a potential to create harm to public. Suppose if your people are placed beyond this hazard distance from the source, then always see the effect or the consequences arise from the released chemical can be minimized. So, ultimately, chemical exposure index should tell me what is the maximum permissible hazard distance, beyond which people should be placed or colony should be located or community services should be planned, etcetera. That is why we call this in the case of emergency response planning guideline; that is the reason why we say emergency.

In case of any accidental release of chemical, if the public is placed beyond the hazard distance; then, the consequences of the released chemical on the public can be minimized and the catastrophe can be controlled. So, interestingly, one should prepare a C E I summary sheet, which should give me the list of E R P G concentration for different levels – 1, 2, and 3, and the corresponding hazard distances. For example, if I know the hazard distance for E R P G level 1, which says there should be no even objectionable odour on the public; then, that distance will be obviously, much large than the top; the E

R P G level 3 concentration, where level 3 concentration admits adverse reversible effects on human body, but does not cause fatal. So, this is the higher concentration, medium concentration and mild concentration.

If I know the respective hazard distances for each concentration for the chemical, which is expected to get released; then, I will know beyond what distance what would be the consequence caused on the human being. Of course, the distances are measured from the point, where the chemical is expected to be released. So, I need to have the complete layout of the plant, the complete population density around the area of the plant, the climatic conditions, the vessel containment details, the pi flow diagram, the inventory details; then, for the inventory, I must also know the E R P G concentrations and the respective hazard distances, which can be computed as an outcome from the C E I in the summary sheet. So, once I know this, I can either modify the existing layout of the plant, modify the process line, modify the layout of the colony, where people are located, etcetera, so that the hazard sequences arising from the unaccepted or accident release of the chemical can be completely mitigated or at least control and avoided.

So, friends, in this lecture, we are able to understand what would be the chemical exposure index, what are the uses of chemical exposure index, what are the pre-requisites if we really wanted to do the chemical exposure index study, which is useful in understanding the consequences of chemical released in the atmosphere, which is totally airborne concentration. Ultimately, how they will be useful during emergency responses and planning, which is recommended by different international associations in the world, so that people located around the plant can be minimized or controlled with the consequences caused by the hazard release of the chemicals from the source. So, now then, we should look into the steps involved in doing or preparing a chemical exposure index study. Here is equations. Then we should take up problems to really understand and apply these equations and know ultimately the C E I summary sheet. And from the summary sheet for different E R P G level concentration, what are the respective hazard distances? If I know this, as a planner, I can always locate, relayout, design, modify my plan in such a manner that, the hazard effects caused by the released of the chemical on the society, can be either minimized or even completely mitigated.

So, in the next lecture, we will talk about the airborne concentration. We will also talk about the equations, which are useful for estimating the liquid release and vapour release.

We will also pick up an example – a couple of examples to really apply these equations and try to understand the hazard distances for different E R P G level for a frozen chemical, which is actually an outburst or which can from process industries like oil and gas industries.

Thank you very much.