Health, Safety and Environmental Management in Petroleum and offshore Engineering

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Module No. # 01

Lecture No. # 6.1

HaZOP

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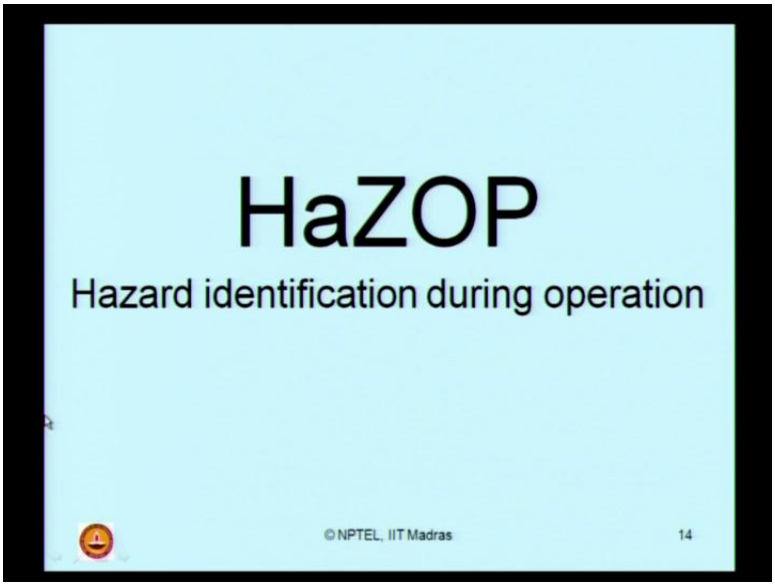

So, ladies and gentlemen, we have been discussing about the tools for hazard identification. Now, we shall discuss one of the very important method which is used for plants in operation which we call generally as an HaZOP study. It is expanded as hazard identification during operations.

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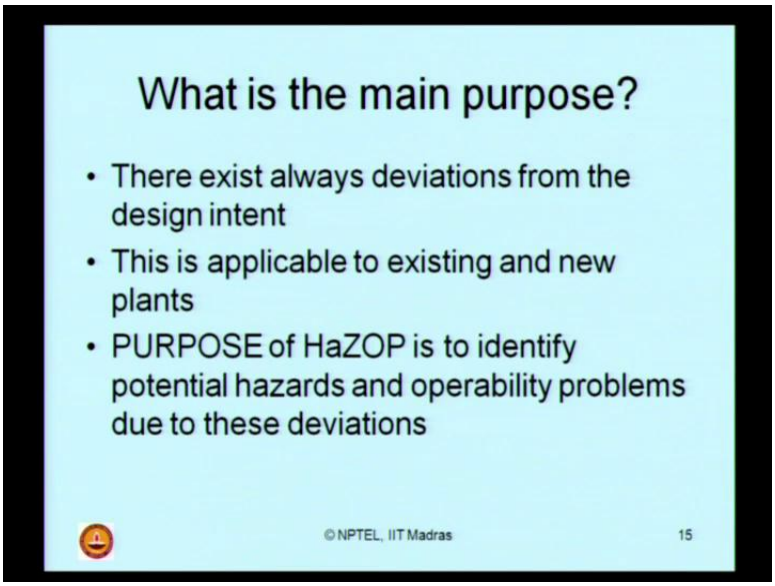

What is the main objective of a HaZOP study? Now, we all understand that there exist always deviations from the design intent. Now, you may be wondering what do you understand by deviation and what you understand by design intent? These are two important keywords which one has to understand, very clearly, before you do an HaZOP study.

So, lets us take it granted, I will explain these keywords later. Let us understand that for every process, industry generally there will be deviations from the design intent. Now, this is a common statement which is applicable to existing industry or for any new plants. The main objective of an HaZOP study is to identify the potential hazards and operability problems due to these deviation. So, HaZOP study throws light on problems or hazards created due to these deviations from the design intent. Now, the question comes what do we understand by design intent? What do we understand by a deviation? And therefore, how this deviation can become a potential hazard for a plant in operation?

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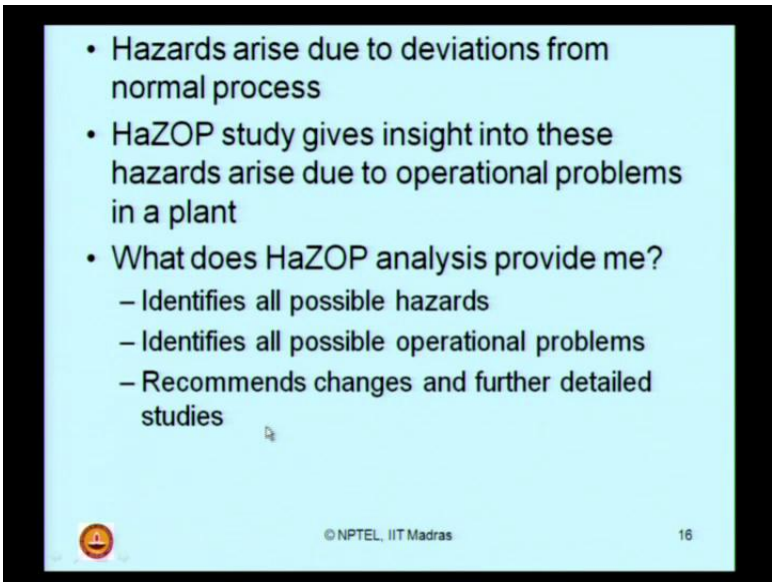

So, as I said, hazards generally can arise due to deviations from a normal process. Hazop study, basically gives a thorough insight into these hazards, arising due to operational problems in a plant. Now, the common question asked is what does an HaZOP analysis provide me? It identifies all possible hazards. It identifies all possible operational problems. It also recommends changes and further detailed studies, which can be carried out subsequently followed by an HaZOP report.

So, HaZOP study should be capable of identifying all possible hazards in a new plant or an existing operational plant. It further identifies all possible operational problems related to the plant. Based on the study conducted, it recommends changes to improve safety of course, in an existing plant, recommends changes in the new plant or in a new design of the plant, and also recommends further detailed studies, which can be carried out to improve the operational feature of an existing plant, or to improve the design feature of a new plant. So, all these will be a successful outcome of an HaZOP analysis.

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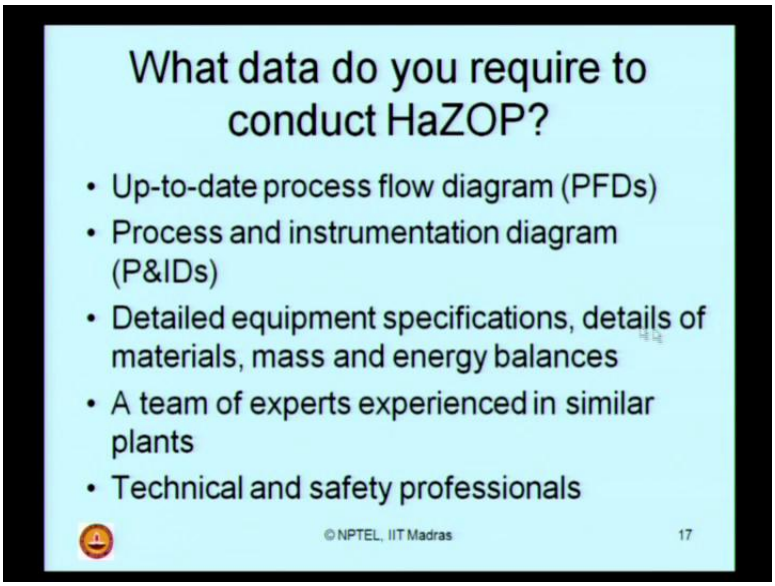

Now, the fundamental question asked is, what data do you require actually to conduct an HaZOP study? Of course, the questions are which are still unanswered remain, what do we understand by a design intent? And what do we understand by deviations from a design intent? I am going to answer that with many examples in the coming slides, but before answering them, let us try to ask a question. If at all, if I want to start an HaZOP study, what data do I require? I, first of all, require process flow diagram, which is referred as PFDS in the literature. This process flow diagram should be an up to date version of the flow chart of the process industry.

As we all understand being a chemical engineer or being a mechanical engineer or working in a process industry, the process flow diagram completely describes the total flow characteristics and situations in a process industry in detail.

I should also have a detailed P and ID - that is process and instrumentation diagram, because, any instrumentation related to the process industry which can address closely the control measures, the existing safe guards, etcetera will be generally indicated in what we call as process and instrumentation diagram.

So, before I start conducting an HaZOP study, I must have an up to date version of the process flow diagram. I must have an up to date version of the process and instrumentation diagram.

In addition, I should also have the detailed specification of all the equipments involved in the process. I should also have details of all the material being used for construction inventory production etcetera of the process, and I must have on hand of understanding the mass and energy balance of the whole process.

A team of experts experienced in similar plants are also mandate requirement to conduct an HaZOP study. The team of experts can also include technical and safety professionals. So, there are some prerequisites to conduct an HaZOP study. You must have a detailed PFD and you should have an updated P and ID, you should have specifications of all the equipments involved in the process industry related to your process industry. Details of all materials being used as a raw material, as a producer of the process industry etcetera. You should also have enough hand and experience about the mass and energy balance of the process.

Hazop study is generally carried out by a team of experts, who have experienced in similar process plants. The team can include technical people of the process industry and safety professionals who have experienced in similar plants.

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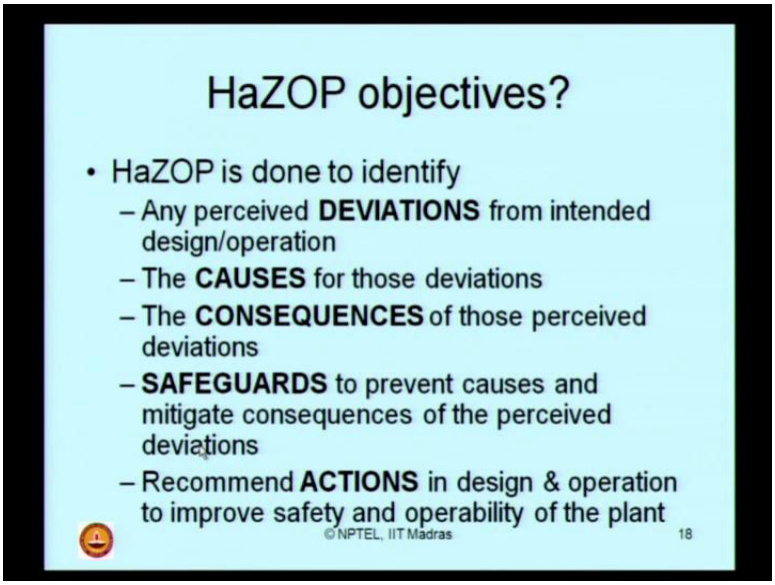

Now, what are HaZOP objectives? What do you achieve when you conduct an HaZOP study. Hazop study is generally done to identify the following. Any perceived deviations from intended design is to be identified. What are the causes for those deviations should be listed. If at all these deviations occur, what will be the consequence of those perceived

deviation should be studied. If at all my process plant has any safe guards, which can prevent the causes and mitigate the consequences they should be studied in detail. Based on the perceived deviations, the causes for those deviations, if they occur as consequences of those deviations. If I have any safeguards in my system, to what extent they can prevent the cause and mitigate the consequences.

Based on this, I will further recommend actions either in the new design of the plant or in the existing operational feature of the plant,, ultimately to improve the safety and operational feature of the plant. So, HaZOP has an objective of improving safety and operability of the plant. The plant maybe an existing one, which is already in operation the plant can be a new one, where you are discussing about the designed features of the plant.

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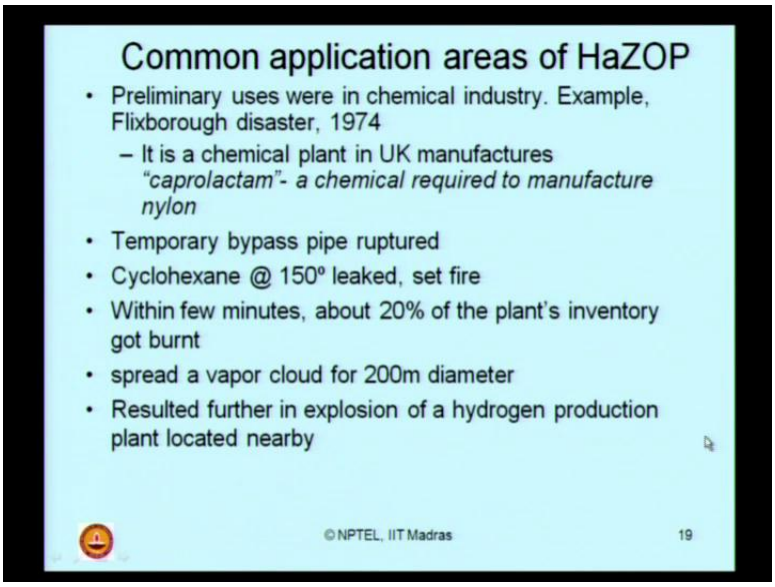

Now, a question commonly comes to mind is where do we actually apply these kind of studies. On the other hand, what are the common application areas has of a HaZOP study? Preliminary uses were seen in the chemical industry. For example, if you looked at the flixborough disaster in 1974, HaZOP study has been made for this disaster. Just to give an overview. Flixborough is a chemical plant in UK, this manufactures caprolactam a chemical that is required to manufacture nylon. I am not discussing in detail about the case study of this disaster, I will do that in module four where I am talking about the HaZOP report in detail.

I will give you brief steps what occurred during this accident in Flixborough. A temporary bypass line ruptured actually. Cyclohexane at a temperature of 150 Celsius leaked out from this ruptured pipelines, which actually set fire. Within few minutes, of this occurrence of the leak, about 20 percent of the plant's inventory got completely burnt. Followed by that, it spread a vapor cloud of about 200 meter in diameter. We will talk about how to model this kind of fire explosion in module three, but you will be able to appreciate then, that spread of a vapor cloud of such a large diameter is a very, very risky situation.

For such industry an HaZOP report or an HaZOP study has been employed. The spread of vapor cloud further resulted in an explosion of an hydrogen production plant located nearby. I think, you will be able to appreciate one of the main objectives of risk management, that if any loss is created to adjacent property, that is also one of our important goal to assess that kind of safety. So, the Flixborough plant disaster result in explosion of hydrogen production unit, which was located nearby.

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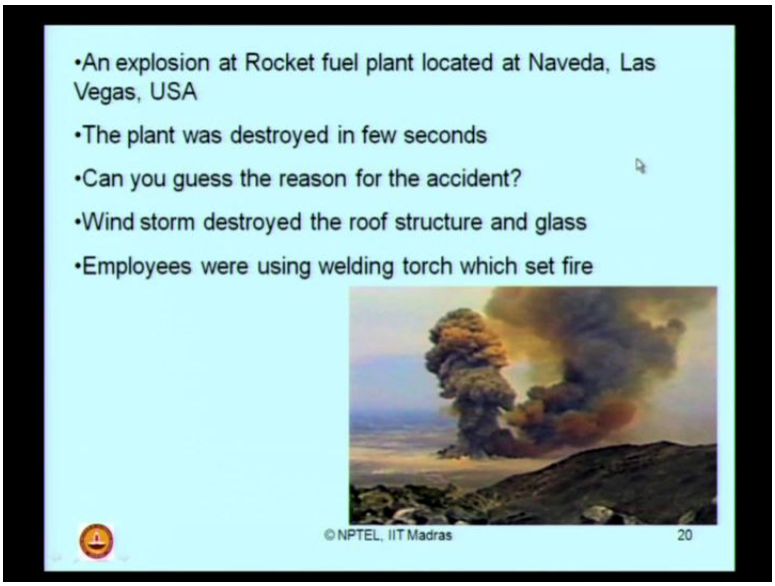

The second example, which I want to point out here, is an explosion of a rocket fuel plant located at Nevada Las Vegas United States. The unfortunate part of this incident was, the whole plant actually got destroyed in few seconds. You can always guess the reason for this accident. There was a strong wind storm blowing which could destroy the roof structure and the glass. And unfortunately, the employees at that time they are using

a welding torch which actually set fire. This is the picture which is illustrating the destruction of this plant, which is a rocket fuel plant located in Nevada Las Vegas in united states.

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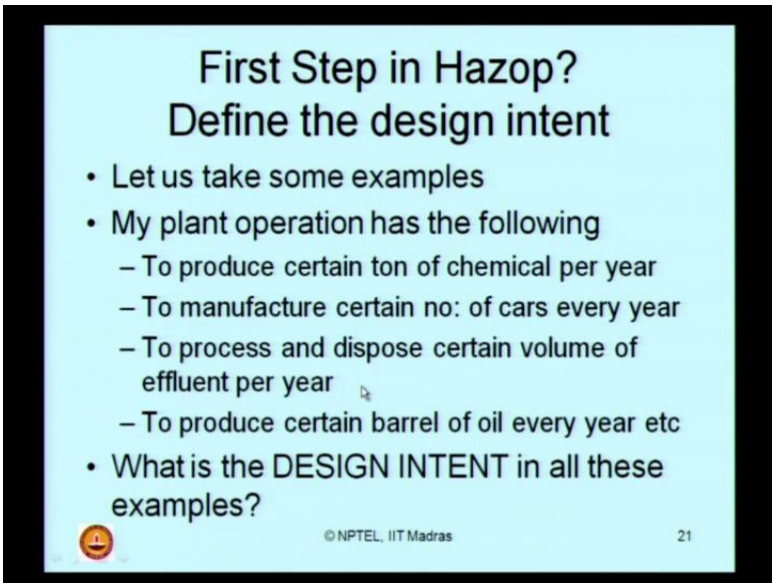

After looking into these two examples, let us try to answer few questions which are still remaining in our mind which is not clear yet. What is the first step in HaZOP study? Obviously I want to define the design intent. Now, many of us are not clear still what do we mean by design intent. In couple of slides from now, I will give you few examples to clarify what do we mean by design intent in an HaZOP study.

Let us say for example, I am considering the following plants. Plant A to produce certain ton of chemical per year; it is a production unit; it is a process plant. It manufactures, it produces certain ton of chemical every year. Plant B is an automobile unit, which manufactures certain number of cars every year. Plant C, to process and dispose certain volume of effluent every year. Of course, plant D is our own parent industry, which produces certain barrel of oil every year. So, I have got four examples here, A which is the production unit of a chemical plant, B an automobile industry, C an effluent treatment plant, four oil industry.

In all these examples, what do we understand by design intent? Can you guess what is the design intent in all these examples? One is a production unit - a chemical plant; other is an automobile unit - manufacturing number of cars; the third one is an effluent -

treatment plant what we call is ETP, which process and disposes certain volume of effluent; the fourth plant is of course, the parent industry - the oil industry. What is the design intent in all these examples?

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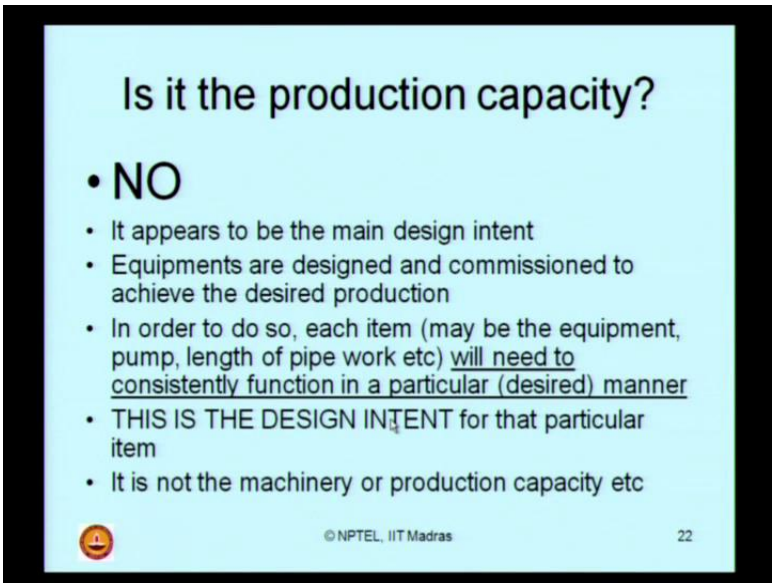

Do you think it is the production capacity? Ladies and gentlemen, I am sorry, your answer is absolutely incorrect. It is not the production capacity which is the design intent of these plants. Then what is the design intent? The production capacity appears to be the main design intent because, you understand that every plant is governed by the production capacity. But in general, plants are assembly of equipments which are designed and commissioned to achieve the desired production. We all understand this very well; there is absolutely no second argument on this statement.

In order to do so, each item that item maybe an equipment, maybe a simple pump, maybe a length of a pipe work etcetera. These items are each one of these items will need to consistently function in a desired manner. We are talking about the functionality of equipment or pump or segment of the pipe etcetera. We need that these equipments or these items should consistently function in a specific manner. Now, this functional aspect of these items is the design intent. It is not the machinery, which is important, it is not the production capacity which is important; it is a functionality of every item involved in that industry which is a design intent.

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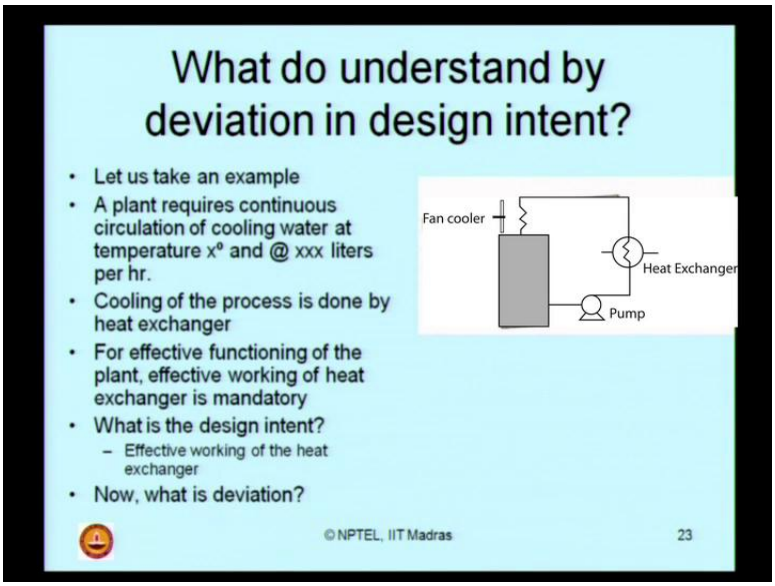

Now, what do you understand by deviation in a design intent? Now, we already know what is a design intent. Design intent is the functional aspect of every item or any one single item present in the process industry. I have an example here, through which I will demonstrate, what is the deviation in the design intent. Let us look at this example closely. I have a tank, the tank has a liquid or a chemical, the tank has to maintain certain temperature; I have a fan cooler.

Now, the chemical or the liquid in the tank is pumped through the heat exchanger and brought backwards. It means the temperature of the liquid inside this tank is being controlled by what we call as heat exchanger. Now, the mechanical components present in this example could be the following. It can be a fan cooler; it can be a pump; it can be a heat exchanger; it can be even the cylindrical tank as well. Now, what do you understand by the deviation in the design intent.

First, let us clarify, what is the design intent in this example? It is not the pump; it is not the heat exchanger; it is not the fan cooler or it is not the container. Because, these are all either equipments or units of equipments, which are all not the design intent. Design intent is the functional aspect of these equipments. If that is the case, then what do we understand by deviation?

Let us say for example, this plant requires a continuous circulation of cooling water or any liquid used for coolant at a temperature x degree, and it requires triple x liters per

hour to be pumped- that is the requirement. Cooling of the entire process is actually done by one component, what we call as heat exchanger. For effective functioning of the plant, effective working of heat exchanger becomes mandatory. So, I think now you understand variable what is design intent of this whole process?

Yes, ladies and gentlemen, the design intent for this process is effective working or function of the heat exchanger. So, that is what we are writing here the design intent is effective working of heat exchanger. Now, we are worried to understand, what is the deviation of the design intent? Suppose, if this heat exchanger is not working properly there will be a deviation in the whole process.

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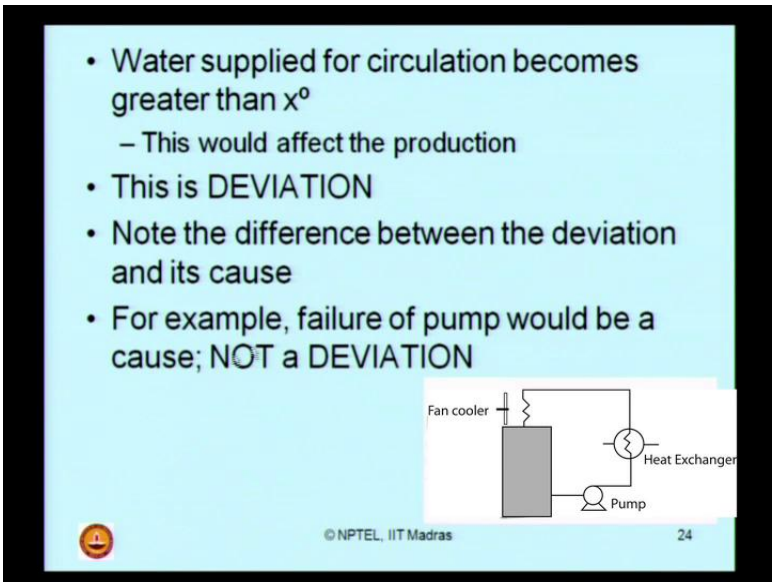

So, water supply for circulation becomes greater than x degree centigrade. For example, you need to supply water of triple x liters of volume at a specific temperature. If you are not able to supply water or any coolant at this specific temperature for circulation, then this will affect the production. Now, this is the deviation, you are unable to supply either the quantity enough for the process or the temperature controlled for the process. If you are not able to supply either one of them through the heat exchanger, then this is what we call as deviation from the design intent. The design intent is effective working of the heat exchanger. Effective working means - it must result in a temperature of x degrees Celsius. I am not getting x degree here; I am getting the temperature more than x degree here. It means, there is a deviation from the design intent for this process.

Now, note the difference between the deviation and its cause. Now, this deviation can be resulted because of ineffective working of the pump etcetera. So, what is the difference between the deviation and its cause? For example, failure of a pump would be a cause not a deviation. The deviation is, ultimately I am not getting the liquid back at x degrees. The design intent was effective functioning of heat exchanger, which must give me the liquid back at x degrees. Now, the effective working of heat exchanger is not possible because, the pump is not supplying enough quantity of water. So, the pump is a fail, pump has failed that can be a cause, but not a deviation.

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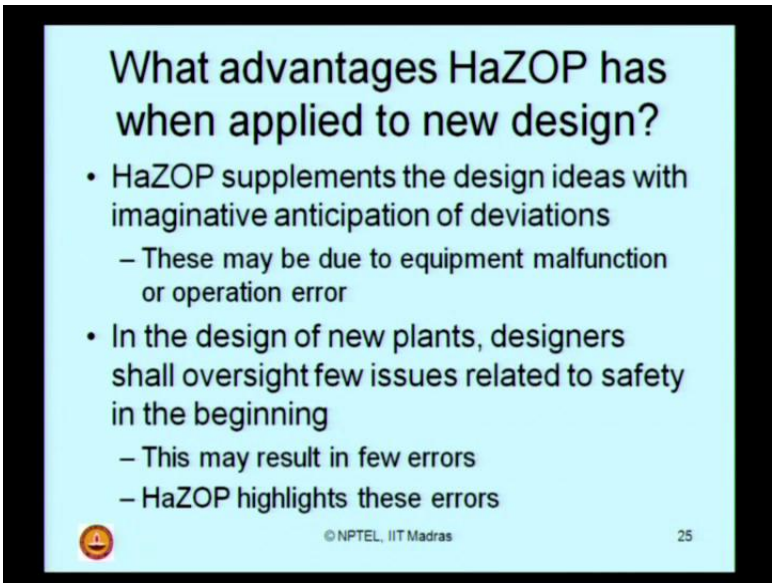

Now, lets us try to understand, what advantages the HaZOP study has when applied to a new design? The fundamental question generally asked is, can I apply this HaZOP study or HaZOP methodology for a new design? Or is it limited to only existing operational plants. It can be applied in new design; it has got some salient advantages when deployed to a new design.

Hazop generally supplements the design ideas, because it imagines anticipation of deviations. These deviations can be equipment malfunction or operational error as well. So, for a newly designed plant if you attempt to do an HaZOP study, the HaZOP study will imagine certain anticipated deviations. They are completely imaginary only, because the plant is not in operation; it is a new design.

So, you imagine certain anticipation of deviations either maybe resulting from equipment malfunctioning, it may result from operational error. In the design of new plants, generally designers shall oversight few issues related to safety in the beginning. This maybe result in kind of few errors. Actually, HaZOP highlights these errors in advance. Remember, the plant is still in design stage, it is not gone to operation; even in the design stage, I am able to perceive the deviations of the design intents, and I am tried to formally put them as a report, which we call as an outcome of an HaZOP study. So, an HaZOP study highlights, even such imaginative anticipations of deviations well in advance for a plant, even at a design stage itself. So, we are now considering a risk mitigation, even when the risk is in at hazard level itself. Remember, hazard is a scenario, risk is a maturity of the scenario.

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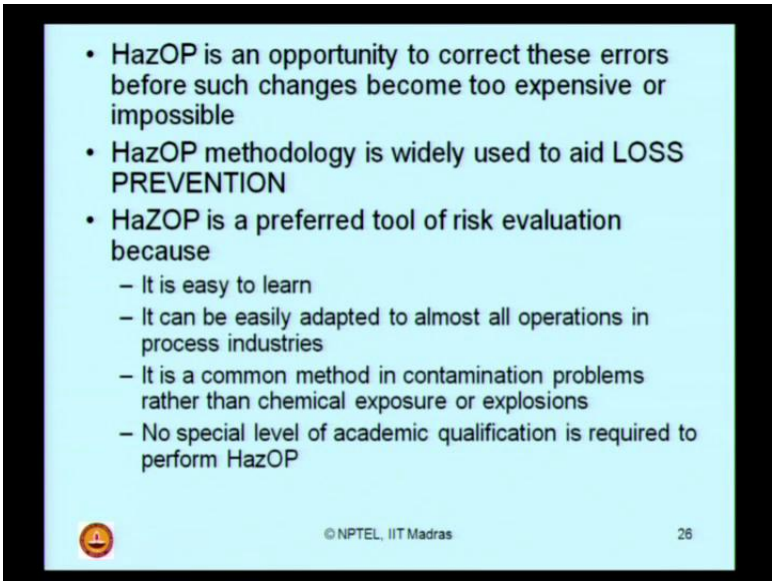

Therefore, ladies and gentlemen, HaZOP is an opportunity to correct these errors before such changes become either too expensive or they become practically impossible. So, HaZOP methodology is widely used as an aid to do or to achieve, what we call as loss prevention. Before any loss is perceived in the design intent or in the operation of a plant, we try to conduct on HaZOP study, which can reduce or minimize, or completely effectively do what we call as loss prevention.

Therefore, HaZOP is a preferred tool of risk evaluation, because it is very easy to learn which I will teach in the successive lectures. It can be easily be adapted to almost all

operations in process industry. It is a very common and popular method in contamination problems. It is not generally employed for chemical exposure or explosion models. Then you may ask me a question, sir what kind of risk analysis are done for chemical exposure problems or fire explosion models? We are discussing this in detail in module three in the coming lectures. The greatest advantage what you see here is a last point.

HaZOP study does not require any special level academic qualification. It can be easily done by an experienced person of process industry; provided he is giving a basic level of training how to prepare such HaZOP reports. But HaZOP experts are actually considered to be an invaluable asset of an organization, because, as you all understand HaZOP report perceives imaginative deviations from the design intent which can even reduce the risk level to a greatest possible extent. So, he is seen as a human life god of the whole process industry, but to prepare an HaZOP report or to conduct an HaZOP study, you need not actually have to have a special level of academic qualification; it is as a simple as that.

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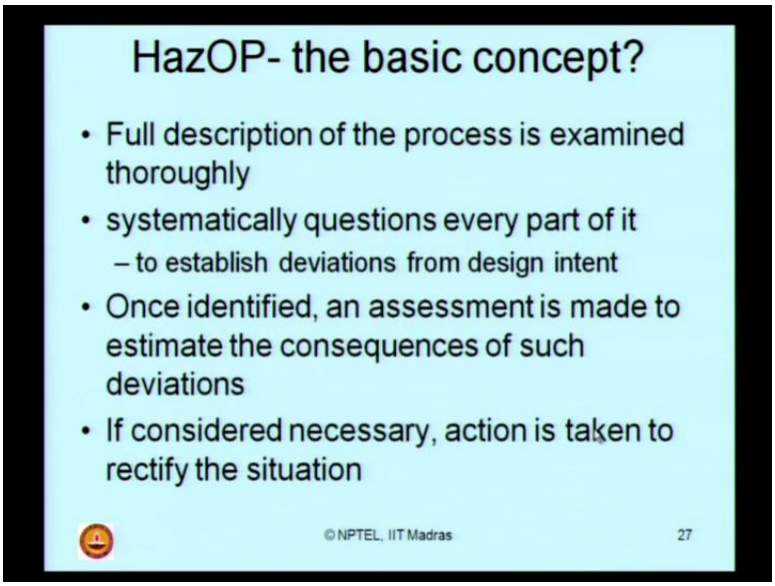

If that is the case, let us ask a question. What is the basic concept of HaZOP? The basic concept of HaZOP actually is the full description of the process, it examines the process thoroughly. It systematically questions every part of it; why It wants to establish deviations from the designed intent? Ladies and gentlemen, now I think, you are comfortable with these two terminologies deviation and design intent. Once the

deviations from the design intent are identified, a thorough assessment is made to estimate the consequences of such deviation, because every deviation will have a consequence. We have got assess the consequence of that.

If considered necessary, if the consequence are very worse, then action is taken to rectify the situation. So, the basic concept of HaZOP is to describe the process fully and thoroughly to systematically examine every part of it, to establish deviations from the design intent of the process plant. Once the deviations are identified, a thorough assessment is made to estimate the consequences of such deviation; if the consequences are very bad, then actions are suggested to rectify or to improve the situation.

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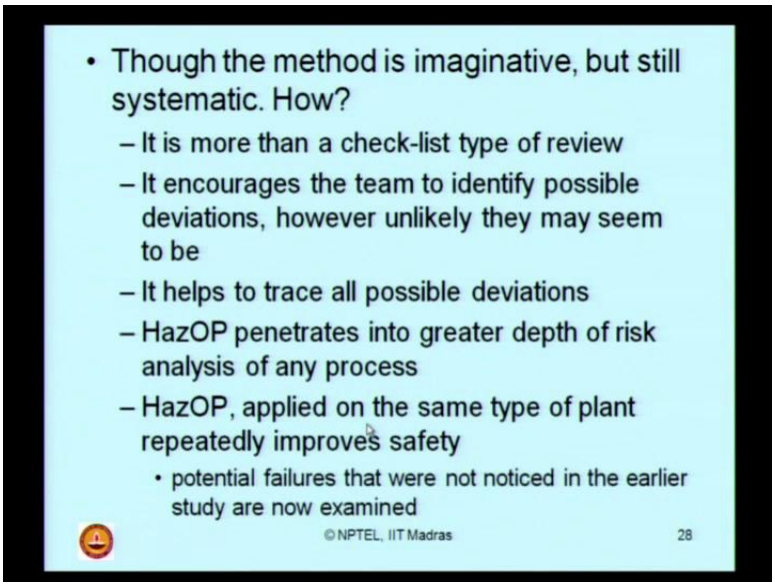

How this is done? You may wonder that HaZOP program or the study is thoroughly looks like imaginative, but it is a systematic method how because, this HaZOP method is more than a checklist type of review. Remember checklist type is also one of the hazards, which can be performed. It encourages the team to identify possible deviations. Some of the deviations you may wonder they are completely unlikely, but still imaginary deviations are also assumed and the team is encouraged to look into those deviations as well. It helps to trace all possible such deviations therefore, one can say HaZOP penetrates into greater depth of risk analysis of any process. The advantage of this situation is that HaZOP when applied on the same type of plant repeatedly, improves the

safety of the plant, why because potential failures that were not noticed in the earlier study are now examined.

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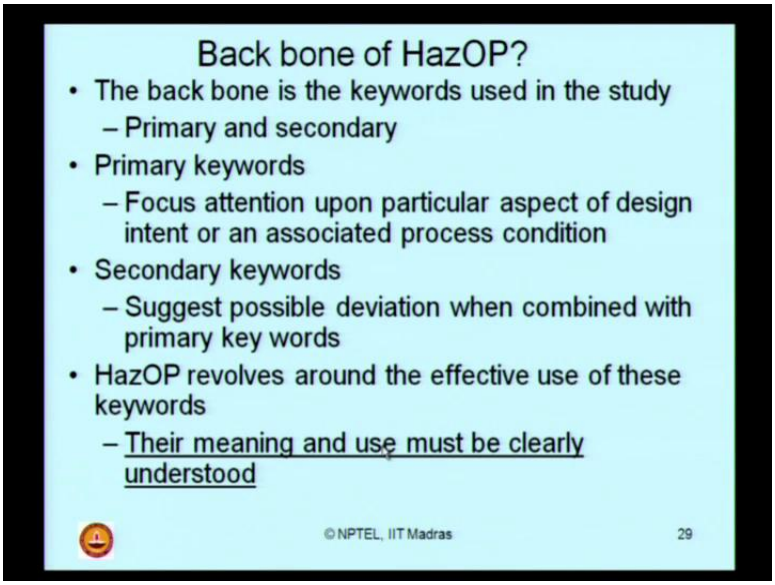

There is something called backbone of HaZOP. Let us see, what is that? The backbone of HaZOP study are, the primary and secondary keywords, which are used in this report. Now, the question comes, what do we understand by primary keywords? Primary keywords generally, focus attention upon particular aspect of design intent or an associated process condition. So, primary keywords address design intent whereas, secondary keywords suggest possible deviation when combined with a primary keyword. So, in actual the back bone of HaZOP revolves around two set of keywords - primary keywords which addresses the design intent, secondary keyword which address the deviation.

So, for a given process industry, if I am able to list down the design intents and the possible deviations from the design intent about 50 percent of my HaZOP study is successfully done. Therefore, I can put it like this, Hazop revolves around the effective use of these keywords. It is therefore mandatory that the meaning and use of these keywords must be clearly understood.

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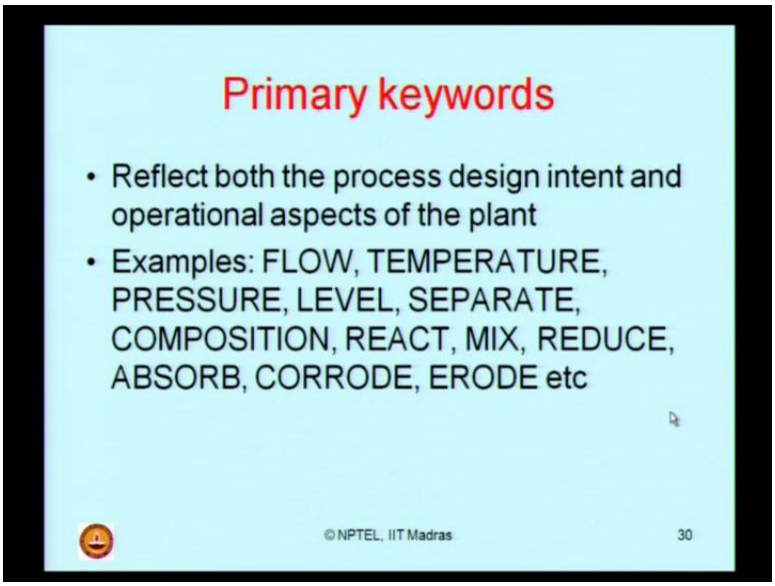

Now the question comes, what are primary keywords? As I already said, primary keywords address the design intent of a process plant; it may be a new plant; it maybe an existing plant in operation. The primary keywords are generally used to reflect both, the process design intent and the operational aspects. Because as you recollect HaZOP addresses the hazards involved in the process as well as in operation that is, why is it called HaZOP. So, the primary keyword should reflect the process design intent and operational aspects of the plant.

I can give some examples. Flow, temperature, pressure, level, separate, composition, react, mix, reduce, absorb, corrode, erode etcetera. You can read these words once again, you will be able to recollect the words are closely associated with the design intent of any plant. You may be confused to understand, why corrosion or corrode can be a design intent, because we generally do not design any plant which should get corroded. On the other hand, you can say erosion, absorption etcetera.

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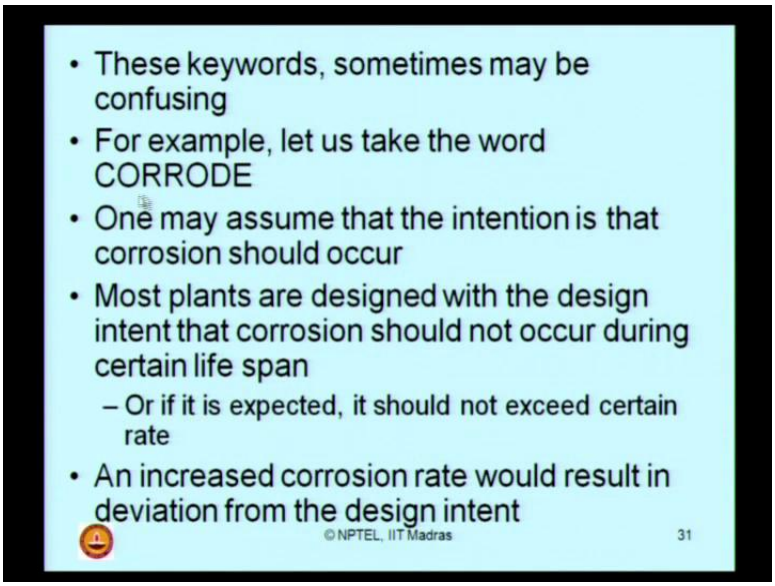

Can we explain these keywords just more in detail, because these keywords sometimes maybe confusing? For example as I said, let us consider the word corrode. One may assume, that the intention is corrosion should occur. One may assume, that looking at the keyword as corrode, you may assume that the intention is that corrosion should occur, but that is not the case. Most plants are designed with the design intent that corrosion should not occur or even if it is expected, it should not exceed certain rate.

An increase corrosion rate would result in deviation within design intent. Therefore, the world corrode is going to address the corrosion rate; if the corrosion rate is increased, then there is a deviation there in an intent. So, do not read the word as such for a primary meaning, try to understand these keywords, so that these keywords are associated with a specific meaning like, for example, corrode is associated with the meaning as corrosion rate. Any increase in the corrosion rate would result in deviation from the design intent.

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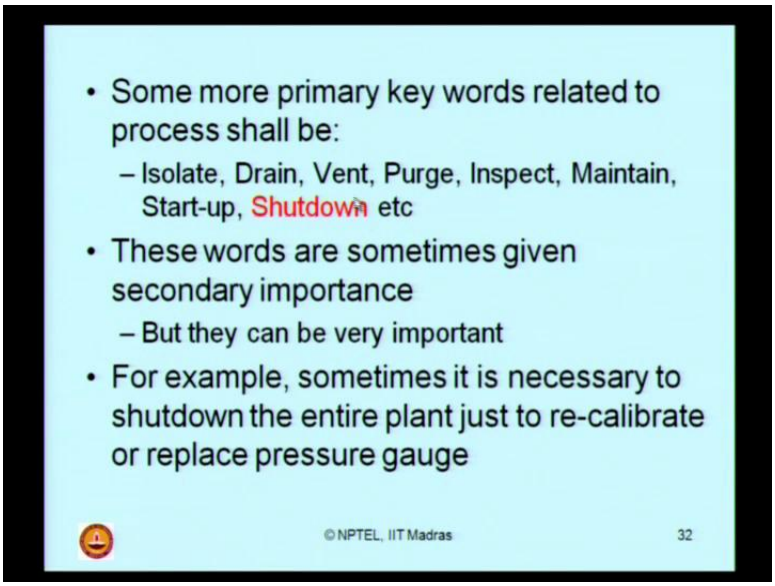

Some more primary keyword related to process are also listed here. Isolate, drain, vent, purge, inspect, maintain, start up, shutdown etcetera. You may wonder where do we get these list of keywords. Do we have any dictionary or any word vocabulary, which can give me what are the primary keywords, and what are the secondary keywords? We will address this specific question at the later part of this lecture.

So, let us say there are some more primary keywords; I am giving example which are related to process. You may wonder why shutdown is considered as a keyword, because the design intent is generally not to shutdown the process at all. You may wonder that some of these words may have a secondary importance sometimes, but they are necessary, because for example, if you consider the shutdown as a keyword it is necessary to shutdown the entire plant, just to recalibrate or replace pressure gauge. If we want to really recalibrate or replace a pressure gauge in a control panel then; obviously, the primary keyword like shutdown can now also be one of the function, and that can if not done properly cause a deviation to the design intent.

Therefore, primary keywords related to either process or design sometimes maybe be very confusing; you have got to try to understand the use of these word very carefully in your report.

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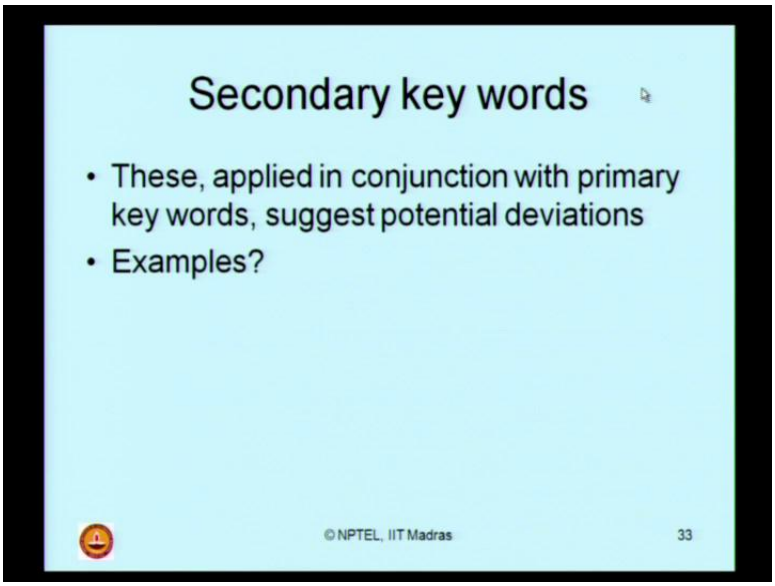

If you look at the secondary keywords, which are also one of the backbone of the HaZOP report. These are generally applied in conjunction with the primary keyword. They generally suggest potential deviations from the design intent. As we recollect, primary keywords talk about design intents; secondary keywords talk about deviations from those design intents. I can give you some examples of secondary keywords.

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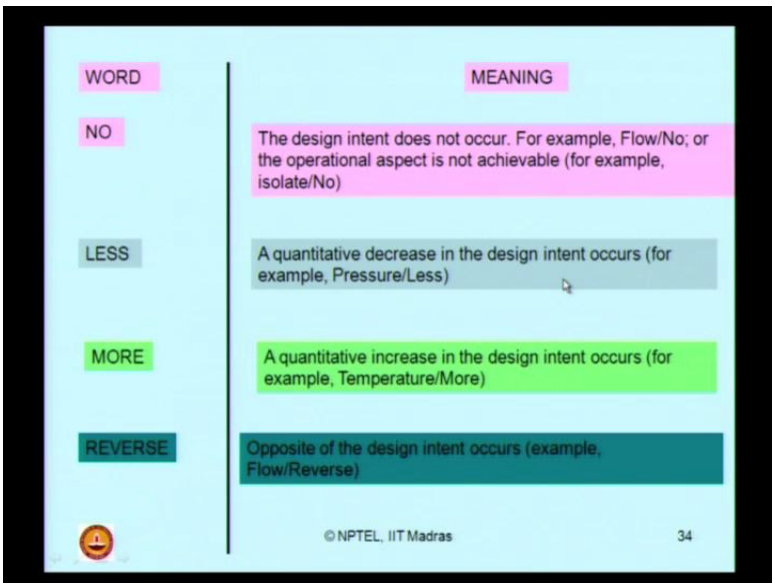

For example let us look at the word NO. The design intent does not occur that is the deviation. For example, flow NO - flow is a primary keyword, NO is a secondary keyword.

Thank you.