Health, Safety and Environmental Management in Offshore and Petroleum Engineering

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Module - 02
Operational Safety
Lecture - 14
Hazop – II

In Lecture-14 on NPTEL course on HSE practices.

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We are discussing module 2, where we are focusing on operational safety. So, in lecture 14, now we are going to talk about Hazop. So, account hazop 2 was in the last lecture also we introduced about hazop studies. Now let us see what are the different steps in hazop study.

In the last lecture we discussed about advantages methods, what are the comparisons of hazop study, what are the data require to perform an hazop study? Who can perform hazop study? When to perform a hazop study? When was it actually originally perform in the beginning? What was the reliable outcome of an hazop study? Why hazop study is considered to be superior in comparison risk analysis though it is quantitative? When address is economic issues because hazop study is more focused towards technical flaws in a given process line, which is more engineering based, it does not mean the rig risk

analysis, not engineering based, but hazop study have more engineering defense in the whole system it is an advantage. So, hazop study generally forms a backbone of much process industry.

It is mandatory as per the rules and regulations of local authorities of any Government including India that any process industry especially oil and gas sector should have hazop reports conducted at least once in a year to re review, what are may be the conditions situations present in the product or the process plant to get the outcome of the possible deviations which can result in accidents a detail hazop study with lot of engineering background with detail analysis and reports could always stand as a referral document for preventing accidents.

In fact, these documents are also seen as post diagnosis document in case of occurrence of any incident or accident. So, people would like to see who conducted hazop report or hazop studies or why this anticipation was not forcing etcetera. So, hazop studies also form a very good reference document in case of post analysis of any accidents. So, hazop studies are considered to be an intelligent way of representing the risk analysis in qualitative terms of course, the only issue here is it may not address the economical consequences directly as if is been very clearly in explicitly seen and presented in risk analysis

So, let us now see what are the steps involved in hazop study in step number one in hazop study one has to very clearly define the design intent. So, for a given problem where you have got the process flow diagram you have got the process and instrumentation diagram which is updated you have got the material specification you have got the product details or the process detail in terms of its operational temperature and pressure etcetera you also have the machinery details which are used in the flow line or in the process line you also have complete information about all safeguards present in the system like sensors alarms buses what are may be the present in the system we have complete information. So, with all these in detail being an experienced person and member of hazop team you would like to capture or focus on the design intent of the given part.

Now, to understand the design intent of a given problem let us take an example let us consider 4 situations.

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The first situation is in automobile industry let us say an automobile industry unit is suppose to manufacture, let say xxx car in a year the second example could be a chemical processing plant to be very specific ETP, let us a fluent treatment plant which has to process. So, many tons of chemicals per year the third could be an offshore plant which has to produce xxx tons or barrels of oil per year. Let us consider all the three parallel our objective now is to really understand what is the design intent in each one of them. So, I am looking for the design intent let say in example one the design intent is enabling the production of xxx cars per year for example, let say we feel that the design intent is focused on production or out turn capacity. In a second example enabling processing of xxx tons of chemical or a fluent per year the third could be enabling production of xxx barrels of oil per year

So, if you really feel that design intent is a focus derived from the production of the plant then you are wrong that is not that is intent design intent is nothing to do with a production or per capacity of the plant at all then what is design intent please understand.

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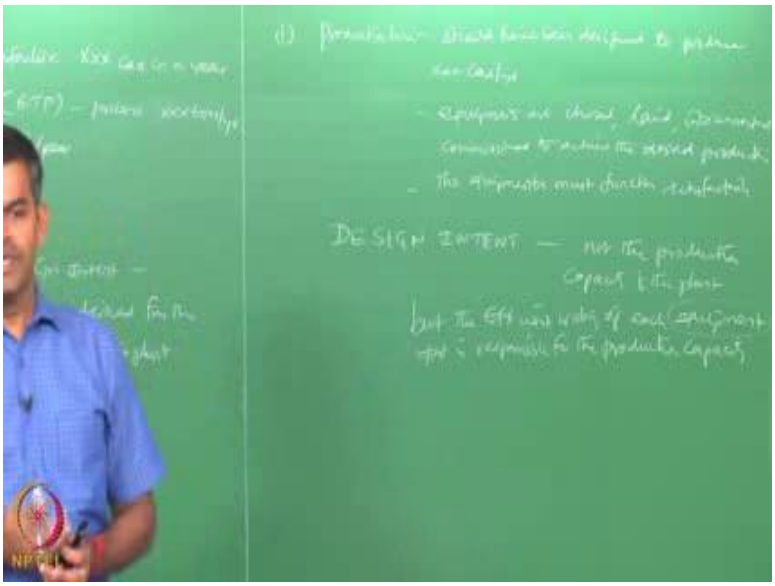

In example one; let us say the process line or the production line I should say should be design or must have been design should have been designed to produce xxx cars per year that is the design goal. So, equipments are generally laid or chosen laid interconnected commissioned to achieve the desired production there is no doubt on that in order to do. So, the equipment should work equipments must function satisfactorily. So, it is therefore, the design intent is not the production capacity of the plant, but the efficient working of each equipment that is responsible for the production capacity.

So, we are looking into the micro detail of the whole process line each and every equipment each and every tools and equipments present in the product line or the process line should be diagnosed individually weather, the equipment have been chosen carefully to produce the designed output weather the equipment has been maintained commission interconnected properly. So, that the medicine works at its full efficiency weather the machine has been selected for designing capacity. So, that for sure the designed output from the plant can be reached even at the possible lowest efficiency of the whole network. So, design intent should focus on micro detail of working capacity of the particular item it is not the production capacity of the whole plant.

So, the first job or the first step in hazop study is to identify the design intent for design intent. For example, an offshore plant is not the production capacity it is the equipments tools items laid in the line of the product line for example, drilling machinery; for

example, in on soil recovery pumps u r pumps for example, heat exchanges all should be checked independently all should be analyzed diagnose independently for any perceived anticipated delay or in efficiency till they are working, so that the overall capacity of the offshore plant cannot be reached. So, we are looking for a micro detail of every equipment present in the product line the second step could be identifying the deviations.

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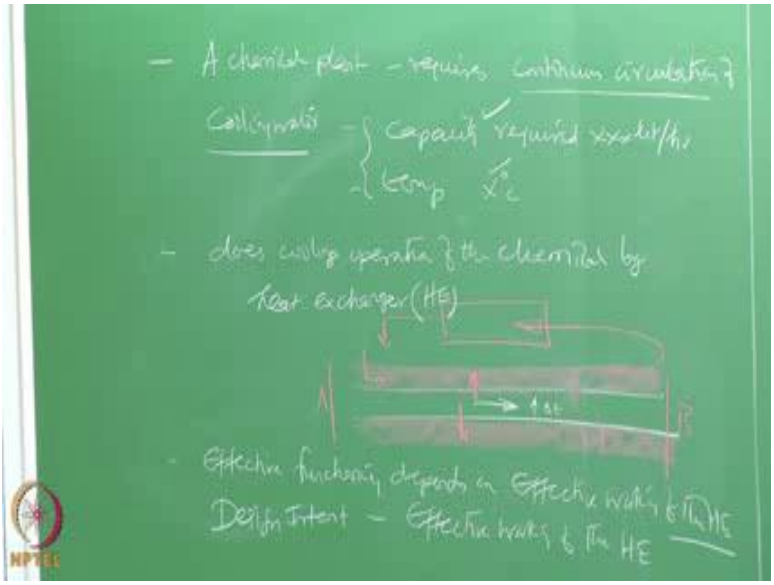

For understanding the deviation in the designed intent consider an example, let us say a chemical plant requires continuous circulation of cooling water the capacity required is xxx car per hour and the temperature at which distribute is apply is x degree Celsius that is a requirement. So, for efficient working of the plant the plant requires the continuous circulation of cooling water at this capacity per hour at this temperature that is a condition working condition.

Now, the plant does cooling operation of the chemical by heat exchanger there are many methods where we heat can be exchanged one can direct in contact one can be indirect contact. For example, we have a process line which is carrying a chemical at a very high temperature you circulate the coolant around the pipe line at a different temperature. So, the heat from the flow line will be transferred to the coolant and the coolant is circulated while the coolant is circulated it get backs through a heat exchanger process and the temperature is completely taken down it is again brought in.

So, depending upon the continuous circulation of this cooling water the heat from the flow line can be transferred as the flow line process from section a - section b. Let us have a plant of that nature which requires a continuous circulation of cooling water at a specific volume or a flow rate at a specific temperature for effective functioning of this plant we all understand that a heat exchanger should function effectively. So, effective functioning depends on effective working of the heat exchanger. So, if the heat exchanger is not properly working; obviously, the very objective of the plant is to cool the flow line which will not happen.

So, what is the design intent design intent is the effective working of the heat exchange it is not the production capacity of the plant. So, design intent in this specific example could be effective working of the heat exchanger for example.

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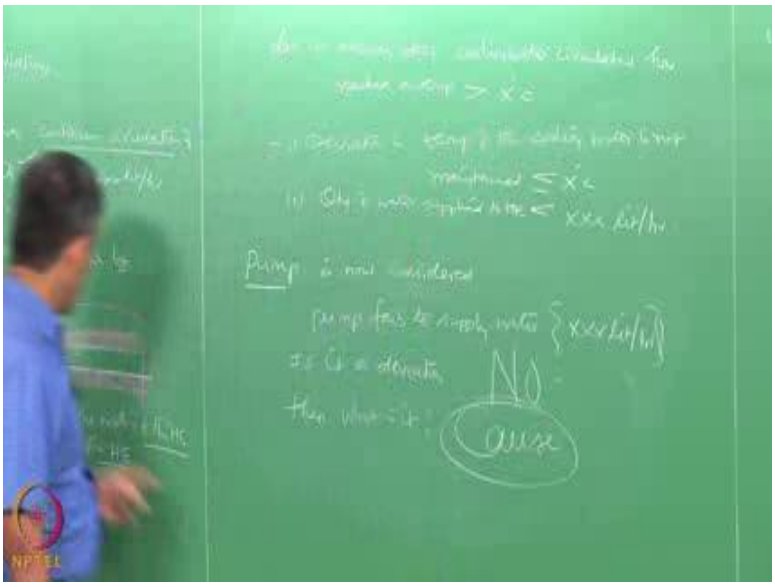

Let us assume that the cooling water circulated has a temperature has reached a temperature greater than x degree centigrade under this condition it is very clear for us to realize that the cooling of the flow line will not be effective. So, the deviation is temperature of the cooling water is not maintained less than or equal to x degree Celsius. So, in the given process system once you know what is the design objective you have to identify the deviations which can cause which can harm the achievement of the design objective.

So, the heat exchanger will not work properly when the cooling water is not supply to heat exchanger at x degree this one deviation now I think you will able to guess a second deviation very easily if the quantity of water supplied to the heat exchanger if less than or equal too lesser than triple x liters per hour.

Then also it can be deviation because it requires triple x liters per hour in terms of its quantity or a flow rate at a temperature of x degree both of them should be met to ensure effective functioning of the heat exchanger if, either one of them is not met heat exchanger will not function effectively it means my design intent is disturbed what is the deviation which can cause which can pose challenge which can disturb the design intent that is the deviation in this case the deviation is quantity of cooling water supply is not xxx liters per hour or the temperature at which the cooling water supplied is higher or greater than x degree Celsius. In both cases individually the efficiency of the heat exchanger will be effected once the efficiency of heat exchanger is effected the very objective of the plant to cool down the flow line will not happen.

So, that is the production capacity. So, it is very clear now the production target the and the deviation in a given flow line can be easily diagnosed and identified for any kind of chemical release problems because as you understand hazop studies are usually applied successfully for chemical plants or process industries.

Now, let us ask a critical question let say I need to pump water to the heat exchanger at a rate of triple x liters per hour. So, pump will also present somewhere in this line because it has got a pump water at this specific rate. So, let us say presence of pump is now diagnosed. Now let us consider considered suppose of pump fails to supply water at triple x liters per hour is not able to supply water is in a deviation is it a deviation the answer is no then what is this it is actually a cause.

So, then what is the difference between deviation and cause deviation is those characteristic or factors which disturb the decent intent directly they are connected to the decent intent directly let us repeat this again for the plant to cool down the flowing liquid from section a to section b heat requires an exchanger heat exchanger works in a very simple principle when a cooling water circulated through exchanger it takes away the heat and cools down the flow line for that the heat exchanger requires 2 parameters, one triple x liters of water in hour at x degree or lower than x degree centigrade.

So, the design intent here is effective function of heat exchanger it is not the volume or the flow rate of the water being cooled in the flow line that is a production capacity now for effective working of the heat exchanger it basically needs water of this capacity and this temperature if these two or one of these two is missing with that rated capacity heat exchange efficiency will be challenged once heat efficiency is challenged the temperature cooling of the flow line will not happen as per the designed objective. So, the production capacity will be affected. So, deviation could be not supplying water or cooling water at this volume or restate or at this temperature. So, this is directly connected to the design intent, but why the water is not supplied at this volume or rate because the pump which is suppose to supply this water has failed though failure of pump has effected sequentially the supply of water which in turn effected efficiency of the heat exchanger; however, the failure of a pump will not be called as a deviation, but it is a cause.

So, now let us see what is the backbone of hazop.

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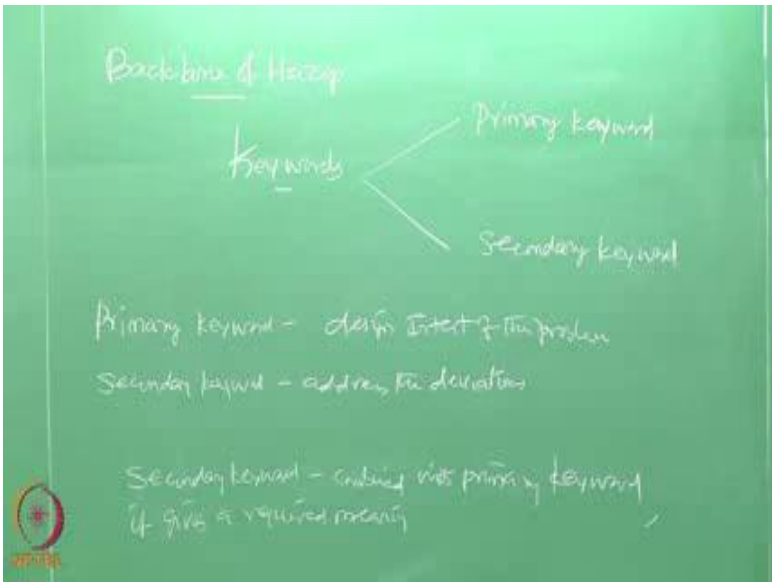

Backbone of hazop essentially depends on the keywords which is being used to write the hazop report there are 2 keywords or 2 set of keywords which are used for writing an hazop report one is what is call primary keyword other is secondary keyword then the primary keyword will focus on design intent of the problem secondary keyword will address the deviations from the design intent. Now when the secondary keyword is

combined with the primary keyword then it gives the required meaning I will give you some examples now hazop study revolves around the effective use of these set of keywords. Therefore, it is very important and why tell to understand the meaning of this keywords and their usage primary keywords essentially should represent the design intent of the process and operational aspects of the plant.

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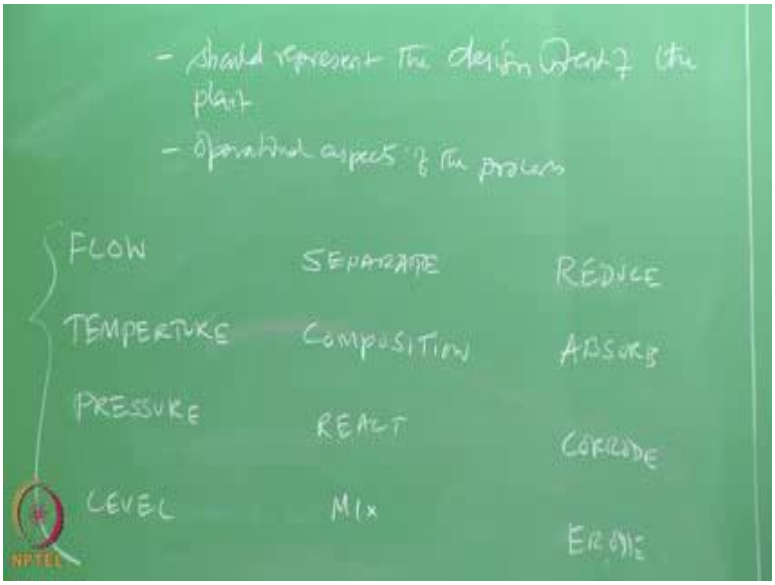

It should represent the design intent of the plant and operational aspects of the process let some examples flow temperature pressure level separate composition react mix reduce absorb corrode erode and so on.

So, one has got to declare the set of keywords in terms the full meaning of them in the beginning of the report because one can use any set of keywords as primary. So, the really should know what are those keywords used as primary in the report they should be pre declared at the beginning of the report now as such if you look at the keywords primary like flow temperature will give stand alone there is no meaning for this words one may even get confused how corrode or erode can be a primary keyword can it be a designed intent can you design a system meant for corrosion can you design a system meant for erosion.

So, are these keywords meaningful can they represent truly the designed intent of any process plant because we do not want corrosion to happen we do not want erosion to take place, but then in that case we do not want to system to absorb we do not want the level

to reduce. So, we will always argue upon these stand alone words or phrases as meaningless because they only and they have to communicate the designed intent in a more meaningful manner to make these words meaningful they should be combined with secondary keywords then only they meaning to the primary keyword can be acquired.

So, some of these words can be even confusing one may assume that the intension is that corrosion should occur as it refers as a primary keyword and primary keyword always refers to designed intent most of the plants generally are designed not to have corrosion therefore, it should not occur during the life span of the system or even if it is expected it should be within certain corrosion permissible rate. So, an increased rate of corrosion would always result in a deviation therefore, corrosion if increased beyond a specific rate will lead to disturbance in the designed intent which can affect the production line which in cause hazard a situation. So, therefore, there should be a word associated connecting corrode. So, that it checks weather the corrosion level is within the permissible limits. So, therefore, primary keyword alone sometimes may be confusing all the times they may not give you the complete meaning as their intended to give in a given system analysis.

Now, if you look at some more primary keywords they will still cause more confusion for example.

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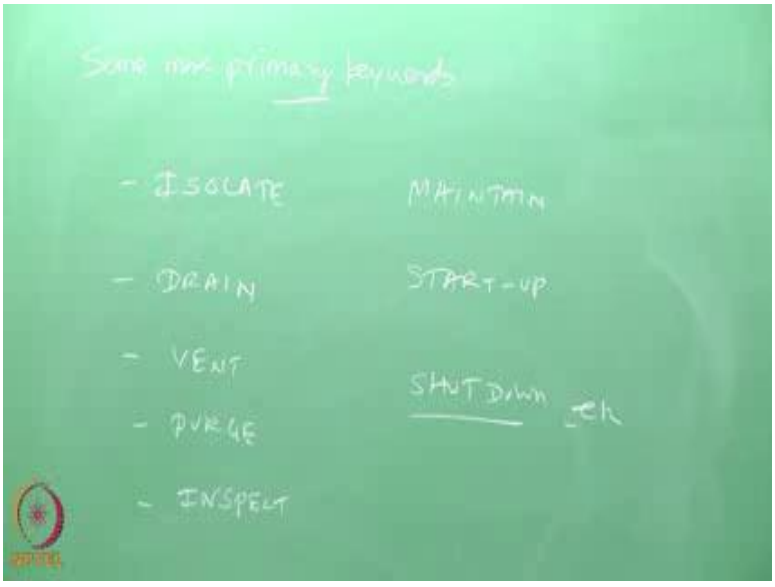

Isolate drain vent purge inspect maintain startup shutdown etcetera some of these words may even have a secondary importance for example, how a plant can be designed intent to have a shutdown if the process plant is already working why a keyword of startup should be referring to design intent because the plant is already working and it should work. So, shutdown sometimes may be required for example, if you have got two lines one is subsidiary of the other one is the bypass line here we go you may have to shut down the main line or the bypass line to active alternate line.

So, shutdown can have some secondary importance in the whole designed intent therefore, it stand alone word will not convey the meaning as required for the hazop study, but it should be combined with the secondary keyword therefore, design intent and deviation go together they are coupled if you look at them individually they cannot communicate any meaning towards the product or production line of the system they should be rewrite understood communicated return together that is important.

Sometimes you know is necessary shutdown the entire plant if we want to recalibrate or replace the pressure gauge in a given process line therefore, shutdown operation may be required may become a design intent in case of emergency where you may have to replace the entire line pressure gauges because they are all out of order. So, therefore, they convey the meaning of deviation from the design intent for example, the secondary keywords coupled along with a primary keyword will give you the meaning of whole phrase.

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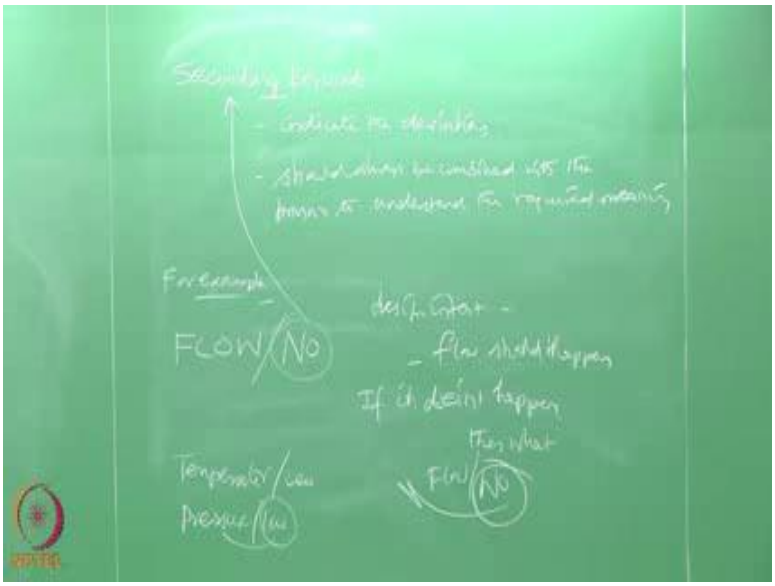

So, the secondary keywords should indicate the deviation that is what our intention is secondary keywords should always be combined with the primary to understand the required meaning, let us say for example; we will take the primary keyword as flow. So, you taken a primary keyword as flow if you agree the primary keyword will represent the design intent. So, we want that a certain flow rate should be maintain in a given process line, that the production can be achieved. So, flow can be recently understandable acceptable design intent, if we say flow no where no is a secondary keyword now this gives me a meaning when there is no flow what would happen to the system.

So, the secondary keyword poses what if question to the primary keyword. So, that is may be say this is deviation from the design intent the design intent is flow should happen the intent is flow should happen should be there or flow rate should be maintain if it does not happen then what. So, flow no secondary keyword actually qualifies the meaning of the primary keyword we can give any examples temperature less pressure low. So, this clarifies improves clarity on the use of primary keyword. So, put together primary and secondary together will now tell me what is the design intent and if it deviates what happens.

But friends interestingly all secondary keywords cannot be combined with all primary keywords I will give an example.

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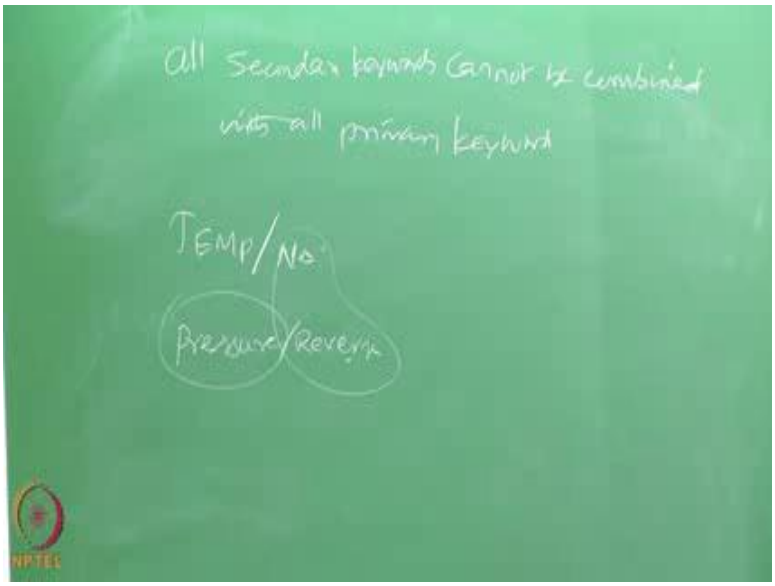

So, all secondary keywords cannot be combined with all primary keywords I can give an example let say temperature no I mean there cannot be a line where there is no temperature, temperature can be either high or low, but there is no temperature does not give any meaning similarly pressure reverse there is no reverse level pressure that can be negative pressure suction pressure or the pressure can be high or low reverse can be related to the flow direction, but pressure cannot it means all primary keywords cannot be combined with all secondary keywords to form a useful meaning. So, it is very important that what are those secondary keyword you are going to use in your report what are the primary keywords you are going to use in the report should be pre declared in the beginning of the report of hazop that is very important because this will improve clarity to the reader that what are your general design intents what are your perceive deviations in the whole system.

So, identify this keywords in a given system one has got a thoroughly study the process flow diagram understand the machineries and equipments placed in the process line understand the specifications of the material being used understand the operational condition and then based on the experience and knowledge they list out meaningful primary keywords because they should give me meaningful connectivity to the design intent meaningful list of secondary keywords because they should tell me the deviations on the chosen design intents and you have to be very careful in combining the chosen secondary keywords to that of the primary keywords because all combinations will not

give you any intent meaning. Therefore, hazop study will result in a very useful outcome what we call as hazop report.

So, secondary keywords will be appeared in conjunction with the primary keywords to suggest or to force or to passive the deviations from the design intent there can be some example of secondary keywords.

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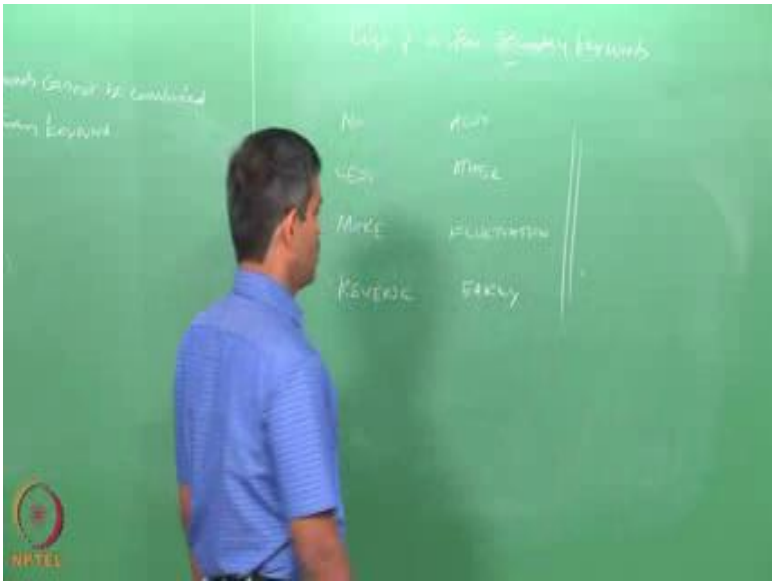

For example, let us say, No less more reverse also other fluctuation early etcetera. So, they will be applied in conjunction with the primary keywords to indicate or to suggest the potential deviation and hazop report will be always in outcome of a formatted statement a hazop report looks like this.

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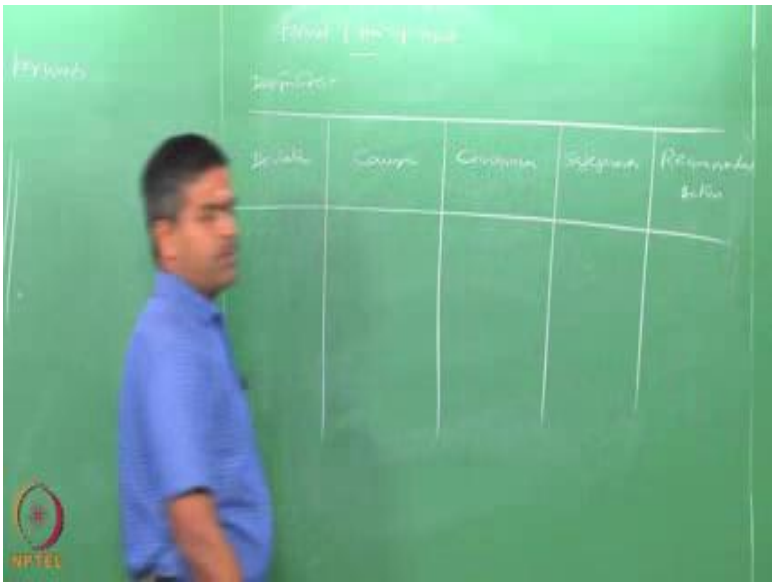

It is in a tabular form it should address the deviation the design intent will be here it should also tell me if the deviation occurs what would be the causes and it will result what consequences what are the safeguards I have in a system and therefore, what are may recommended actions. So, it should be in a tabular form better in xl sheet which can have all the values written in good understandable English.

So, hazop study are generally done on segments of each plant within a segment perceive deviations are identify from those design intents and a report is prepared and in the given flow line what are the safeguards already present and therefore, what do you recommend or suggest we will take an example and then it will be very clear how to write hazop report we will also show you a case study reality how an hazop report was prepared using a software.

Thank you very much.