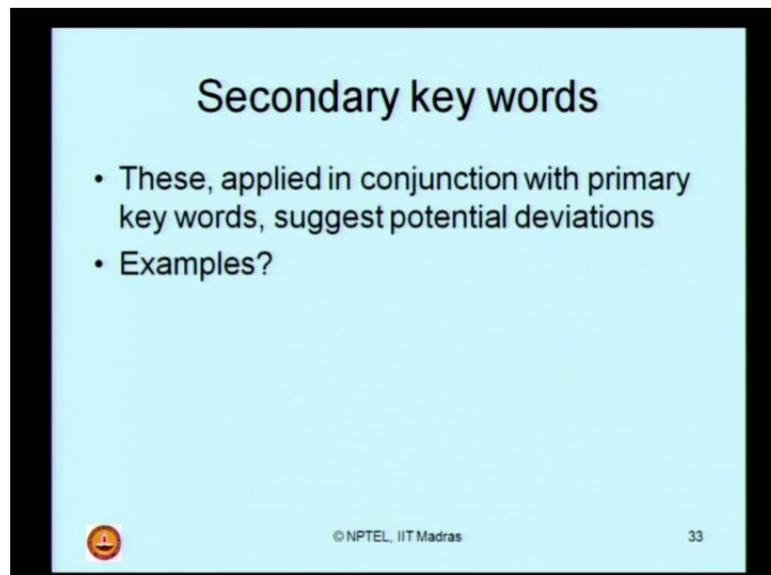


# Health, Safety and Environmental Management in Petroleum and Offshore Engineering

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Module No. # 01  
Lecture No. # 6.2  
HAZOP (continued)

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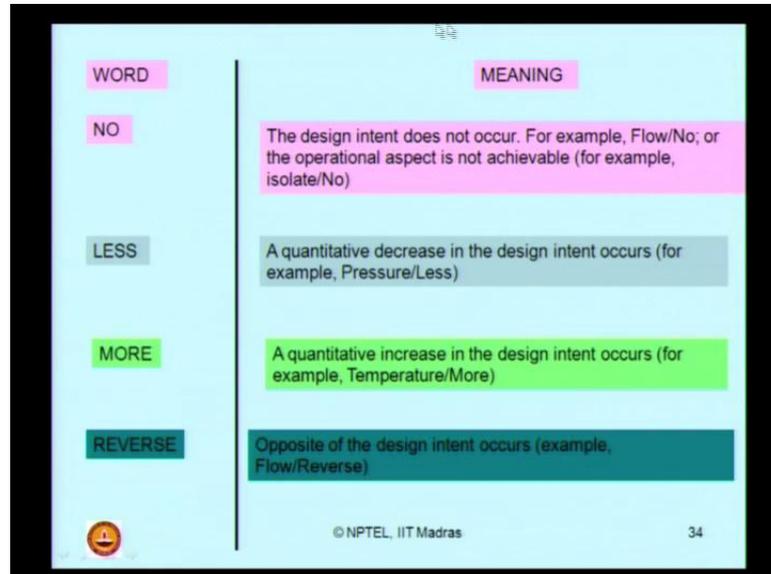


So, we have been discussing about the secondary key words for HAZOP report. These are actually applied in conjunction with the primary key words. As we recollect, primary keywords address the design intents of the process, and secondary keywords address the potential deviations from those design intent. So, we can understand that secondary keywords get combine with the primary keywords, to explain the possible deviations in the design intent. Therefore, deviations on the design intent is exactly the root analysis of an HAZOP study.

What are the list of secondary keywords? How can we combine them with the primary keywords? Can we combine all possible secondary keywords with all probable primary

keywords? What are the successful combinations? What are meaningless combinations? To answer that, let us see at least some examples of secondary keywords first.

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WORD	MEANING
NO	The design intent does not occur. For example, Flow/No; or the operational aspect is not achievable (for example, isolate/No)
LESS	A quantitative decrease in the design intent occurs (for example, Pressure/Less)
MORE	A quantitative increase in the design intent occurs (for example, Temperature/More)
REVERSE	Opposite of the design intent occurs (example, Flow/Reverse)

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Look at this table. I have selected certain secondary keywords, and I am trying to associate certain meaning of the secondary keywords when combined with the primary keyword. Remember secondary keyword should address the deviations for example, if a deviation is considered to be No, I tried to add this or combine this with the primary keyword as flow. Then if you read it like this flow stroke No, what does it mean? It means the design intent in the process is flow should occur, the deviation is No flow is occurring; that is basically an hazardous situation. On the other hand, when No flow occurs the operational aspect of the process is not achieved.

I can also say isolate No, you want to isolate specific sector of a pipe line in a process flow diagram, you are not able to isolate that - it means if the process flow of a specific sector is not isolated what would be the consequences. So, I am looking for the possible deviations from the design intent. Look at this keyword LESS, I want a specific value in my process to stay at a threshold level may be for example, pressure. So, pressure becomes the primary keyword, I combine the secondary keyword LESS to pressure. Now I read it like this pressure stroke LESS. It means, the design intent is I need to have certain pressure in the process. If that pressure is lesser than that value, what happens to my consequence. So, deviation is LESS pressure on the process.

Look at for example, MORE I am looking for a temperature as my primary keyword. I need to maintain certain temperature for my process, if this temperature is quantitatively increased, because of some erroneous occurrence in the flow, then if we say, if temperature is more than a threshold value, there will be a deviation. So, the word MORE uses secondary keyword on the primary keyword temperature makes a meaning for my process. Look at this keyword which is reverse for example, I want the flow to occur on a specific direction from a to b for example, in a process. If the flow is reverse, because of pressure variation, because of mal operational error of any specific valve then what would be the deviation from the design intent? I do not want the flow to get reversed at all. If at all the flow reverses, then there will be a deviation in my process. So, reverse can also be used as a secondary keyword with the primary keyword as flow.

Now, remember, these secondary keywords are combined with certain primary keywords to give them some meaning. So, it is your judicious combination of selected secondary keywords to combine with only selected primary keywords ultimately to make the whole combination meaningful. So, by this way nevertheless one can make a statement that, all secondary keywords may not be possible to combine with all primary keywords. I will give some examples in the successive slides.

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WORD	MEANING
ALSO	Design intent is completely fulfilled, but in addition, some other related activity occurs (for example, Flow/Also indicating contamination in the product stream. Level/Also meaning material in the tank or vessel which should not be there)
Other	The activity occurs, but not in the way intended . For example, Flow/Other could indicate a leak or product flowing where it should not.
Fluctuation	Design intent is achieved only part of the time (for example, an air-lock in the pipe line might result in Flow/Fluctuation)
Early	Usually used when studying sequential operations. This would indicate that a step is started at a wrong time or done out of sequence

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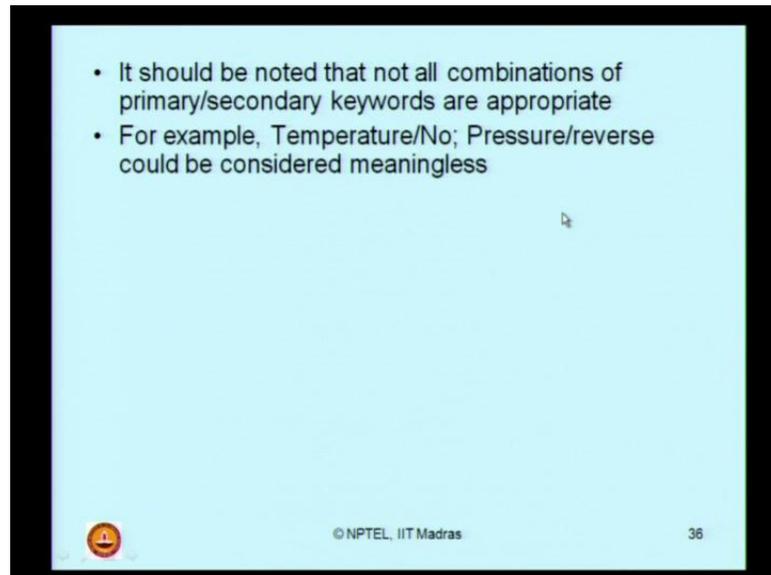
Before that let us also see some more secondary keywords example, for example, let us say, also the design intent is completely fulfilled, but in addition some other related activity also occurs. For example, flow also the design intent is to have a sufficient flow in addition this combination indicates contamination in a specific product stream. Another example can be level also. So, this means material in the tank or the vessel which should not be there. So, there is a material also present whose level is showing an higher threshold value which is not desirable. So, this also can also tell me the deviation on the design intent.

There can be secondary keyword like other also the activity occurs, but the way in which it occurs is not intent for example, flow other could indicate a leak or a product flowing where it should not flow. For example, I want the liquid air to flow through a pipe segment, but liquid A is not flowing through pipe segment some other liquid B is flowing. So, flow other can be a deviation, you can also have keyword like fluctuation. The design intent is achieved only part of the time because there is a fluctuation. The fluctuation can be in pressure, the fluctuation can be in flow. This fluctuation can be resulting because of an airlock in the pipe. So, this combination would tell me there is a fluctuation in flow there is a fluctuation in pressure for example, then that can be resulted from an airlock. So, airlock can be a cause for this deviation

I think you are slowly getting the point how to identify the secondary keywords, the primary keywords and the cause. On other hand, how to identify the design intent, the deviation and the cause for the deviation?

You can also have a secondary keyword by name, early usually youth when studying sequential operations. For example, I have a style of operation to be followed. The operation has to stay or slowly follow a specific order, but this keyword can tell me alarmingly some operation would have occurred early than it must have started. So, the operation has started in a wrong time or the operation has occurred in a wrong sequence. So, this early combined with the error of flow or pressure etcetera can tell me a deviation from the specific design intent

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So, now ladies and gentlemen, in an HaZOP study, you are able to identify the design intents in a process, you are able to identify or list the deviations possible from the design intents, you should also know that all combinations of this keywords are not appropriately meaningful for example, temperature no pressure reverse could be considered as a meaningless combination as there is nothing like no temperature there can be a low temperature there can be high temperature there can be no pressure there can be high pressure, but there is no reverse of pressure there can be reverse of flow

So, you cannot combine all possible secondary keywords with all possible primary keywords because sometimes such combination could give you meaningless statements as well. So, be careful when you draft an HAZOP report how to combine the secondary possible words with primary keywords.

Ultimately this should tell me a deviation on the design intent which should ultimately give me some meaning, In this case these statements are combination, do not give me any meaning at all

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• Results of HaZOP study are recorded in a desired format

• Termed as Hazop report

Deviation	Cause	Consequence	Safeguards	Action

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Now, the question comes how a HAZOP report is generally prepared? You have a standard format of an HAZOP report. The results of HAZOP study is recorded in a desired format. This is what it termed as an HAZOP report. The format looks like in a given process industry, try to identify all possible deviations for a specific design intent.

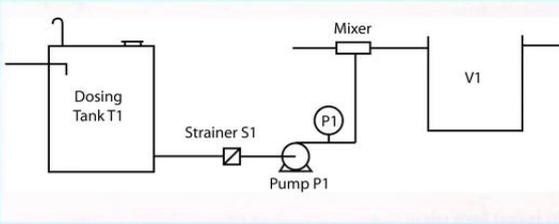
You may wonder why I am not using a column here. Design intent I am using deviation, basically I will write here flow no. So, that combination will tell me what is the design intent and what is the deviation because one is mainly worried about the deviation on the design intent.

So, instead of separating the design intent and deviation, I am putting them together and calling them as a deviation in the process plant. Then I have to fill here what could be the cause for such kind of deviation. I will list all those causes in this column, if that cause occurs or the deviation results in a process what could be the consequence or what all the consequences can take place when the deviation is realized. Can I have or do we have any existing safeguards which can control limit mitigate completely these consequences? If it is not there what kind of action should I recommend?

So, ladies and gentlemen, HAZOP report is a comprehensive document in a tabular form which has these five columns which explicitly states their own meaning in a written report. And now can you guess, my primary and secondary keywords will be located in

which column of this report. Your guess is right, the primary and secondary keywords will be located in the deviation column of this report

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The diagram illustrates a process flow starting from a Dosing Tank T1. The liquid from the tank passes through a Strainer S1, then through a Pump P1, and finally through a Mixer before entering a tank labeled V1. A pressure indicator (P1) is shown on the line between the pump and the mixer.

- Example problem
- Deviation: keyword being applied is FLOW/NO
- Cause: Potential causes that would result in deviation- Strainer S1 blockage due to impurities in the Dosing Tank T1 might cause No Flow

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Now, let us take another example that make you to understand how we can explicitly write this five columns for this specific example. Look at this example carefully, this example has a clear line diagram which will give you real process of flow diagram. There is a dosing tank T 1 - the dosing tank T 1 receives a chemical in, there is an inlet. The level of dosing tank should also control because if it overflows it may be a problem. I can have a level indicator here or I can have a pressure release indicator here because if the pressure inside the tank exceeds a threshold value, I should be able to release the pressure here. So, I have a tank T 1 , which contains the dosing chemical. this dosing chemical has to pass through this line and reach V 1. Our two tanks T 1 and V 1 not only receive chemical dose from T 1 some more chemical like T 1 is also further added to V 1 through a mixture here.

Now, the chemical from T 1 flows through V 1 not on gravity, but I pump this liquid to V 1 because I need a specific pressure to be maintained I pump this liquid to V 1 or this dosing liquid to V 1 through this line while doing. So, this dosing time may have certain impurities which do not want to be participating in the reaction in the tank V 1 therefore, I use what they called a strainer S 1.

So, the function of the strainer S 1 is to filter certain chemicals certain impurities which are not desired to take place as a reaction in the tank V 1. So, I have a pressure gauge P 1, which can also control and indicate the pressure in this line and this can be one of the safeguards of a pressure release, if the pressure in the line exceeds a specific desired value.

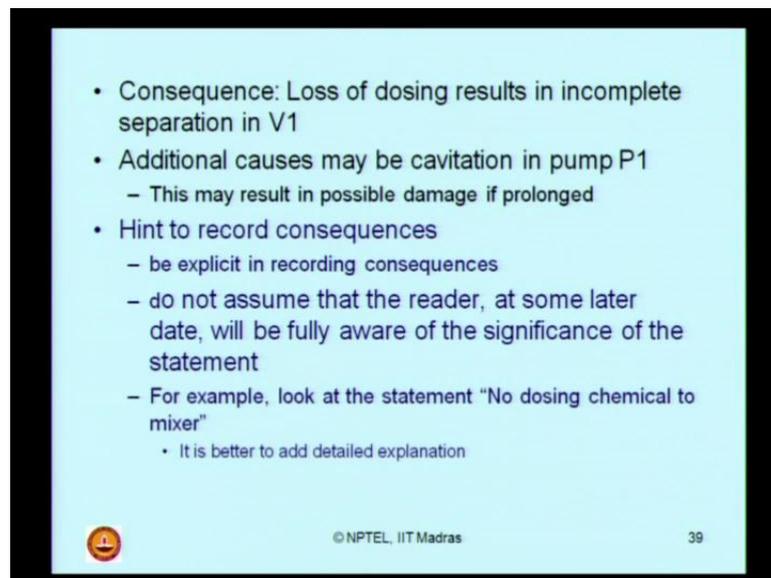
Now, the mechanical components present in this process and flow diagram can be listed as follows one a strainer, strainer is not a simply filter; it can be electronic filter; it can be a mechanical filter. The pump P 1 the pressure gauge for the pump P 1, the mixture and of course, the tank V 1 and the tank T 1 and of course, the inlet control wall the pressure release valve etcetera of tank T 1, you can have a similar arrangement in tank V 1 as well and then from this segment the process is further flowing.

I am taking only one segment of this process to understand how can a record the deviation the design intent then the causes the consequences and the action. So, I will explain them one by one slowly. So, this is an example problem given before. I try to explain you this problem. Can you attempt to write down the list of design intents in this problem? The possible deviations from the design intent in this problem, the possible causes which could result in such deviations, if at all any such deviation occur what are all the consequences of the deviation do you see any safeguard measure in this problem? If at all no safeguard measures are seen what actions you want to recommend for this p f d process?

Let us say take one specific example. I am filling up the first column of this report, I am picking up the keyword flow no. Ladies and gentlemen, you can easily recapitulate that this is one of a very interesting combination which we saw in the previous slide. The design intent is, I need the chemical to flow through the line not in the reverse direction from T 1 to V 1. Suppose if there is no flow occurring in this line, there is a deviation because V 1 needs chemical from tank T 1 to do a process. It also needs further chemical from mixture from some other tank T 2. I am not talking about the segment on the discussion at all I am considering only one segment of T 1 receiving supplying chemical to the process at V. So, the keyword what I am addressing here is flow no, what could be the cause if there is no flow?

The potential cause that would result in the deviation could be the strainer S 1 can get blocked, how this can happen? The blockage in strainer S 1 can occur when there are lot of impurities present in the tank T 1, because dosing tank T 1 receives chemical from the direct line there can be lot of impurities in this tank T 1. If that is allowed to flow through this line, the strainer may get choked or blocked due to this impurities present in the tank T 1. Therefore, there is no flow taking place beyond this point. So, the deviation is no flow.

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• Consequence: Loss of dosing results in incomplete separation in V1

• Additional causes may be cavitation in pump P1

- This may result in possible damage if prolonged

• Hint to record consequences

- be explicit in recording consequences
- do not assume that the reader, at some later date, will be fully aware of the significance of the statement
- For example, look at the statement “No dosing chemical to mixer”
  - It is better to add detailed explanation

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What could be the consequence if the flow does not occur if the flow does not occur? The dose from tank T 1 to the tank V 1 is not properly mixed whereas, for the process to be successful V 1 needs certain dose from tank T 1 which remains incomplete. So, that is a consequence.

So, ladies and gentlemen, we saw what is the design intended deviation of this process which is a flow stroke. We also saw what could be the cause for this. For example, one such cause could be the strainer S 1 can be choked because of impurities as a result of which the consequence is there is no flow the consequence will be tank V 1 may not receive sufficient quantity from the tank T 1.

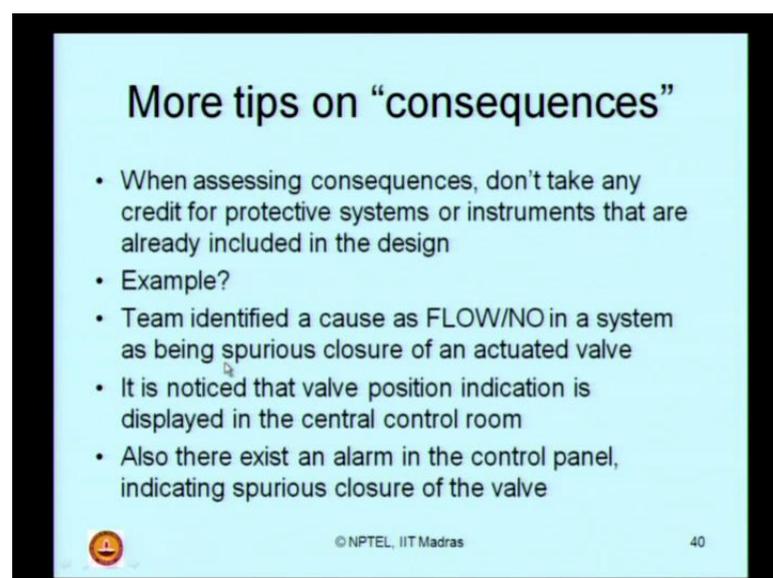
The additional causes may also be pumped to P 1 may result in cavitations. The pump P 1 actually has to pump the liquid or the dosing chemical from the tank T 1 to the tank V 1 when there is no flow occurring because of the strainer S 1 being choked or blocked

then there will be what we call a cavitations in the segment of the pipeline where the pump P 1 is installed.

Now, this can be an additional cause which are also has resulted from the same deviation flow stroke. The consequence of this additional cause could be there whole line or the pump may get completely damaged if this is prolonged. To record the consequence I suggest the following hints when you record any consequence be explicit in recording here. Do not assume that the reader at any later date will be fully aware of the significance of the statement for example, look at the statement no dosing chemical to the mixer that can be a consequence, but you should explain very clearly what could be the consequence if no dosing chemical in the mixer occur you must say that the volume V 1 or the tank V 1 needs certain chemical quantity from T 1 if no such chemical dosing is supplied what could be the consequence.

So, try to record the consequence in detail be explicit. Do not assume that the reader is understanding the whole process in detail as you have understood and therefore, add better detailed explanation in the consequence column. Do not try to be very brief HAZOP report is an extensive elaborate report, why because this report is going to serve as a backbone, if you want to address risk mitigation in the later part of the planned process.

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**More tips on “consequences”**

- When assessing consequences, don't take any credit for protective systems or instruments that are already included in the design
- Example?
- Team identified a cause as FLOW/NO in a system as being spurious closure of an actuated valve
- It is noticed that valve position indication is displayed in the central control room
- Also there exist an alarm in the control panel, indicating spurious closure of the valve

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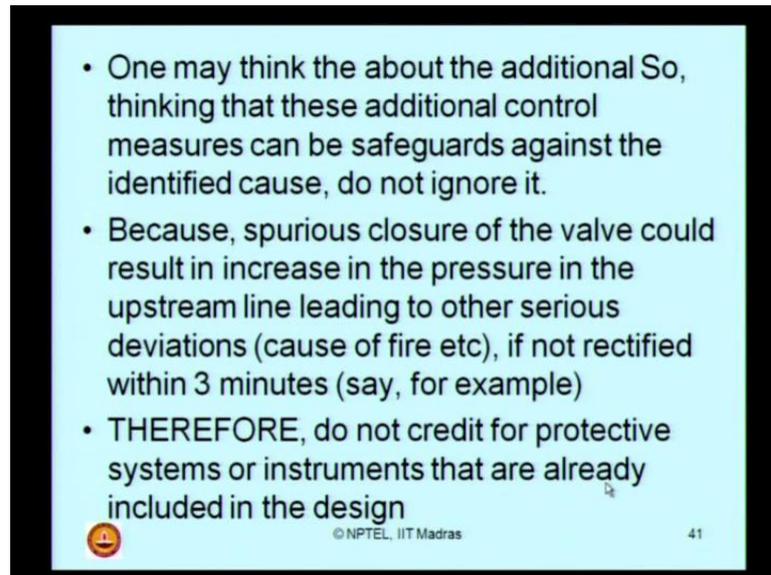
We can also suggest some more tips on consequences. When assessing the consequences, do not take any credit for the existing protective system or any such instruments that are already included in the design. What you understand in this statement? For example, if you already have a safeguard system already present in the process and flow diagram which you explicitly see from a process instrumentation diagram, do not try to take a credit of those systems and do not ignore the consequences because you may wonder that already protect systems are in position why this consequence will occur.

Can you have an example of this specific statement? Here is an example, let us say, an expert team like you identified a cause in an example problem as flow no which has occurred due to a spurious closure of an actuated valve. Let us say there is a valve which controls the flow from tank T 1 to tank V 1. Flow no is a deviation, I am looking for this specific problem that deviation is perceived, because of a spurious closure erroneous closure of a specific valve you may wonder that the valve position indication is displayed in the central control room.

Ladies and gentlemen, in a complicated process industry like the petroleum industry all valve positions or generally indicated for their functional value whether the valve is closed open etcetera either by a light indicator in the control room, for example, there is a valve V 1 the light is green it means the valve V 1 is open the valve V 2, the light is red in the control room it means the valve V 2 is closed. So, for each and every critical valve location generally the central control room in a process industry like the petroleum industry has an indication. So, that is one of the control missions which is already included in the design, but if you think that the valve position is indicated in the central control room therefore, there is no chance of spurious closure of this valve need to be mentioned in the consequence, then you are wrong. Why because, there is also an existing alarm in the control panel which indicates the spurious closure of the valve.

You may wonder there is a double check one, the valve position is shown in the control room two if at all there is a spurious closure of the valve there is an alarm which is also going to indicate to me in the control panel. So, taking granted that these two are already existing measures presenting the design, do not try to ignore this spurious closure possibility in your consequence column at all.

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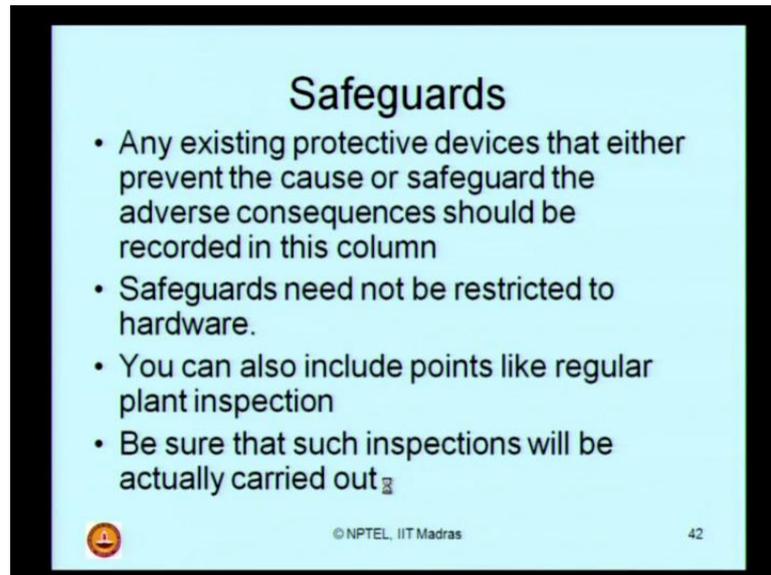
- One may think about the additional So, thinking that these additional control measures can be safeguards against the identified cause, do not ignore it.
- Because, spurious closure of the valve could result in increase in the pressure in the upstream line leading to other serious deviations (cause of fire etc), if not rectified within 3 minutes (say, for example)
- **THEREFORE**, do not credit for protective systems or instruments that are already included in the design

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So, what we mean is one may think that about the additional thinking of such additional control measures can be safeguards against identified causes do not ignore. Because thinking them as additional control you may ignore, but spurious closure of the wall could result in increase in pressure in the upstream line see the control panel will only show that the valve is spuriously closed. The control panel will give an alarm if this valve is spuriously closed fine, but this spurious closure of the wall will result in increase in pressure in a segment of a pipeline which is not seen neither in the control panel nor through an alarm and you also ignored it because you possibly thought the spurious closure of the wall is a default indication in the control panel. Therefore, I am not going to mention the consequence of this at all.

The consequence what you could mention is if the spurious closure of valve is included then the pressure in the line increased, beyond the threshold value and that increase in pressure can result in fire accident. Therefore, any such spurious closure of the valve etcetera for example, even though you have additional control measures indicated in the control panel do not ignore them in your consequences recording. Therefore do not credit for protective systems that already included in the design these protective systems can only indicate for example, the closure of the wall it does not indicate anything about the increase in the pressure of a segment of a pipe because of this spurious closure of the wall is it clear.

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## Safeguards

- Any existing protective devices that either prevent the cause or safeguard the adverse consequences should be recorded in this column
- Safeguards need not be restricted to hardware.
- You can also include points like regular plant inspection
- Be sure that such inspections will be actually carried out

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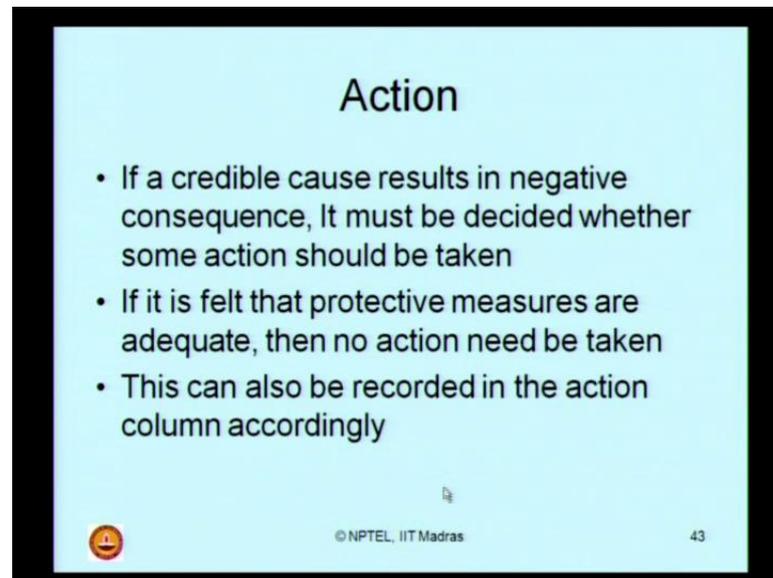
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Let us come to the next column of recording in an HAZOP report which we call as safeguards ladies and gentlemen HAZOP report has basically five columns to be filled up you can recollect parallelly. As I keep on telling you the first column talks about the deviation on the design intent, the second column talks about the causes which could result in such deviations. The third column talks about the consequences, if such deviations occur in the process; the fourth column is going to talk about the safeguards what do you understand by safeguard. If you notice any existing protective device in your P N id either to prevent the cause or safeguard, the adverse consequence record this in this safeguard column to indicate. You mention anything about the existing safeguards available in the existing process instrumentation diagram or in the process plan in this column.

Remember that safeguards need not be only restricted to hardware. For example, if you have a fire sprinkler, if you have a smoke detector, if you have a temperature sensor which are all hardware components of the system. Do not think only such kind of things be mentioned in the safeguards system, you can also include points like regular plant inspection in the safeguard. This can also become one of the important aspects of risk assessment and evaluation, if the plant contains or has a policy of regular plant inspection can include that also in safeguards system be sure that such inspections should be actually carried out that is very important because if we install a device for sure the device will work, but if you make a plan to do a regular inspection then do not do a

regular inspection then the whole advantage of excluding this safeguard will be lost. So, if you say that regular plant inspection is scheduled as a safeguard then you be ensured that such inspections generally should be carried out.

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**Action**

- If a credible cause results in negative consequence, It must be decided whether some action should be taken
- If it is felt that protective measures are adequate, then no action need be taken
- This can also be recorded in the action column accordingly

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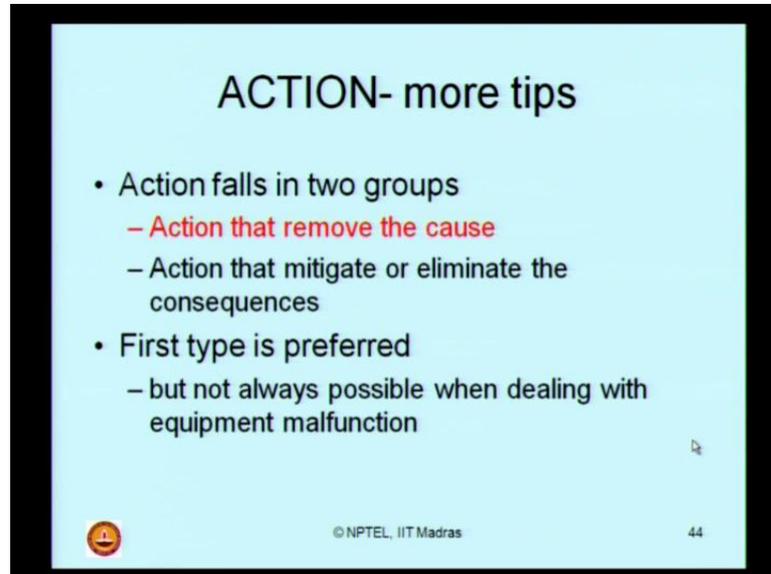
The last column, ladies and gentlemen, in the HAZOP study is what we call as action column if a credible cause results in a negative consequence, it must be decided whether some action should be taken or not. For example, you have noticed a deviation from a design interest you have also identified the cause the root cause for such deviation and you also ascertain that the root cause is giving a very serious negative consequence.

Now, in this column decide whether you must take any action against such consequence or not. So, you have basically mentioned in this column what action is recommended either to mitigate the consequence or to limit the risk resulting from such consequences. If it is felt that protective measures are adequate, then no action need to be taken mention that in your column for example, if already have enough protective measures which you feel there are adequate enough to take care of such consequences, if they occur in a process industry due to any perceived deviation on the design intent then mention that no action need to be taken.

You can also recollect the gold plated process system which you discussed previously

So, if you feel any such adequate measures are available kindly mention that in the action column accordingly

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The slide is titled "ACTION- more tips" and contains the following content:

- Action falls in two groups
  - Action that remove the cause
  - Action that mitigate or eliminate the consequences
- First type is preferred
  - but not always possible when dealing with equipment malfunction

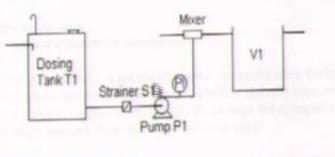
At the bottom of the slide, there is a small logo on the left, the text "© NPTEL, IIT Madras" in the center, and the number "44" on the right.

I can give you more tips for writing this action column. Action column generally falls in two groups, action that removes the cause action that mitigates or eliminates the consequence. Remember there can be action which can address the cause directly there can be action which can address the consequence directly. So, action can fall in two groups. Out of these two, kindly address those actions give importance to those actions which generally attempt to remove the cause instead of addressing those actions which can mitigate or eliminate or reduce the consequences because consequence is occurrence of any action cause is the root reason for that occurrence.

So, let us try to address actions related to the cause and not related to the consequence in general. First type is preferred, but not always possible when dealing with equipment malfunction because equipment malfunctioning can occur. If you do not do a periodic inspection and maintenance of the equipment therefore, you will not be able to avoid the cause for such any failure, but it can always reduce the consequences of this scale. First type is preferred in general, but it may not be possible in all the situations.

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### Let us consider an example



- Possible actions are good for the problem
  - Ensure that impurities cannot get into T1- **fit strainer in the road tanker itself**
  - Consider carefully whether strainer is required in the suction to the pump
  - Examine whether it is necessary that no such matters should enter V1
  - Fit a duplex strainer, with a regular schedule to changeover and clean the standby unit

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Let us look at the same example again quickly. I hope you can recollect this example, I have a dosing tank T 1 which should supply a specific chemical at a specific at a specific concentration volume to the vessel V 1 to initiate the process. Further, the vessel V 1 also receives a similar chemical from tank T 2 which is not a part of this dialogue at all. I have a strainer S 1 through which the line passes to reach V 1, I want to maintain a specific pressure at tone therefore, I pump this dose of chemical dose in chemical from tank T 1. We have already seen the design intent and deviation and causes and consequences of this specific example.

I am looking only for the actions that are good for the problem; the actions can be the following. Please ensure that impurities do not enter the tank T 1 because the impurities enter the tank T 1 the strainer get choked and that becomes a problem therefore, fit the strainer in the tank itself there can be an action that you can suggest for this problem. Consider carefully whether strainer is recruit in suction to the pump, because if the strainer is choked this segment of the pump receives a negative pressure or suction pressure and that will cause what you will call knocking of the pump and the pump may get damaged if this is prolonged.

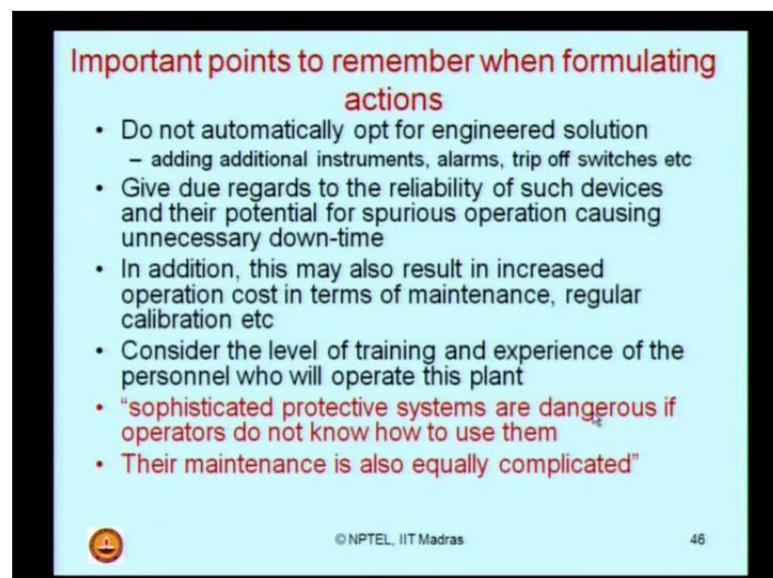
Think seriously do you really require a strainer in this segment or you can replace this strainer somewhere of the inlet of the tank itself. Examine whether it is necessary that no such matters should enter V 1 for example, if my V 1 has a contaminated chemical which

is because of the impurities present in the dosing tank T 1, remove the strainer, for example, and check whether this chemical in V 1 should really not have those impurities.

For example if you format the impurities that present in V 1 as well kindly remove this one from this location as well as from this location. So, that can be also an action in this whole exercise. If you say that the chemical in V 1 should not contain any impurities at all likely to come in T 1 then fit what we call as a duplex chain; that means put this trainer here as well as here as well as somewhere here. So, that the strainer completely purifies the chemical entering in V 1.

But to insist that in the action column that these strainers should be periodically and regularly cleaned for its maintenance, and also have a standby unit of this line because if this strainer is choked, you should be able to pass this liquid V 1 by an alternate line, because if there is no T 1 flow into V 1 the whole process is affected. So, action column is now thoroughly understood, I hope HAZOP report has five columns, basically deviations from design intent the causes the consequences the existing safeguards and the recommended actions.

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**Important points to remember when formulating actions**

- Do not automatically opt for engineered solution
  - adding additional instruments, alarms, trip off switches etc
- Give due regards to the reliability of such devices and their potential for spurious operation causing unnecessary down-time
- In addition, this may also result in increased operation cost in terms of maintenance, regular calibration etc
- Consider the level of training and experience of the personnel who will operate this plant
- “sophisticated protective systems are dangerous if operators do not know how to use them”
- Their maintenance is also equally complicated”

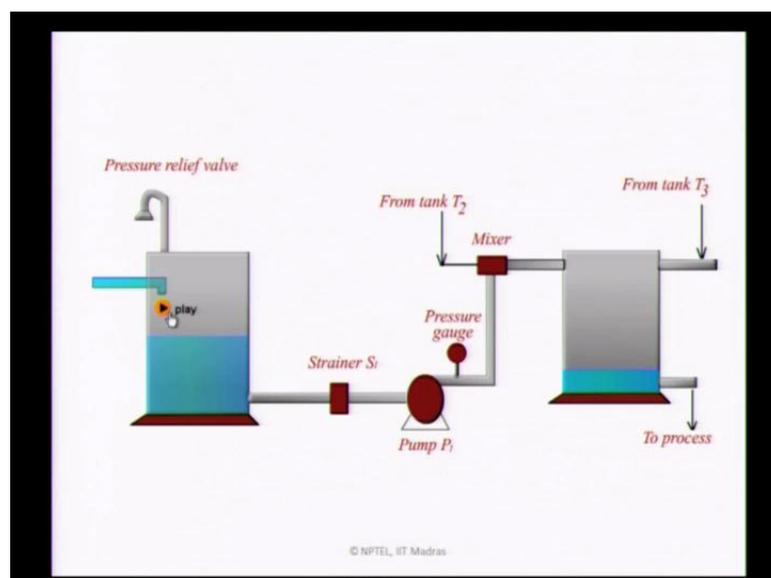
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I now list certain important points, if you are going to write the actions column on an HAZOP report do not automatically opt for an engineered solution, adding additional instruments adding more alarm systems, adding more trip off switches are not an effective method of recommending actions.

Give due regards to the reliability of such devices how reliable are these devices think about them before you suggest any such action for rectifying. The deviation in your design intent in addition such recommendations may also result in increase operational cost. So, you report should justify any such recommended action, if it is inevitable kindly recommend them if you can have a alternative engineering solution do not only rely on hardware components for safeguard or actions, for example, you can add certain actions like periodic inspection periodic maintenance they can also be an action column which increases the cost of course, marginally, but not to this extent, but the effect of this action could be far superior in comparison to adding this segments in a given existing line.

So, you can also consider the level of training and experience to be given to those personnel who will operate this plant that can also improve the deviations in the design intent and you can minimize the consequences. Remember that sophisticated protective systems are dangerous. if operators do not know how to use them because their maintenance can also be equally complicated. So, just by recommending certain additional instruments do not think your action column is completely fulfilled. If you recommend sophisticated protective systems, they can also be equally dangerous and their maintenance can also equally complicated.

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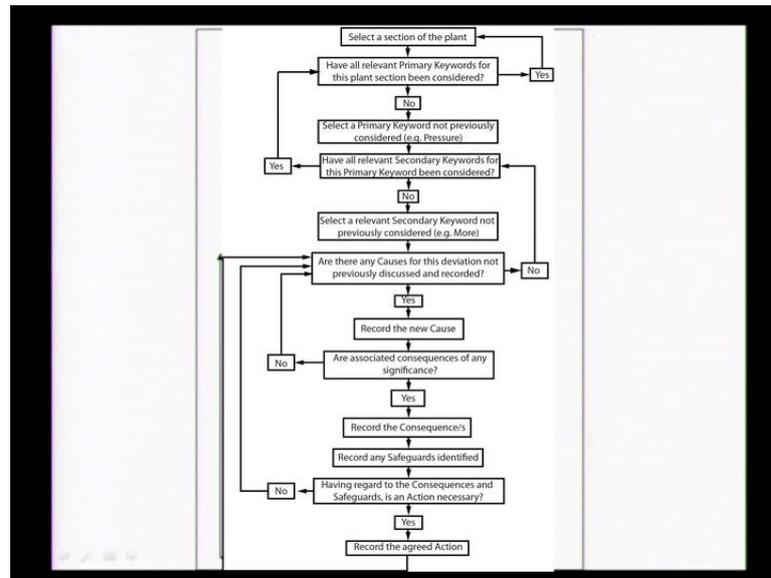
Ladies and gentlemen, let us try to narrate the same thing with an illustrated example here. Let us say have a tank which we call as tank tone. The tank tone receives a

chemical from some inlet source, this chemical has to be supplied to the tank V 1, the tank V 1 also receives supply from another two tanks T 2 and T 3. Let us now not consider this supply source from T 2 and T 3 under the discussion, we will now consider that let us say tank V 1 is receiving supply only from tank T 1. Tank T 1 has some control measures, if the pressure inside this tank exceeds a specific value then the pressure release valve which will safeguard this tank. So, the tank which receives supply from an external source may have some impurities present. To avoid this impurities to be supplied to this tank, I am putting a strainer S 1 which is nothing, but a fast filter.

Now, I want to maintain a specific pressure in this supply line, I have a pump P 1 the pump initiates or causes pressure in this supply line and then there is a mixture from t two and now the content and the specific pressure and temperature reaches tank V 1. No I want to do a basic HAZOP analysis for this facility. Let us see how does it happen, let us say tank T 1 receive a supply close to the pipe and tank V 1 is getting filled up. Now there is a possibility that there may be impurities in the line and due to that impurities the strainer gets choked and there is no flow beyond this strainer line therefore, the liquid content present in V 1 is completely coming to the minimum requirement. Let us see this once again.

I have a supply from tank T 1 the line goes through the pipe fills volume or tank V 1 there is a possibility because of impurities getting choked in strainer S 1 the supply to V 1 stops. Here and there is no supply beyond the line S 1 and that results in reduction of volume in tank V 1 and this is hazardous to my process now what are all the keywords; I can employ to write an HAZOP study for this example. Can you guess, what we can do is, we can first consider one primary keyword which I call as flow and the secondary keyword could be either less or NO. The second keyword primary could be pressure, because pump is operating and the secondary keyword to pressure could be low or high. So, two examples are there in these keywords one is the primary keyword what I call as flow associated by secondary keyword no less more the second set could be pressure associated with secondary keyword high low etcetera. So, by this way one will be able to easily generate the HAZOP report

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Let us see how a flow chart can help us to write or prepare an HAZOP report. So, there is a flow chart here, let us try to explain in simple terms, how an HAZOP report can work on this select a section of the plant. Try to identify all relevant keywords primary for this section being. Consider if you are not identifying all the primary keywords then select those primary keywords which has not been previously considered in the section of this plant, for example, pressure let us say then further consult all possible. All possible secondary keywords check whether have you considered all of them.

If you have not considered all of them then try to select relevant secondary keywords which has not been considered previously in the existing analysis of HAZOP report. Once I now identify all possible primary and secondary keywords in the system, then let us find or every cause for this deviation not previously discussed and recorded. If every cause for this deviation is not recorded then record the new cause then check whether these are associated of any significance because of this consequence. If this consequence are associated with any specific significance, then record those consequences as well then check whether you are plant has any existing safeguards.

If the plan has existing safeguards identify then regard to those consequences safeguards is action necessary has been carried out if a given enough regard to those safeguards present in the action then record the agreed action. Otherwise, if you have not regarded for the safeguards present then consider them now and repeat the chart again.

Once we are done this completely for a specific section of the plant, get back to the next section of the plant and start doing the process as well. So, this is a very simple illustration as well in terms of sort of a thumb rule. How to start an HAZOP section on the plant, and then how to identify and where to identify the primary and secondary keywords then identify the deviations identify the cause, identify the consequences, record the consequences, check for the existing safeguards, check for whether these safeguards have been regarded properly in your report then record the agreed action.

Ladies and gentlemen, remember that HSE or offer industry always allow what we call as an accepted level of risk that is why we emphasize that record the action what you agree upon. It is not completely require to mitigate the whole risk involved in the plant, you have got to reduce the risk to a level what we call as level of minimum acceptance. Once you do that for a specific section, then repeat the same exercise for all other remaining sections of the plant; that is how you complete HAZOP for the whole study of the plant.

In the next lecture, we will discuss about some more details on HAZOP report, and we are expected to discuss through case studies on HAZOP report, and that is how you will be completing very shortly this module on HSE.

Thank you very much.