


Chemical Engineering
Professir Shishir Sinha
Department of Chemical Engineering
Indian Institute of Technology, Roorkee
Lecture 38: Hazard Identification Methods & HAZOP



Welcome to this module of Hazard Identification & HAZOP study.

(Refer Slide Time: 00:39)

What we have studied in last modules...

- Hazard
- Basics of hazards
- Probabilistic Risk assessment
- Quantitative Risk Analysis
- Strategies of Hazard Identification



 IIT ROORKEE  NPTEL ONLINE CERTIFICATION COURSE

2


In the previous modules we have studied about the hazard the basic definition of hazard and risks what are the basics of hazards. We had the discussion about the probabilistic risk assessment and the quantitative risk analysis and a brief about the strategies of hazard identification.

(Refer Slide Time: 01:01)

HAZARD IDENTIFICATION

The hazard identification methods include the following:

1. Preliminary Hazard Analysis
2. Process hazards checklists
3. Hazards surveys
4. Hazards and operability (HAZOP) studies
5. Safety review



IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 3

So, in continuation to that particular aspect the hazard identification methods this may include the following aspect like preliminary hazard analysis, then we have to construct the process hazard check list on the basis of the different hazard analysis and identification protocol. Then we need to perform the hazards surveys, go for the hazard and operability studies that is called the HAZOP studies and we need to perform the safety reviews.


(Refer Slide Time: 01:34)

HAZARD IDENTIFICATION

1. Preliminary Hazard Analysis

It is semi-quantitative analysis that is performed to:

- Identify all potential hazards and accidental events that may lead to an accident.
- Rank the identified accidental events according to their severity.
- Identify required hazard controls and follow-up actions.

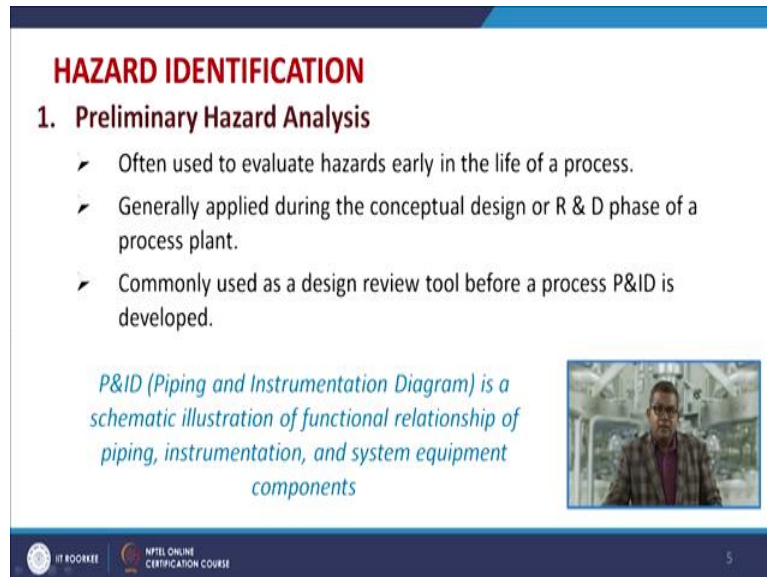


IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 4

So, let us have a look about the first task right that is the preliminary hazard analysis this is some sort of a semi quantitative analysis that is performed to identify all potential hazards

and accidental events that may lead to an accident. So, you need to identify all those things, then basis of your, on the basis of your identification you need to rank the identify the accidental event according to their severity. And then identify the required hazard control and follow up actions.

(Refer Slide Time: 02:08)




HAZARD IDENTIFICATION

1. Preliminary Hazard Analysis

- Often used to evaluate hazards early in the life of a process.
- Generally applied during the conceptual design or R & D phase of a process plant.
- Commonly used as a design review tool before a process P&ID is developed.

P&ID (Piping and Instrumentation Diagram) is a schematic illustration of functional relationship of piping, instrumentation, and system equipment components



IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 5

So, sometimes they are used to to evaluate the hazard early in the life of a process and generally applied during the conceptual design or R & D phase of a process plant so that once you go far the implementation then you must know that what kind of the probable hazard represent at the work place. They are commonly used as a design review tool before a process P&ID developed so the piping an instrumentation diagram is a schematic illustration of functional relationship of a piping instrumentation and our system equipment components.


(Refer Slide Time: 02:51)

HAZARD IDENTIFICATION

1. Preliminary Hazard Analysis

The benefit of PHA is:

- The final product must be “safe”.
- PHA helps designer to identify and deal with hazards.
- Modifications that are made in the earlier design stages are less costly and easier to implement than modifications that are made in the later design stage.
- Helps the designers to anticipate hazards, thereby reducing the number of surprises that occur during the design process.



IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 6

So the benefit of this preliminary hazard analysis they are in the states as below. The final product your basic motto is that your final product must be safe so PHA help in that particular aspect. PHA helps designer to identify and deal with the various kind of the hazard. This benefits the modification that are made in the earlier design stages.

They are less costly and easier to implement then the modification that are made in the later design stage. So this helps the designer to anticipate the hazards thereby reducing the number of surprises that occur during the design process.


(Refer Slide Time: 03:37)

HAZARD IDENTIFICATION

1. Preliminary Hazard Analysis: Scope

The PHA shall consider the following factors:

- Hazardous plant equipment and materials (fuels, highly reactive chemical, toxic substances, explosive, high pressure system etc).
- Safety related interfaces between plant equipment and materials (fire/explosions initiation and propagation, and control/shutdown systems).
- Safety related equipment (mitigating systems, fire suppression & protective equipment).
- Environmental factors (earthquake, vibration, flooding, extreme temperatures, electrostatic discharge & humidity).
- Operating, test, maintenance, built-in tests, diagnostics & emergency procedures.
- Facilities support (storage, testing equipment, utilities).



IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 7

Let us have a look about the scope of the preliminary hazard analysis. This shall consider the different factors like hazardous plant equipment and materials like fuel, highly reactive chemical, toxic substances, explosives, high pressure systems, etc. Then the safety related interfaces between the plant equipment and material again the examples are the fire explosion initiation, propagation and control shut down systems.

Then the safety related equipments that is mitigating the system like, like fire suppression protective equipments, etc. The environmental factors like earthquake, vibration, flooding, extreme temperatures, electrostatic discharge and humidity, operating test and maintenance, built in test diagnostic and emergency protocols etc. Then the facilities support like storage, testing equipment, utilities, etc.

(Refer Slide Time: 04:48)

The slide is titled "HAZARD IDENTIFICATION" in red. Below the title, it says "1. Preliminary Hazard Analysis: Steps". To the left, there is a list of four steps, each preceded by a diamond symbol: "PHA prerequisites", "Hazard identification", "Frequency and consequence estimation", and "Risk ranking and follow-up actions". To the right of the list, there is a vertical "TO DO LIST" with five numbered items (1 to 5) in colored boxes. Below the list, there is a small video inset showing a man in a lab coat. At the bottom left, there is a diagram showing a sequence of four numbered circles (1, 2, 3, 4) connected by arrows, with a hand pointing to the fourth circle. The bottom of the slide features the IIT ROORKEE logo and the text "NPTEL ONLINE CERTIFICATION COURSE".

HAZARD IDENTIFICATION

1. Preliminary Hazard Analysis: Steps

- ❖ PHA prerequisites
- ❖ Hazard identification
- ❖ Frequency and consequence estimation
- ❖ Risk ranking and follow-up actions

TO DO LIST

- 1
- 2
- 3
- 4
- 5

IIT ROORKEE NPTEL ONLINE CERTIFICATION COURSE


Now, there are various steps involved in this preliminary hazard analysis one is so we are going to in detail, that what has the PHA prerequisites. You must have a proper hazard identification list with you, you must have a frequency and a consequences estimation, then you must have a risk ranking and a follow up action. So by this way you can go for this to do list.



(Refer Slide Time: 05:10)

HAZARD IDENTIFICATION

1. Preliminary Hazard Analysis: Prerequisites

- ❖ Develop PHA team.
- ❖ Define and describe the system to be analyzed.
 - ❖ System boundaries.
 - ❖ System description (lay out drawings, process flow diagrams, block diagrams etc).
 - ❖ Use and storage of energy and hazardous material in the systems .
 - ❖ Operational and environmental conditions to be considered.
 - ❖ System for detection and control of hazards and accidental events, emergency system, and mitigation actions.
- ❖ Collect risk information from previous and similar system (form accident data bases).



 IIT Kharagpur  NPTEL ONLINE CERTIFICATION COURSE


9

So, let us have a look about the prerequisites, now, first thing is that you need to develop the preliminary hazard analysis team. Now, this team may include those who are very much aware about the process, those who are very much about the safety reviews of that particular process, etc. Then define and describe the system to be analysed like what are the system boundaries, you may go give the system description, layout drawing process pro diagram, block diagram and flowsheets etc.

Use and storage of energy and hazardous material in the system, you must have a proper MSDS, etc. The operational and environmental conditions to be considered, it is a well-documented, system for detection and control of hazards and accidental event, emergency system and a mitigation actions. Now, collect all information from the previous and similar system, so you may get all those information from the accidental database.

(Refer Slide Time: 06:18)

HAZARD IDENTIFICATION			
Example for a fired heater			
Subsystem/Item	Fired Heater	Trigger event causing potential accident	Burners ignite explosively
Operating Mode	Normal Operation	Potential accident	Explosion and/or fire
Hazardous elements	Fuel supply	Measures to prevent	Provision of flame failure detectors and alarms. Trip systems must be used
Trigger events which causes hazardous condition	No flames on burners and fuel valve open		
Hazardous condition	Fuel enters heater and accumulates		



Now, let us have an example of a fired heater. This gives you a good clue about this PHA. There are various subsystems and item like operating mode sometimes fired heater normal operation hazardous element may present like that is called the fuel supply. The triggered event which is which causes the hazardous condition that may be no flame on the burners or a fuel valve open.



Sometimes Hazardous conditions like fuel enters into the heater accumulates, so triggered events they are also enlisted like potential accident sometimes it may lead to the, to the explosion or fire. Now, measures to prevent that is a provision of a flame failure detectors and alarm and trip systems must be used. So, this gives you the brief outline about this these fired heaters.

(Refer Slide Time: 07:13)

HAZARD IDENTIFICATION

2. Process hazards checklists

- Attempts to compensate for potential limits of hazard recognition, human memory, and attention to specific details.
- Helps to ensure consistency and completeness in carrying out a task from an individual, within a work group, or across an institution.
- Two basic types of checklists: Process-based and Behavior-based.



IT ROORKEE | NPTEL ONLINE CERTIFICATION COURSE

11


Now, next step is that the process hazard checklist now this is attempt to compensate for the potential limit of hazard recognition, human memory and attention to specific details. This helps to ensure the consistency and completeness in carrying out a task from an individual within a workgroup or across an institution.

(Refer Slide Time: 07:47)

HAZARD IDENTIFICATION

2. Process hazards checklists: Process Based

- Address safety hazards associated with a specific, well-defined work task.
- They establish a set of steps for the checklist user to implement.
- To be successful, checklist developers must be able to identify the critical workflow for which the hazard assessment is based.
- Relevant safety protocols are then established and explicitly integrated into the checklist.



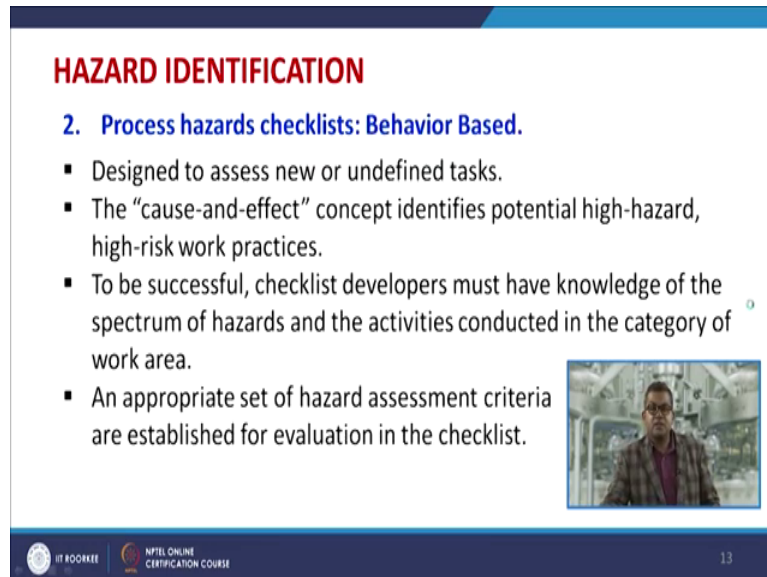
IT ROORKEE | NPTEL ONLINE CERTIFICATION COURSE

12

Now, there are 2 basic type of checklist one is that process based another one is the behaviour based. Now, let us have a look about the process based checklist, this addresses the safety hazard associated with a specific well defined work task. Now usually they establish a set of

the steps for the checklist user to implement. Now, to be successful checklist developer one must be able to identify the critical work flow for which the hazard assessment is based. And you must have a relevant safety protocols then established an explicitly the, integrate all those protocols in to the checklist.

(Refer Slide Time: 08:25)



HAZARD IDENTIFICATION

2. Process hazards checklists: Behavior Based.

- Designed to assess new or undefined tasks.
- The “cause-and-effect” concept identifies potential high-hazard, high-risk work practices.
- To be successful, checklist developers must have knowledge of the spectrum of hazards and the activities conducted in the category of work area.
- An appropriate set of hazard assessment criteria are established for evaluation in the checklist.

IT KOOORKE | NPTEL ONLINE CERTIFICATION COURSE

13


Second is the behaviour based they are designed to assess new and undefined task or scenarios. The cause and effect this concept identifies the potential high hazard high risk work practice. To be successful checklist developer or engineer must have a knowledge of the spectrum of hazard and activities conducted in the category of work area. An appropriate set of hazard assessment criteria they are established for evaluation in the checklist.

(Refer Slide Time: 09:01)

HAZARD IDENTIFICATION

2. Process hazards checklists: Combined Process & Behavior Based.

- Checklists don't have to be strictly process-based or behavior-based. Sometimes, a process-based checklist may incorporate behavior-based checks, and vice versa.
- Often, a behavior-based checklist may be conducted for a higher level risk assessment. If activities are then identified as higher risk, a process-based checklist can be developed to mitigate those risks.



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 14


Now, sometimes we may need to have a combine process and behaviour based system. Now checklist do not have to be strictly processed based or a behaviour based. Sometimes, a process based checklist may incorporate behaviour based checklist or vice versa that depends on the need of the system. So often behaviour based checklist may be conducted for a higher level risk assessment. Now, if activities are then identified as higher risk a process based checklist can be developed to mitigate those kind of risk present at the work place.

(Refer Slide Time: 09:44)

HAZARD IDENTIFICATION

2. Process hazards checklists

- List of possible problems and regions to be examined.
- Questions are usually answered in **Yes** or **No**.
- Reminds the reviewer or operator of the potential problem areas.
- Used during the design of a process to identify design hazards, or can be used before process operation.



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 15

Now, we may have certain things in our mind that list of the possible problem and region to be examined that is extremely important by this way you can identify those regions which are problematic. Now, questions are usually answered in terms of yes or no whether the hazard is present yes or no.



Now reminds the reviewer or operator of the potential problem area this is again in the good practice sometimes you may adopt a loop that whether this particular system operates, yes ok then go ahead and then again you may ask the reviewer that whether this particular thing is good or not, reassure the things. Now, use during the design of a process to identify the design hazard or can be used before the process operation.

(Refer Slide Time: 10:43)

HAZARD IDENTIFICATION

2. Process hazards checklists

- Example: An automobile checklist that one might review before driving away on a vacation.
- This checklist might contain the following items:
 - Check oil in engine.
 - Check air pressure in tires.
 - Check fluid level in radiator.
 - Check fluid level in windshield washer tank.
 - Check headlights and taillights.
 - Check exhaust system for leaks.
 - Check fluid levels in brake system.
 - Check gasoline level in tank.



Handwritten notes: "yes or no" with arrows pointing to "Check oil in engine." and "Check air pressure in tires."; "yes" with an arrow pointing to "Check fluid level in windshield washer tank."

IT KODAKKE
NPTEL ONLINE
CERTIFICATION COURSE

16

There are several examples of process hazard checklist one example is that an automobile checklist that one might review before driving away on a vacation the checklist might contain the following item – check oil in engine - yes or no. Now if it is no then go ahead then again relook that whether the oil in the engine is at the proper level or not check air pressure in the tire - yes or no, check fluid level in the radiator if it is not if it is not then try to go for replenishment.

Then check fluid level in the windshield washer tank – yes or no, if it is not up to the mark then refill it. Check headlight and tail light if it is not working properly then go for the correction, check exhaust system for the leak if it is not functioning properly then go for repair, check fluid level in the brake system if it is not up to the mark then refill it up to the



desired level, check gasoline level in the tank so you have to assure yourself that the petrol or fuel in the level in the tank is up to the mark.



(Refer Slide Time: 12:15)

HAZARD IDENTIFICATION

2. Process hazards checklists

- Design of the checklist depends on the intent.
- Different for use in the course of initial design of the process and for a process change.
- Applied only in the preliminary stages of hazard identification and should not be used as replacement at later stages of hazard identification procedure.
- Most effective in identifying hazards arising from process design, plant layout, storage of chemicals, electrical systems, and so forth.



NPTEL ONLINE CERTIFICATION COURSE17


So design of this checklist depends on the intent. What kind of intent you are having? So based on your intent you may design the checklist as per your requirement. Now different for users in course of initial design of the process and for a process change so they apply it only in preliminary stages of hazard identification, it should not be used as the replacement at later stage of hazard identification. First of all so most effective in identifying hazard arising from process design, plant layout, storage of chemicals, electrical systems and so on.



(Refer Slide Time: 12:50)

HAZARD IDENTIFICATION

2. Process hazards checklists: Advantages

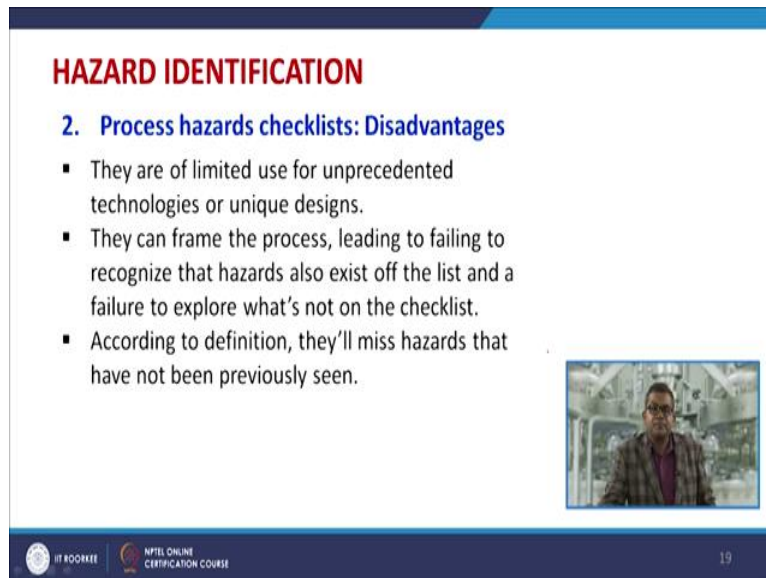
- They can be used by non-system safety engineering experts.
- They are useful for practiced technologies and standard designs.
- They capture a wide range of previous knowledge and experience.
- They ensure that common or obvious problems are not overlooked.



NPTEL ONLINE CERTIFICATION COURSE18

Now, now what are the advantages associated with process hazard checklist? Some of them some of advantages are listed over here, now they can be used as a non-system safety engineering experts. They are useful for the practiced technologies and standard designs. They capture a wide range of previous knowledge and experience and they ensure that the common or obvious problem are not overlooked because you are reaffirming that whether you have checked or not.

(Refer Slide Time: 13:25)



The slide is titled "HAZARD IDENTIFICATION" in red. Below the title, it says "2. Process hazards checklists: Disadvantages" in blue. There are three bullet points: "They are of limited use for unprecedented technologies or unique designs.", "They can frame the process, leading to failing to recognize that hazards also exist off the list and a failure to explore what's not on the checklist.", and "According to definition, they'll miss hazards that have not been previously seen." To the right of the text is a small video inset showing a man in a plaid shirt. At the bottom, there are logos for IIT Kharagpur and NPTEL Online Certification Course, and the number 19.

HAZARD IDENTIFICATION

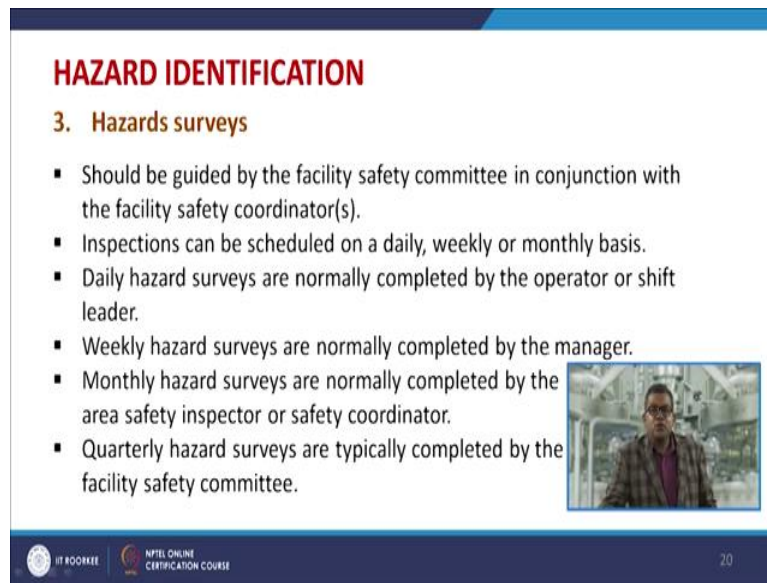
2. Process hazards checklists: Disadvantages

- They are of limited use for unprecedented technologies or unique designs.
- They can frame the process, leading to failing to recognize that hazards also exist off the list and a failure to explore what's not on the checklist.
- According to definition, they'll miss hazards that have not been previously seen.

IIT Kharagpur NPTEL ONLINE CERTIFICATION COURSE 19

Then we are having so many advantages of these process hazard checklist there are certain disadvantages. Now, these disadvantages are they are limited use of unprecedented technologies or unique design. They can frame the process leading to, failing to recognize the hazard also exist in the list and a failure to explore what is not on the checklist, sometimes you may overlook any kind of things which need to be listed in checklist.

(Refer Slide Time: 14:11)



HAZARD IDENTIFICATION

3. Hazards surveys

- Should be guided by the facility safety committee in conjunction with the facility safety coordinator(s).
- Inspections can be scheduled on a daily, weekly or monthly basis.
- Daily hazard surveys are normally completed by the operator or shift leader.
- Weekly hazard surveys are normally completed by the manager.
- Monthly hazard surveys are normally completed by the area safety inspector or safety coordinator.
- Quarterly hazard surveys are typically completed by the facility safety committee.

20

According to definition they will miss hazard that have not been previously seen. So that is again a very crucial issue. So based on these particular things you need to perform the hazards survey. Now, these hazards surveys they should be guided by the, the facilities safety committee in conjunction with the facility safety coordinators. So you need to perform all those things in consideration with these 2 bodies. The inspections can be scheduled on a daily weekly, monthly or yearly basis, usually yearly basis it is performed in case of safety audit.


Now, daily hazards surveys are normally completed by the operator or shift leaders. Weekly hazards surveys are normally completed by the manager or supervisors. Monthly hazards surveys are normally completed by the area safety inspector or safety coordinators. And above all the quarterly safety hazard survey are typically completed by the facilities safety committee.

(Refer Slide Time: 15:08)

HAZARD IDENTIFICATION

3. Hazards surveys

- Should be completed by including as many individual viewpoints as possible.
- Each person on the hazard survey team should be familiar with the process or operation and should have acquired insights concerning problems, faults and situations that could cause accidents.
- Before completing a hazard survey, the inspection team should review past near misses, accidents, employee complaints and written policies that pertain to the area of inspection.



IT ROOKIE | NPTEL ONLINE CERTIFICATION COURSE | 21

Now, these should be completed by including as many individual view point as possible, so that you must have a number of n number of resources because if you are having the large number of resources the quality of those survey will be on the higher side. So each person on the hazard survey team should be familiar with the process or operation and should have acquired the insights concerning problems fault and situation that could cause the accidents.

Now, before completing the hazard surveys the inspection team should review the past near misses because this may give a proper clue. Accidents, employee complaints and return policies that pertain to the area of inspection because these return policies may give a clue and sometimes these return policies may include the local rules or the rules and regulations those who are applicable to the area in question.

(Refer Slide Time: 16:24)

Example of Fire Safety Survey:

General

☐ Yes ☐ No Home has smoke alarms on every level.

☐ Yes ☐ No Home has a smoke alarm in every bedroom.

☐ Yes ☐ No Smoke alarms are located outside each separate sleeping area.

☐ Yes ☐ No Smoke alarms are located at least 10 feet from a stationary or fixed cooking appliance.

☐ Yes ☐ No For larger homes (where the interior floor area on a given level is greater than 1,000 square feet), there is an average of at least 1 smoke alarm for every 500 square feet. [See NFPA 72-2007 11.5.1.3, 29.5.1.3 (2010)]

☐ Yes ☐ No Smoke alarms are interconnected so when one sounds, they all sound. (Best protection)

☐ Yes ☐ No Home has ionization smoke alarms.

☐ Yes ☐ No Home has photoelectric smoke alarms.

☐ Yes ☐ No Home has combination (photoelectric and ionization) smoke alarms.

☐ Yes ☐ No All smoke alarms are working.

☐ Yes ☐ No Family has a home fire escape plan.

☐ Yes ☐ No Family practices the home fire escape plan at least twice a year.

☐ Yes ☐ No The home has occupant(s) that require assistance to escape. Occupants discuss escape planning and occupant requirements in case of a fire or emergency escape.

☐ Yes ☐ No House number is visible from the street.

☐ Yes ☐ No Windows used for escape open easily — not blocked by furniture, security bars or nailed/painted shut.

IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 22

Now, as far the example of this sight survey or hazard survey one example which we have enlisted is the fire safety survey. Now, this is you can see we have asked these things in responses in terms of yes or no. Now, these are the general things like home has this smoke alarm on every level, suppose you put 'no' then again you need to go for the collective measures.

Home has a smoke alarm in every bedroom, smoke alarms are located outside at each separate sleeping area, smoke alarms are located at least 10 feet from a stationary or fixed cooking appliances. Sometimes you put yes no, yes no so if yes then you are relatively safe and if no then you need to go for the corrective measures.

Again that home has ionization smoke alarms, home has a photoelectric smoke alarms, so home has a combination of photoelectric ionization smoke alarms, so all now the crucial question is that all smoke alarms are working if they are no, if you put no then definitely it will look into the previous aspects.


It gives you an opportunity that you can relook the different responses. Now, family has a home fire escape plan, if it is not then definitely you have to work upon. So this particular survey gives you a proper information about the problems associated in the particular facility.

(Refer Slide Time: 18:04)

HAZARD IDENTIFICATION

3. Hazards surveys

- Very simple process.
- Formal systematized approaches using a rating form, similar to an income tax form.
- Final rating number provides a relative ranking of the hazard.
- Two popular forms of hazards survey are:
 - Dow Fire and Explosion Index (F&EI)
 - Dow-Chemical Exposure Index (CEI)



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 23


Now, these hazards surveys are very simple process as we have shown in the, this particular slide. These are the simple questions which you need to ask, then formal systematized approach using a rating form similar to an income tax form. Now final rating number provides a relative ranking to the hazard. Now, there are 2 popular forms of hazard surveys they are, one is the Dow Fire and Explosion Index that is F&EI another one is the Dow Chemical Exposure Index that is CEI.

(Refer Slide Time: 18:28)

HAZARD IDENTIFICATION

3. Hazards surveys: Dow Fire and Explosion Index (F&EI)

- A method (developed by Dow Chemical Company) for ranking the relative fire and explosion risk associated with a process. Analysts calculate various hazard and explosion indexes using material characteristics and process data.
- Designed for rating the relative hazards with the storage, handling, and processing of explosive and flammable materials.
- Idea is to provide a purely systematic approach, mostly independent of judgmental factors, for determining the relative magnitude of flammable hazards in a chemical plant.

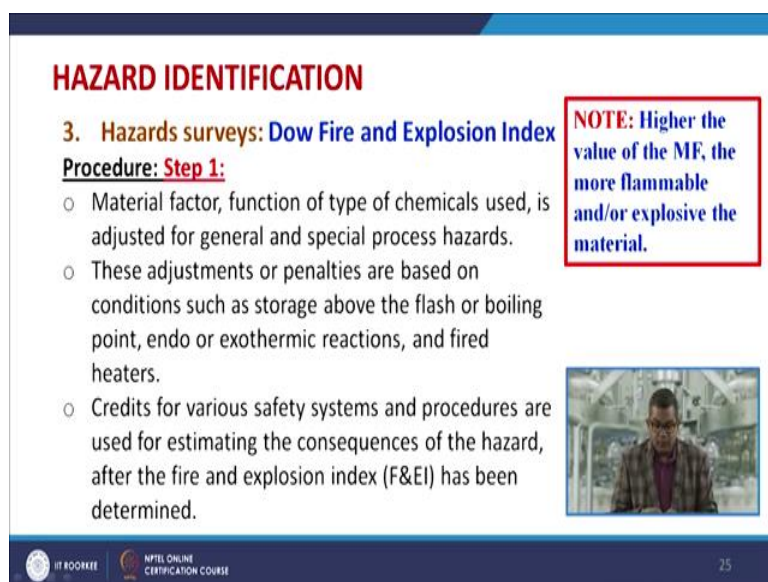


IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 24

So let us have a look of the one by one, the first one is the Dow fire and explosion index, F&EI that is a method developed by the Dow chemical company for ranking the relative fire and explosion risk associated with the process. Now, analysis, the analyst calculate the various hazard and explosion indexes using the material characteristics and process data available.

Now, they are designed for rating the relative hazard with the storage handling and the processing of explosive and the flammable materials. Now, the basic idea is to provide a purely systematic approach mostly independent of judgement factors for determining the relative magnitude of flammable hazard in the chemical plant.

(Refer Slide Time: 19:20)




HAZARD IDENTIFICATION

3. Hazards surveys: Dow Fire and Explosion Index

Procedure: Step 1:

- Material factor, function of type of chemicals used, is adjusted for general and special process hazards.
- These adjustments or penalties are based on conditions such as storage above the flash or boiling point, endo or exothermic reactions, and fired heaters.
- Credits for various safety systems and procedures are used for estimating the consequences of the hazard, after the fire and explosion index (F&EI) has been determined.

NOTE: Higher the value of the MF, the more flammable and/or explosive the material.



IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 25

Now, this is a multistep process and the first step in this to perform the hazard survey pertaining to the Dow fire and the explosion indexes the material factor, function of type of material used, is adjusted for the general and special process hazard. Now, these adjustment or penalties are based on the conditions such as storage above the flash or a boiling point, endo or exothermic reactions and fired heaters.

Now, credits for various safety systems and procedures are used for estimating the consequences of hazard and after the fire and explosion index has been determined. So one must note that higher the value of MF the more flammable and explosive the material.


(Refer Slide Time: 20:15)

HAZARD IDENTIFICATION

3. Hazards surveys: Dow Fire and Explosion Index (F&EI)

Procedure (cont...) Step 2:
Determination of general process hazards. Penalties are applied for the following factors:

- Exothermic reactions that might self-heat, or endothermic ones that could react because of an external heat source such as a fire,
- Material handling and transfer,
- Enclosed process units preventing dispersion of escaped vapors,
- Limited access for emergency equipment, and
- Poor drainage of flammable materials away from the process unit.



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 26

The second step is that determination of general process hazard. Now, penalties are applied for different factors like exothermic reactions that might self-heat or endothermic ones that could react because of an external heat source, such as fire, etc. The material handling and transfer the enclosed process units preventing dispersion of escaped vapours, the limited access for emergency equipment that is a very serious issue and poor drainage of flammable material away from the process units. So penalties may be Imposed for if the process facilities having such type of system.


(Refer Slide Time: 20:59)

HAZARD IDENTIFICATION

3. Hazards surveys: Dow Fire and Explosion Index (F&EI)

Procedure: Step 3:
Determination of penalties for special process hazards.

- Less than atmospheric pressure operation with a risk of outside air entering.
- Low-temp operation with potential embrittlement of carbon steel vessels.
- Hot oil heat exchange systems where the hot oil is above its ignition temp.
- Toxic materials or flammable material, which could impede fire fighting.
- Corrosion and erosion of process unit structures.
- Operation in or near the flammable limits.
- Dust explosion risks.
- Leakage around joints and packings.
- Use of fired heaters, providing a ready ignition source.

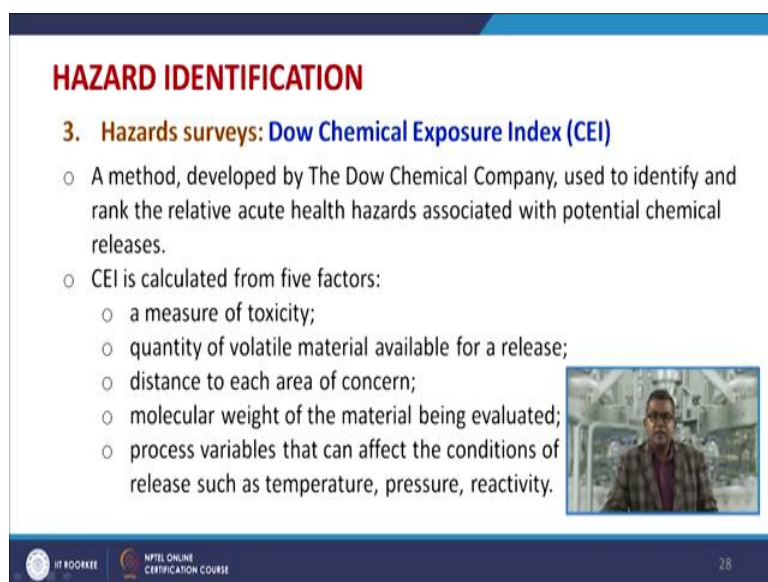


IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 27

The next step is the determination of a penalties for special process hazards that is less than atmospheric pressure operation with risk of outside air entering, so that there may be a chance of flammability. Low temperature operation with the potential embrittlement of carbon steel vessel. Hot oil heat exchange system where the hot oil is above its ignition temperatures sometimes it may lead to the auto ignition scenario.

The toxic material or the flammable material which could impede the firefighting equipments. Corrosion and erosion of process unit structures. Operation in or near the flammable limits like UFL and LFL. Dust explosion risks. Leakage around joints and packing. Use of fired heater, providing the ready ignition sources, etc. So these are the, these were the, the things which need to be addressed.

(Refer Slide Time: 21:56)



HAZARD IDENTIFICATION

3. Hazards surveys: Dow Chemical Exposure Index (CEI)

- A method, developed by The Dow Chemical Company, used to identify and rank the relative acute health hazards associated with potential chemical releases.
- CEI is calculated from five factors:
 - a measure of toxicity;
 - quantity of volatile material available for a release;
 - distance to each area of concern;
 - molecular weight of the material being evaluated;
 - process variables that can affect the conditions of release such as temperature, pressure, reactivity.

NPTEL ONLINE CERTIFICATION COURSE

28


Now, next is you Dow chemical exposure index, this is again method developed by the Dow chemical company used to identify and rank the relative acute health hazard associated with the chemical releases. So this chemical exposure index is calculated from a 5 broad factors that is a measure of toxicity, the quantity of volatile material available for release, the distance to each area in question, the molecular weight of the material being evaluated and the process variables that can affect the conditions of release such as temperature, pressure, reactivity, etc.

(Refer Slide Time: 22:48)

HAZARD IDENTIFICATION

3. Hazards surveys: Dow Chemical Exposure Index (CEI)

- Simple method of rating the relative acute health hazard potential for people in neighboring plants or communities arising from possible chemical release incidents.
- To use the CEI, the following items are required:
 - An accurate plot plan of the plant and the surrounding area,
 - Simplified process flow sheet showing the containment vessels, major piping, and
 - chemical inventories,
 - physical and chemical properties of the materials investigated,
 - CEI guide, and CEI form.



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 29

Now, this simple method of rating the relative acute health hazard potential for people in neighbouring plants or communities arising from the possible chemical release incidents. Now, the use of this chemical exposure index you need the following items, one is that accurate plot plan of the plant and the surrounding area, the simplified process flow sheet showing the containment vessels, measure piping, you must have a proper chemical inventory data with you, the physical and chemical properties of material investigated and chemical exposure index guide and chemical exposure index form.


(Refer Slide Time: 23:39)

HAZARD IDENTIFICATION

3. Hazards surveys: Dow Chemical Exposure Index (CEI)

Procedure:

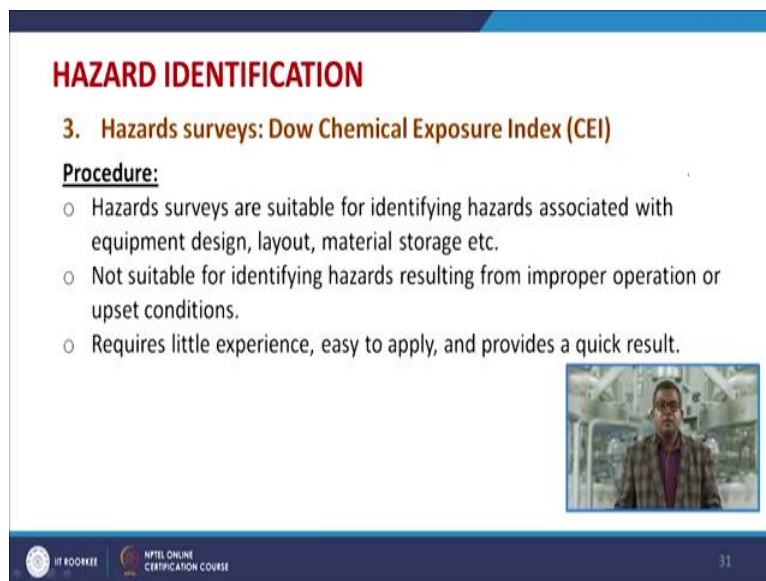
- Begins with a definition of possible release incidents including releases from pipes, hoses, pressure relief devices relieving directly to the atmosphere, vessels, and tank overflows and spills.
- Incidents are used with a number of simplified source models to estimate the release rate of material.
- Emergency Response Planning Guidelines (ERPGs) are used with a simplified dispersion model to determine the CEI value and downwind hazard distances resulting from the release.



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 30

Now, the process for this hazard survey pertaining to CEI is this relatively simple that this begins with a definition of possible release incidents including releases from pipes, hoses, pressure relief devices relieving directly to the atmosphere, vessels, tank overflows and spills. Now, sometimes incidents are used with the number of simplified source models to estimate the release rate of material. We have already discussed these source models. Now, emergency response planning guidelines (ERPGs) that are used with the simplified dispersion model to determine the, the chemical exposure index value and downwind hazard distances resulting from the release.

(Refer Slide Time: 24:30)






HAZARD IDENTIFICATION

3. Hazards surveys: Dow Chemical Exposure Index (CEI)

Procedure:

- Hazards surveys are suitable for identifying hazards associated with equipment design, layout, material storage etc.
- Not suitable for identifying hazards resulting from improper operation or upset conditions.
- Requires little experience, easy to apply, and provides a quick result.



  NPTEL ONLINE CERTIFICATION COURSE

31


The hazards survey is they are suitable for identifying the hazard associated with equipment design, layout, material storage, etc. They are not suitable for identifying the hazard resulting from improper operation or upset conditions. And they require little experience easy to apply and provides a quick result.

(Refer Slide Time: 24:53)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies

- **Definition:** Structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation.
- Qualitative technique based on guidewords
- Carried out by a multi-disciplinary team (HAZOP team) during a set of meetings.



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 32


Now, next is the Hazard and Operability Studies (HAZOP). The basic definition of this HAZOP is that this is structured and systematic examination of plant or existing process or operation, in order to identify and evaluate problem. That may represent risk to personal or equipment or prevent efficient operation. This is the qualitative technique based guidewords carried out by multidisciplinary team that is called the HAZOP team during the set of meeting.

(Refer Slide Time: 25:32)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies

- Used for many years as a formal procedure to identify hazards in a chemical process facility.
- Systematic search for hazards which are defined as deviations within these parameters that may have dangerous consequences.
- Basic idea is to let the mind go free in a controlled fashion in order to consider all the possible ways that process and operational failures can occur.
- Before study is started, detailed information on the process must be available which includes up-to-date process flow diagrams, process and instrumentation diagrams, detailed equipment specifications, materials of construction, mass and energy balances.



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 33



They are used for many years as a formal procedure to identify hazard in chemical process facility, the systematic search for hazard which are defined as deviation within these parameters that may have a dangerous consequences. Now, the basic idea is to let the mind go free in a controlled fashion in order to consider all the possibilities that process and the failure can occur. Now, before studies started detailed information on the process must be available which includes up to date process flow diagram, process and instrumentation diagram, detailed equipment specification, material of construction, mass and energy balances may be in terms of equations.

(Refer Slide Time: 26:25)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies

- In the process industry, these deviations concern process parameters such as flow, temperature, pressure etc.
- HAZOP is a team approach, involving a team of people representing all different functions in a plant. They identify all the deviations by 'brainstorming' to a set of guide words which are applied to all parts of the system.



NPTEL ONLINE CERTIFICATION COURSE 34

Now, in the process industry these deviation concerned process parameters such as flow, temperature, pressure etc. Now, HAZOP analysis is a team approach having a team of people representing all different functions of a plant. They identify all deviation by the brainstorming among themselves to a set of guide, words which are applied to all parts of the system.


(Refer Slide Time: 26:54)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies

Objective of carrying out a HAZOP study:

- To check a design.
- To decide whether and where to build.
- To decide whether to buy a piece of equipment.
- To obtain a list of questions to put to a supplier.
- To check running instructions.
- To improve the safety of existing facilities.



IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 35

Now, there are set of objectives carrying out for the HAZOP study. One is to check the design whether it is proper or improper. To decide whether and where to build the things to decide whether to buy a piece of equipment or not, to obtain a list of a questions to put to a supplier, to check running instruction that may be imposed to a worker, to improve the safety of any existing facilities.

(Refer Slide Time: 27:25)


HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies:

Team Composition

- Team Leader, an expert in the HAZOP Technique
- Technical Members, for example

New Design	Existing Plant
Design or Project Engineer	Plant Superintendent
Process Engineer	Process Supervisor (Foreman)
Commissioning Manager	Maintenance Engineer
Instrument Design Engineer	Instrument Engineer
Chemist	Technical Engineer



IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 36

Now, the team composition of HAZOP studies it still have a team leader that is an expert in the HAZOP technique. There are several technical members, like, for, if you are having the,

the new design, then design or project engineer, the process engineer usually a chemical engineer, the commissioning manager, the instrument design engineer, a chemist because sometimes you may have go through for a chemistry reaction. Now, if you are performing this thing for the existing plant then you must have a plant superintended, the process supervisor that is sometimes called the foreman, the maintenance engineer, the instrument engineer, the technical engineer, etc.


(Refer Slide Time: 28:15)



HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies

The process is as follows:

- ✓ System is divided into suitable parts or sub-systems, which are then analyzed one at a time.
- ✓ For each sub-system each parameter (flow, temperature, pressure, volume, viscosity etc.) that has an influence on it, is noted.
- ✓ Guidewords are applied to each parameter in each subsystem. The intention is to prompt creative discussion of deviations and possible consequences.
- ✓ For each significant deviation, possible causes are identified.



IIT KHARAGPURNPTEL ONLINE
CERTIFICATION COURSE37


Now, as far as the process is in question this is as follows that the system is divided into suitable parts or subsystems which are analysed one at a time. Now, for each sub-system each parameter like flow temperature, pressure, volume, viscosity, etc. Has an influence on it if it is then it should be noted. The guidewords are applied to each parameter to each sub-system the intention is to prompt creative discussion of deviation and possible consequences and for each significant deviation the possible causes and they are usually identified so that you can look in to the remedial measures.

(Refer Slide Time: 28:58)

4. Hazards and operability (HAZOP) studies

The process is systematic and it is helpful to define the terms that are used:

- **Study Nodes:** The locations (on piping and instrumentation drawings and procedures) at which the process parameters are investigated for deviations.
- **Intention:** The intention defines how the plant is expected to operate in the absence of deviations at the study nodes. This can take a number of forms and can either be descriptive or diagrammatic; e.g., flowsheets, line diagrams, P&IDs.
- **Deviations:** These are departures from the intention which are discovered by systematically applying the guide words (e.g., "more pressure").



IT KOOKEE | NPTEL ONLINE CERTIFICATION COURSE

38

Now, this process is systematic and it is helpful to define the terms that are used like study notes the location for example on piping and instrumentation drawing and procedure. The location at which the process parameters are investigated for deviation. Then the intention, the intention defines that how the plant is expected to operate in absence of deviation at the study nodes.


Now, this can take number of forms and can either be descriptive or diagrammatic like flowsheet, line diagram, P&IDs, etc. Then you may look in to the deviations and these are the departure from the intentions which are discovered by systematically applying the guidewords like more pressure, high pressure, etc.

(Refer Slide Time: 29:51)

4. Hazards and operability (HAZOP) studies

The process is systematic and it is helpful to define the terms that are used:

- **Causes:** Reasons why deviations might occur. Once a deviation has been shown to have a credible cause, it can be treated as a meaningful deviation. These causes can be hardware failures, human errors, an unanticipated process state (e.g., change of composition), external disruptions (e.g., loss of power), etc.
- **Consequences:** Results of deviations should they occur (e.g., release of toxic materials).
- **Guide Words:** Simple words which are used to qualify or quantify the intention in order to guide and stimulate the brainstorming process and so discover deviations.



IT KODAKKE NPTEL ONLINE CERTIFICATION COURSE 39


Then the causes the reason why the deviation might occur, once a deviation has been shown to have a credible cause it can be treated as a meaningful deviation. Now these causes can be hardware failure, human error, unanticipated process states, etc. or sometime external disruptions like loss of power, etc. which is not in your control. Then consequences, these are the result of deviation and should they occur like release of toxic materials etc. You may have certain guidewords like simple words which are used to qualify or quantify the intention in order to guide and stimulate the brainstorming process and discovered the deviations.

(Refer Slide Time: 30:39)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies

<u>Guideword</u>	<u>Definitions</u>
NO or NOT	No part of the design intent occurs, such as no flow in a pipeline due to blockage.
MORE or LESS	A quantitative increase or decrease of some parameter, such as flow, temperature etc.
AS WELL AS	All the design intentions are fulfilled and something happens in addition
PART OF	Only part of the design intention is fulfilled ✓
REVERSE	The logical opposite of the design intention occurs
OTHER THAN	Something completely different than attended occurs



IT KODAKKE NPTEL ONLINE CERTIFICATION COURSE 40

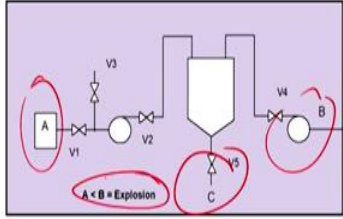
So whenever you perform these HAZOP studies there are few guidewords like no or not and the definition is no part of the design intent occurs such as no flow in the pipeline due to blockage. More or less a quantitative increase or decrease of some parameters such as flow temperature etc. As well as all the design intentions are fulfilled and something happen in addition. Part of only part of the design intention is fulfilled the reverse that is a logical opposite to the design intention occurs other than something completely different than attended occurs.

(Refer Slide Time: 31:29)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies

Example:
Consider the simple process diagram below. It represents a plant where substances A and B react with each other to form a new substance C. If there is more B than A, there may be an explosion.



The process diagram shows a chemical reaction setup. Substance A flows from a tank through valve V1 and pump V2. Substance B flows from a tank through valve V4 and pump V3. Both streams enter a reactor vessel. The output of the reactor is substance C, which flows through valve V5. A red oval highlights the reactor area with the text 'A < B = Explosion'. A small inset video shows a person in a lab coat.

41

Now, one example is that consider a simple process diagram this figure it represents a plant where a substance A and B reacts with each other to form a new substance that is called C. There is if there is more B then A there may be an explosive, so this is the chance of explosive.


(Refer Slide Time: 31:55)



HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies:

Guide Words	Deviation	Possible Causes	Consequences	Proposed Measures
NO, NOT	No A	Tank containing A is empty. V1 or V2 is closed. Pump does not work. Pipe broken.	Not enough A = Explosion	Indicator for low level. Monitoring of flow.
MORE	Too much A	Pump too high capacity. Opening of V1 or V2 is too large.	C contaminated by A. Tank overfilled	Indicator for high level. Monitoring of flow.
LESS	Not enough A	V1, V2 or pipe are partially blocked. Pump gives low flow	Not enough A = Explosion	As above.

The HAZOP sheet for the section of the plant from A to C.





42

Now, let us have an analysis of this HAZOP analysis, no or not that is no A so tank containing A is empty this one.


(Refer Slide Time: 32:07)



HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies:

Guide Words	Deviation	Possible Causes	Consequences	Proposed Measures
NO, NOT	No A	Tank containing A is empty. V1 or V2 is closed. Pump does not work. Pipe broken.	Not enough A = Explosion	Indicator for low level. Monitoring of flow.
MORE	Too much A	Pump too high capacity. Opening of V1 or V2 is too large.	C contaminated by A. Tank overfilled	Indicator for high level. Monitoring of flow.
LESS	Not enough A	V1, V2 or pipe are partially blocked. Pump gives low flow	Not enough A = Explosion	As above.

The HAZOP sheet for the section of the plant from A to C.



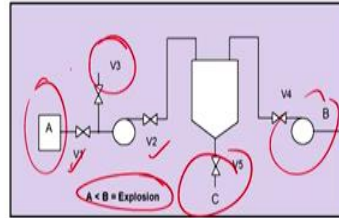


42

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies

Example:

Consider the simple process diagram below. It represents a plant where substances A and B react with each other to form a new substance C. If there is more B than A, there may be an explosion.



And V_1 and V_2 , this V_1 and V_2 is closed so pump does not work that is pipe broken the consequences is not enough A this may lead to the explosion. Now the proposed measures are indicator for low level, monitoring of flow.

Now more that is too much A, the pump too high capacity opening of V_1 and V_2 is too large. This one V_1 and V_2 is too large. The consequences are C contaminated by A so tanks are overfilled this is indicator of high level. And the monitoring of flow is needed.

Less not enough A that is means V_1 or V_2 that the valve V_1 & V_2 the pipe are partially block and pump gives off low flow. So not enough A, this may lead to an explosion.

(Refer Slide Time: 33:05)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies:

Guide Words	Deviation	Possible Causes	Consequences	Proposed Measures
AS WELL AS	Other Substance	V3 open – air sucked in.	Not enough A = Explosion	Flow monitoring, based on weight.
REVERSE	Liquid pumped backwards	Wrong connector to motor.	Not enough A = Explosion, A is contaminated	Flow monitoring.
OTHER THAN	A boils in pump	Temperature too high.	Not enough A = Explosion	Temperature (and flow) monitoring.

The HAZOP sheet for the section of the plant from A to C... cont...



As well as the deviation is other substances may present. Sometimes V3 is open the air sucked in, so not enough A that is a consequence and it may lead up to the explosion. The proposed measures are flow monitoring based on weight.

Reverse liquid pump backward that is wrong connector to the motor, so not enough A may lead to explosion and A is contaminated so you must go for the flow monitoring,

other than the A boils in pump the temperature is too high that is not enough A in the system then it may lead to explosion. Then temperature and flow monitoring is essential.

(Refer Slide Time: 33:51)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies: HISTORY

- Developed by **Lawley (1974)** of Imperial Chemical Industries of UK, based on early account by **Elliott & Owen (1968)**.
- The technique originated in the Heavy Organic Chemicals Division of ICI, which was then a major British and international chemical company.
- History has been described by **Trevor Kletz** who was the company's safety advisor from 1968 to 1982.

IIT KHARAGPUR NPTEL ONLINE CERTIFICATION COURSE 44

So, since it is a very systematic approach let us have a look about the history of this HAZOP study this is developed by Lawley in 1974 by ICI that is Imperial Chemical Industry of UK. Based on earlier account of Elliot & Owen 1968 which was developed in 1968. The technique originated in the heavy organic chemical division of ICI which was then a major British & International chemical company. So history this has been described by Trevor Kletz who was a company safety advisor from 1968 to 1982.

(Refer Slide Time: 34:35)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies: PROCESS

The system is divided into functional blocks:

- Every part of the process is examined for possible deviations from the design intention.
- Can the deviations cause any hazard or inconvenience?
- Each deviation is considered to decide how it could be caused and what the consequences would be.
- Every phase of the process.
- Each system and person.
- Questions formulated around guide words.
- For the hazards preventive/remedying actions are defined.



The process of this HAZOP study is the system divided into the functional blocks. So every part of process is examined for the possible deviation from the design function. Now can the deviation caused any hazard or inconvenience to the system, must analyse. Each deviation is considered to decide that how it could be caused and what the consequences would be. Now, every phase of the process must be well defined each system and person must be well defined the question formulated around the guideword this is extremely important because you are having the set guidewords for this one.


(Refer Slide Time: 35:20)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies: PROCESS

The system is divided into functional blocks:

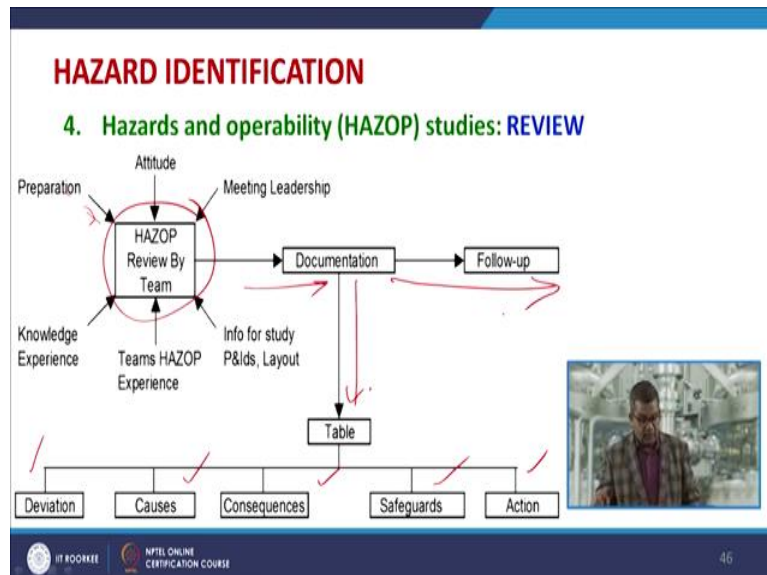
- Every part of the process is examined for possible deviations from the design intention.
- Can the deviations cause any hazard or inconvenience?
- Each deviation is considered to decide how it could be caused and what the consequences would be.
- Every phase of the process.
- Each system and person.
- Questions formulated around guide words.
- For the hazards preventive/remedying actions are defined.



IT KOOKEE NPTEL ONLINE CERTIFICATION COURSE 45

Now, for the hazard and preventive remedying action they are must be they are well defined and they must be well defined this is the primarily requirement.

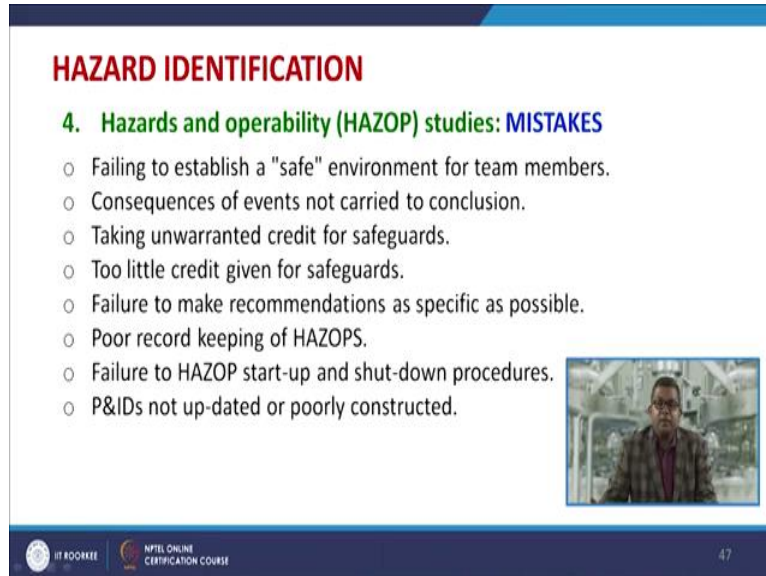
(Refer Slide Time: 35:26)



The next aspect is to go for a review. Now, here you are having a diagram where you are having a HAZOP review which was given by the team. This may lead to the preparation based on a knowledge experience teams of HAZOP experience they may have attitude meeting leadership. They give the proper documentation. Now, these documentation may lead to the various tables sometimes enlisted with the deviation various causes consequences

methodology for safeguard action and you must go for the follow up that whether your recommendation and whether the study has something so that it must be follow up.

(Refer Slide Time: 36:25)



HAZARD IDENTIFICATION

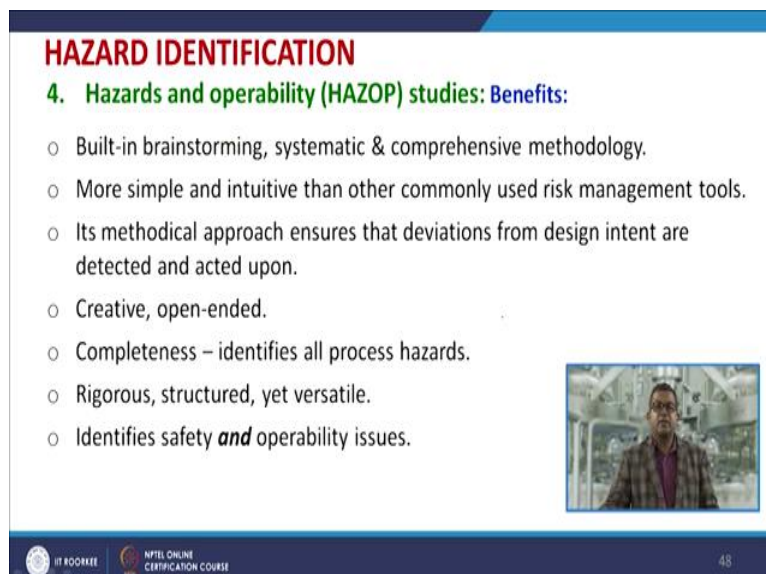
4. Hazards and operability (HAZOP) studies: MISTAKES

- Failing to establish a "safe" environment for team members.
- Consequences of events not carried to conclusion.
- Taking unwarranted credit for safeguards.
- Too little credit given for safeguards.
- Failure to make recommendations as specific as possible.
- Poor record keeping of HAZOPS.
- Failure to HAZOP start-up and shut-down procedures.
- P&IDs not up-dated or poorly constructed.

47

Now, sometimes certain mistakes may take place that may be attributed to the failing to establish a safe environment for the team members. Consequences of events that not carried out to conclusion taking unwanted credit of for safeguard too little credit given for safeguard failure to make the recommendation as specific as possible. Poor record keeping of all those HAZOPs failure to HAZOP a start-up and shutdown procedure. P&IDs are not up to dated, updated or poorly constructed.

(Refer Slide Time: 36:54)



HAZARD IDENTIFICATION

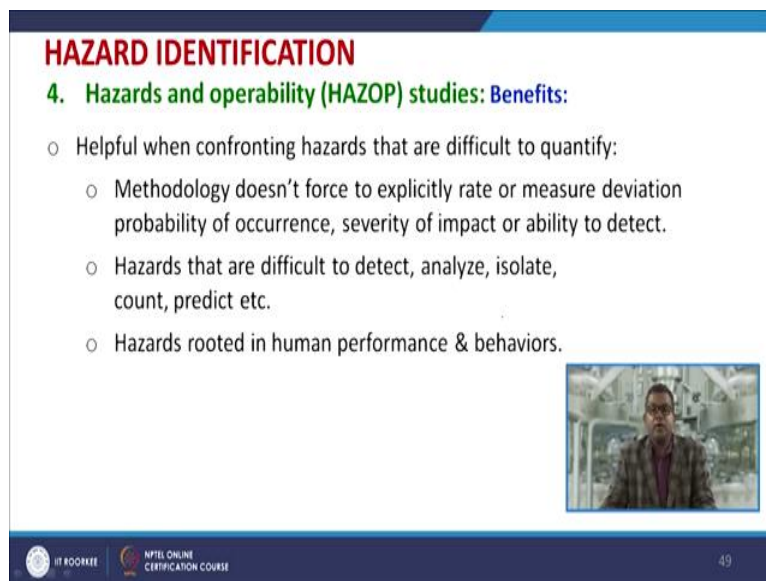
4. Hazards and operability (HAZOP) studies: Benefits:

- Built-in brainstorming, systematic & comprehensive methodology.
- More simple and intuitive than other commonly used risk management tools.
- Its methodical approach ensures that deviations from design intent are detected and acted upon.
- Creative, open-ended.
- Completeness – identifies all process hazards.
- Rigorous, structured, yet versatile.
- Identifies safety **and** operability issues.

48

Now, there are certain benefits associated with these HAZOP studies. They are having the built in brainstorming and systematic and comprehensive methodologies you may develop all those things they are more simple and intuitive than other commonly used risk management tools. It is methodical approach ensures that deviation from design intent are detected and acted upon they are very much creative and open ended. They gives the completeness and identifies all kind of process hazards, they are rigorous, structured and yet very versatile. It identifies the safety and operability issues, they are helpful when confronting hazards that are difficult to quantify.


(Refer Slide Time: 37:44)





HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies: Benefits:

- Helpful when confronting hazards that are difficult to quantify:
 - Methodology doesn't force to explicitly rate or measure deviation probability of occurrence, severity of impact or ability to detect.
 - Hazards that are difficult to detect, analyze, isolate, count, predict etc.
 - Hazards rooted in human performance & behaviors.



  49


The methodologies does not force to explicitly rate or measured deviation probability of occurrence severity of impact or ability to detect. The hazards that are difficult to detect, analyse, isolate, count, predict etc. These hazards are rooted in human performance and behaviour.

(Refer Slide Time: 38:06)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies: Limitation

- Can be time-consuming (e.g., includes operability).
- No means to assess hazards involving interactions between different parts of a system or process.
- No means to assess effectiveness of existing or proposed controls (safeguards).
- HAZOP utilizes a team approach and hence can not be conducted by a single analyst.
- Relies on having right people in the room.
- No risk ranking or prioritization capability.



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 50


There are certain limitations attributed to these HAZOP studies, they are enlisted in these particular slides. Now they can be time consuming this because they have included the operability. No means to assess the hazards involving the interaction between the different parts of system or a process, there is no mean to assess the effectiveness of existing or proposed controls. HAZOP utilizes a team approach and hence cannot be conducted by a single analyst so you must have a well formulated team. They relies on having right people in the room. No risk ranking or prioritization capabilities.

(Refer Slide Time: 38:52)

HAZARD IDENTIFICATION

4. Hazards and operability (HAZOP) studies: Limitation

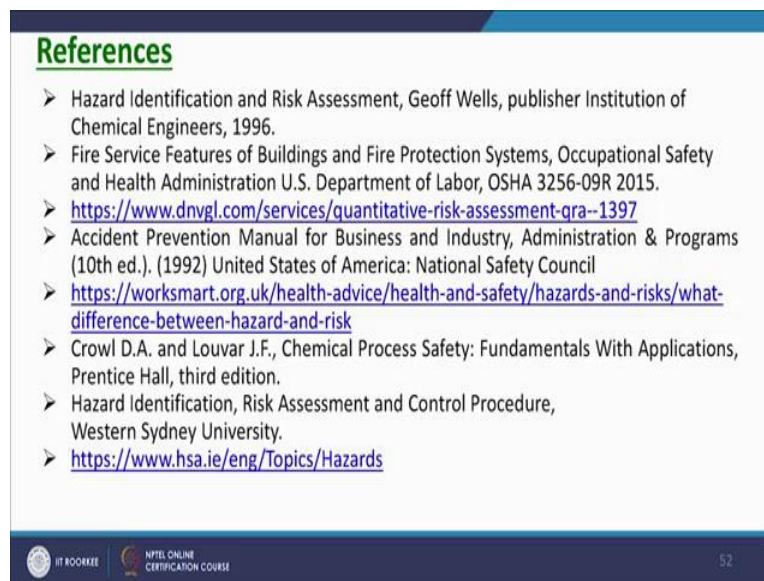
- Team should be skilled and multidisciplinary with good knowledge of the plant, its intended design and operation.
- Does not distinguish between low probability, high consequence events (and vice versa).



IT ROORKEE NPTEL ONLINE CERTIFICATION COURSE 51

And one more requirement is that the team should be skilled and multi-disciplinary with good knowledge of plant, now, its intended design and operations so all thing all the team members should have well acquainted with the all aspect of the plant. And they does not distinguish between the low probability high consequences event or vice versa. So in this particular module we have discussed about the hazard identification tool we have performed the, we have discussed the various kind of HAZOP studies, given one example for this one.

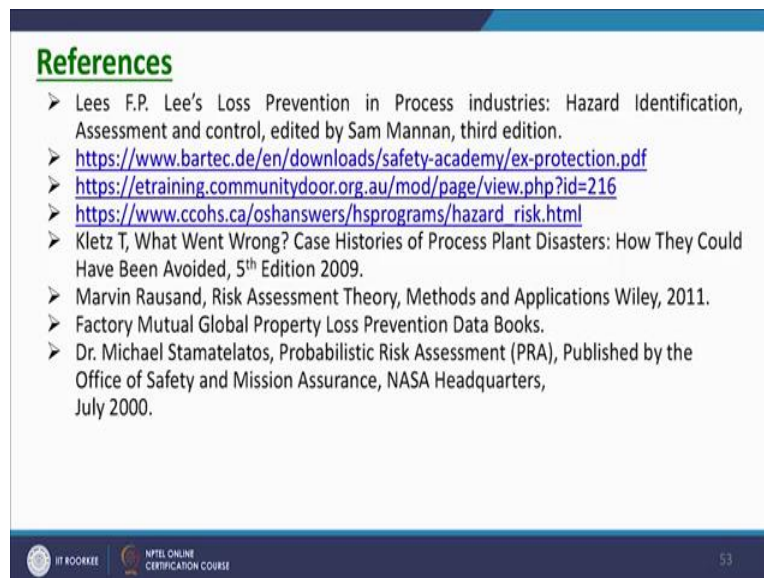
(Refer Slide Time: 39:34)



References

- Hazard Identification and Risk Assessment, Geoff Wells, publisher Institution of Chemical Engineers, 1996.
- Fire Service Features of Buildings and Fire Protection Systems, Occupational Safety and Health Administration U.S. Department of Labor, OSHA 3256-09R 2015.
- <https://www.dnvgl.com/services/quantitative-risk-assessment-gra--1397>
- Accident Prevention Manual for Business and Industry, Administration & Programs (10th ed.). (1992) United States of America: National Safety Council
- <https://worksmart.org.uk/health-advice/health-and-safety/hazards-and-risks/what-difference-between-hazard-and-risk>
- Crowl D.A. and Louvar J.F., Chemical Process Safety: Fundamentals With Applications, Prentice Hall, third edition.
- Hazard Identification, Risk Assessment and Control Procedure, Western Sydney University.
- <https://www.hsa.ie/eng/Topics/Hazards>

IT ROORKEE | NPTEL ONLINE CERTIFICATION COURSE 52



References

- Lees F.P. Lee's Loss Prevention in Process industries: Hazard Identification, Assessment and control, edited by Sam Mannan, third edition.
- <https://www.bartec.de/en/downloads/safety-academy/ex-protection.pdf>
- <https://etraining.communitydoor.org.au/mod/page/view.php?id=216>
- https://www.ccohs.ca/oshanswers/hsprograms/hazard_risk.html
- Kletz T, What Went Wrong? Case Histories of Process Plant Disasters: How They Could Have Been Avoided, 5th Edition 2009.
- Marvin Rausand, Risk Assessment Theory, Methods and Applications Wiley, 2011.
- Factory Mutual Global Property Loss Prevention Data Books.
- Dr. Michael Stamatelatos, Probabilistic Risk Assessment (PRA), Published by the Office of Safety and Mission Assurance, NASA Headquarters, July 2000.

IT ROORKEE | NPTEL ONLINE CERTIFICATION COURSE 53

And in case if you wish to have further reading there are lot of references enlisted. Thank you.