

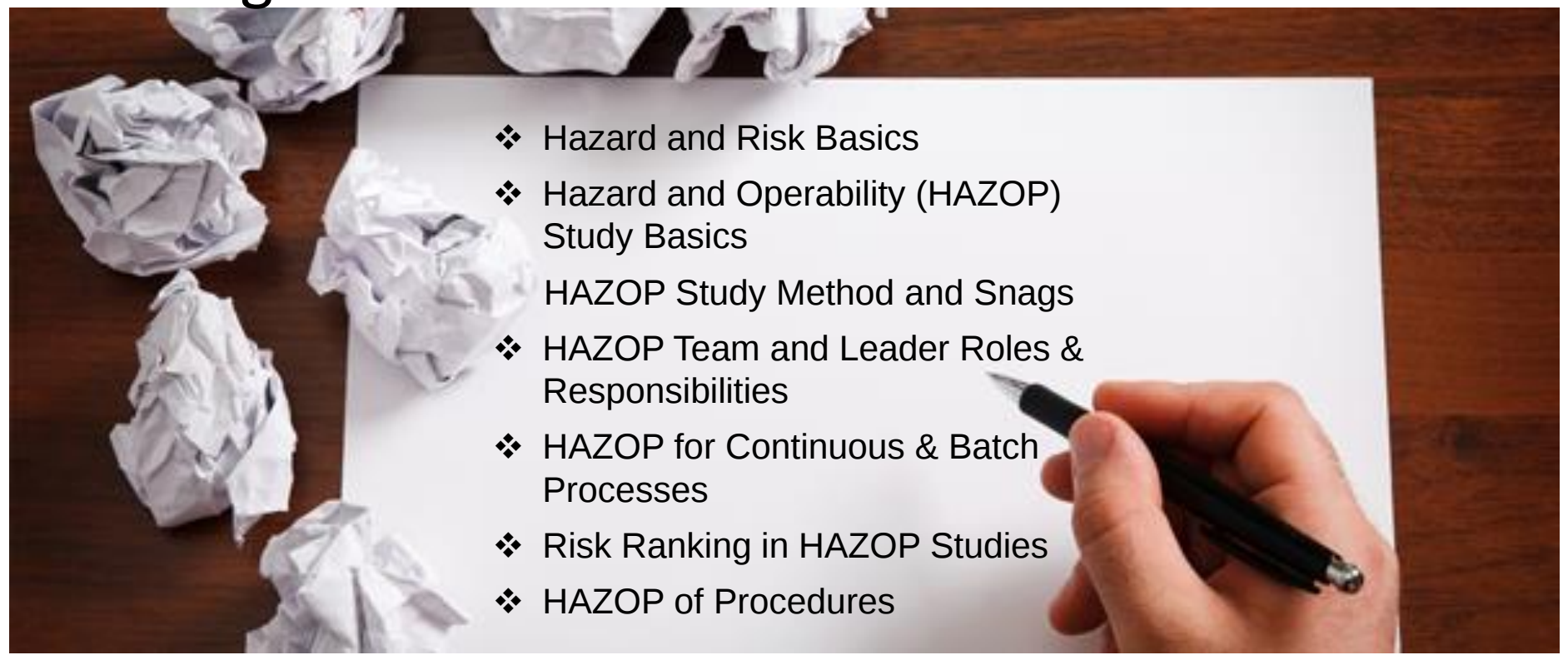
HAZARD & OPERABILITY STUDY (HAZOP)

TRAINING MODULE



AGENDA

By the end of this Module you will have gone through:

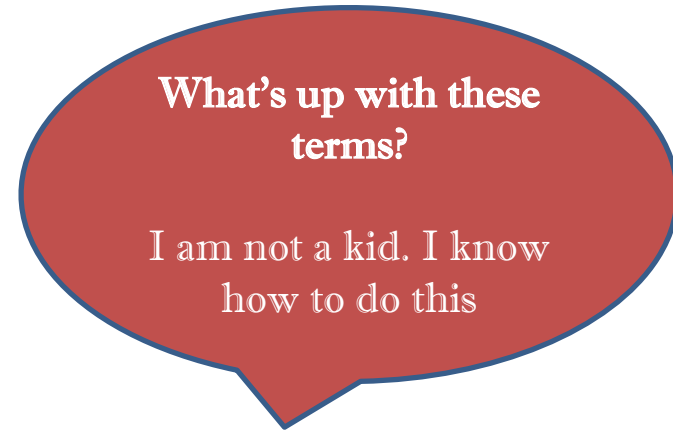
- 
- A photograph showing a hand holding a black pen over a white piece of paper. The paper contains a list of topics. To the left of the paper are several crumpled white paper balls. The background is a dark wooden surface.
- ❖ Hazard and Risk Basics
 - ❖ Hazard and Operability (HAZOP) Study Basics
 - HAZOP Study Method and Snags
 - ❖ HAZOP Team and Leader Roles & Responsibilities
 - ❖ HAZOP for Continuous & Batch Processes
 - ❖ Risk Ranking in HAZOP Studies
 - ❖ HAZOP of Procedures

BASICS

- What is Hazard?
 - Step-by-Step Process
 - Let's lay out the Terms.
- What is Risk?
- How to find it? What is it?
- Can I handle it?
- How to reduce



Please Sir,
Can you
Share?



What's up with these
terms?

I am not a kid. I know
how to do this

WHAT IS MEANT BY HAZARD ?

- ANY MATERIAL OR PROCESS WHICH HAS POTENTIAL TO CAUSE HARM

P.E.A.R

- PEOPLE
- ENVIRONMENT
- ASSET
- REPUTATION

CONCEPT

HAZARD

PROPERTY

It is the property/
condition that makes a
thing Hazardous

HAZARDOUS SUBSTANCE

A substance/
material can have
multiple properties

Example: Hydrogen Sulfide (H_2S)
is corrosive, flammable, and toxic
(3 hazards in one hazardous
substance)

HAZARDOUS PROCESS

RISK ASSESSMENT

SEVERITY	CIRCUMSTANCE
Critical (15)	Fatality, Severe and permanent disability or illness. Prosecution by enforcement authorities. More than 50k in damage
Major (10)	Lost time injury. Temporary disability or fractures. Prohibition or improvement notice issued by enforcement authorities, 10k to 50k in damage
Serious (6)	Medical treatment, alternative duties, requirement to report incident to enforcement authorities, 1k to 10k in damage.
Minor (2)	First aid/ Nil treatment or Irritation. Minor, short term environmental impact. Up to 1k in damage.

RISK ASSESSMENT

PROBABILITY	DESCRIPTION
HIGHLY LIKELY (15)	Certain to happen, possibly frequently, every time or daily while performing the activity
LIKELY (12)	Not surprised, to be expected once in a while, i.e., 2-3 times a monthly
POSSIBLE (9)	Could occur, been known to happen, i.e., 2-3 times a half yearly
UNLIKELY (7)	Unlikely, although conceivable, i.e., 2-3 times a yearly
IMPROBABLE (5)	So unlikely that probability is close to zero, negligible or happened more than a year

RISK RANKING

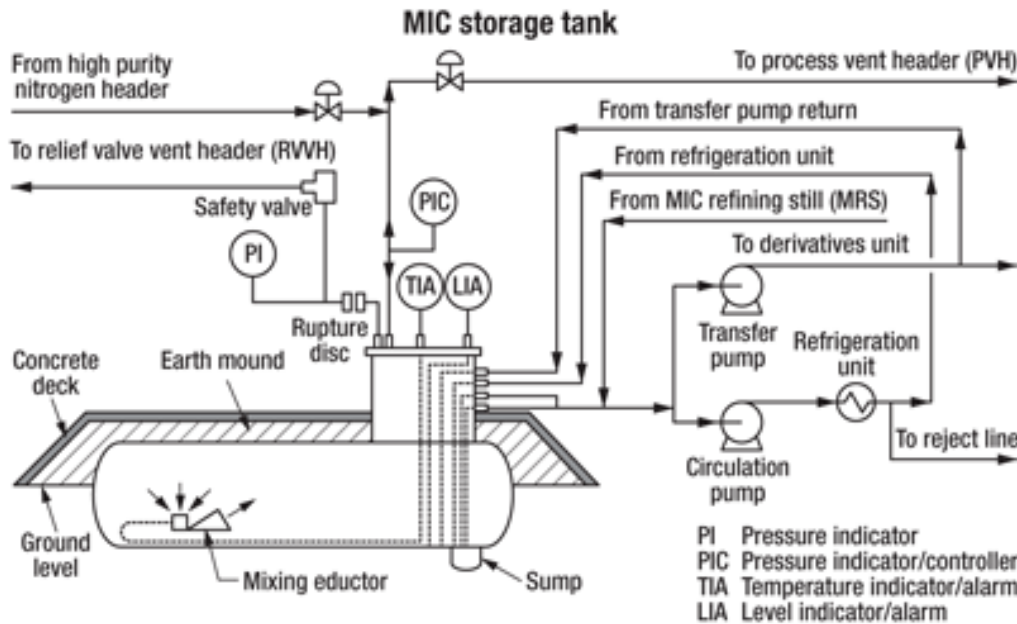
RISK RATING		DESCRIPTION
	180-225	VERY HIGH RISK
	120-150	HIGH RISK
	72-105	MEDIUM RISK
	40-70	LOW RISK
	10-30	VERY LOW RISK

RISK ASSESSMENT

RISK RATING NUMBER = INJURY, DAMAGE or ENVIRONMENTAL SEVERITY X POTENTIAL OF EXPOSURE TO RISK

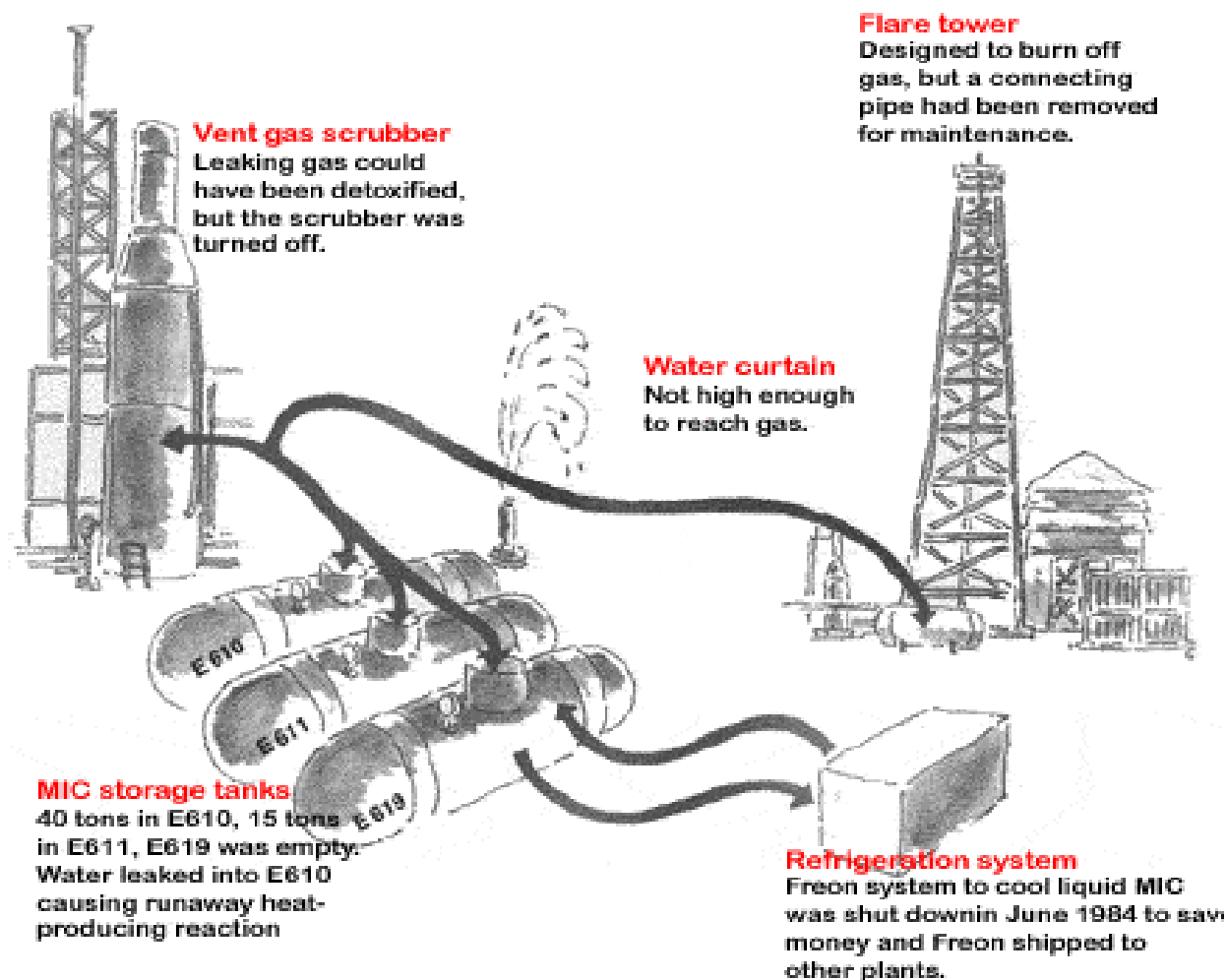
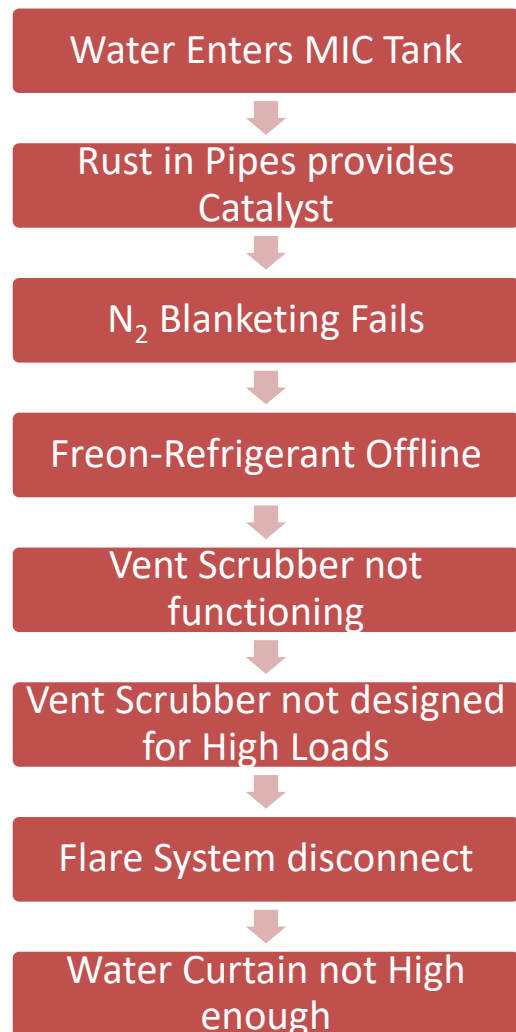
CRITICAL (15)	75	105	135	180	225
MAJOR (10)	50	70	90	120	150
SERIOUS (6)	30	42	54	72	90
MINOR (2)	10	14	18	24	30

BHOPAL, 3rd December 1984



- Bhopal presents a lot of arenas for learning.
- Human Error / System Defects ?
- Effect of news & rumour ?
- Layers of Protection
- Psychosocial Impacts
- Business Impacts
- Series of Failures
- Data Control

In April 1982, factory workers printed hundreds of handouts expressing their concern about decisions being made inside the factory that might influence the community outside the factory. In May 1982, an independent audit team from the US performed a Safety Audit and **complimented the factory's creative approach to improving workplace safety with nonstandard operating and maintenance procedures.**



WHAT IS A HAZARD?

What characteristic of something/ someone causes harm?

HAZARD Vs. THREAT

What causes loss of control over it?



HAZARD

Inherent Property/ Aspect that may cause harm to P. E. A. R.

PROCESS HAZARDS



EXAMPLES:

Pressure (Positive)

concerning the use, storage,
ous substances

Vacuum

Temperature

Flammability –

Vapour Pressure

Flash Point

Boiling Point

Viscosity

Pour Point

Composition

Reactivity/ Stability

Refer: HAZOP Procedure Annexure-5 for a Prompt List of Process Hazards encountered

PROCESS HAZARD STUDIES

- Checklists
- What-if Analysis
- Hazard Identification (HAZID)
- Hazard and Operability Study (HAZOP)
- Layer of Protection Analysis (LOPA)
- Safety Integrity Levels (SIL)
- Quantitative Risk Analysis (QRA)

Why hazop study is required?

**MANUFACTURE, STORAGE AND IMPORT OF
HAZARDOUS CHEMICAL RULES, 1989**

HAZARD AND OPERABILITY (HAZOP) STUDY

- **Structured** analysis/
“**Brainstorming**” of a
System, Process or
Operation
 - **Carried out by a Multi-disciplinary Team**
 - **Line-by-Line or Stage-by-Stage Examination**
 - **Systematic and Rigorous**
 - **Open and Creative**
 - **Well developed and is useful in most applications**

What is HAZOP

When to do
HAZOP?

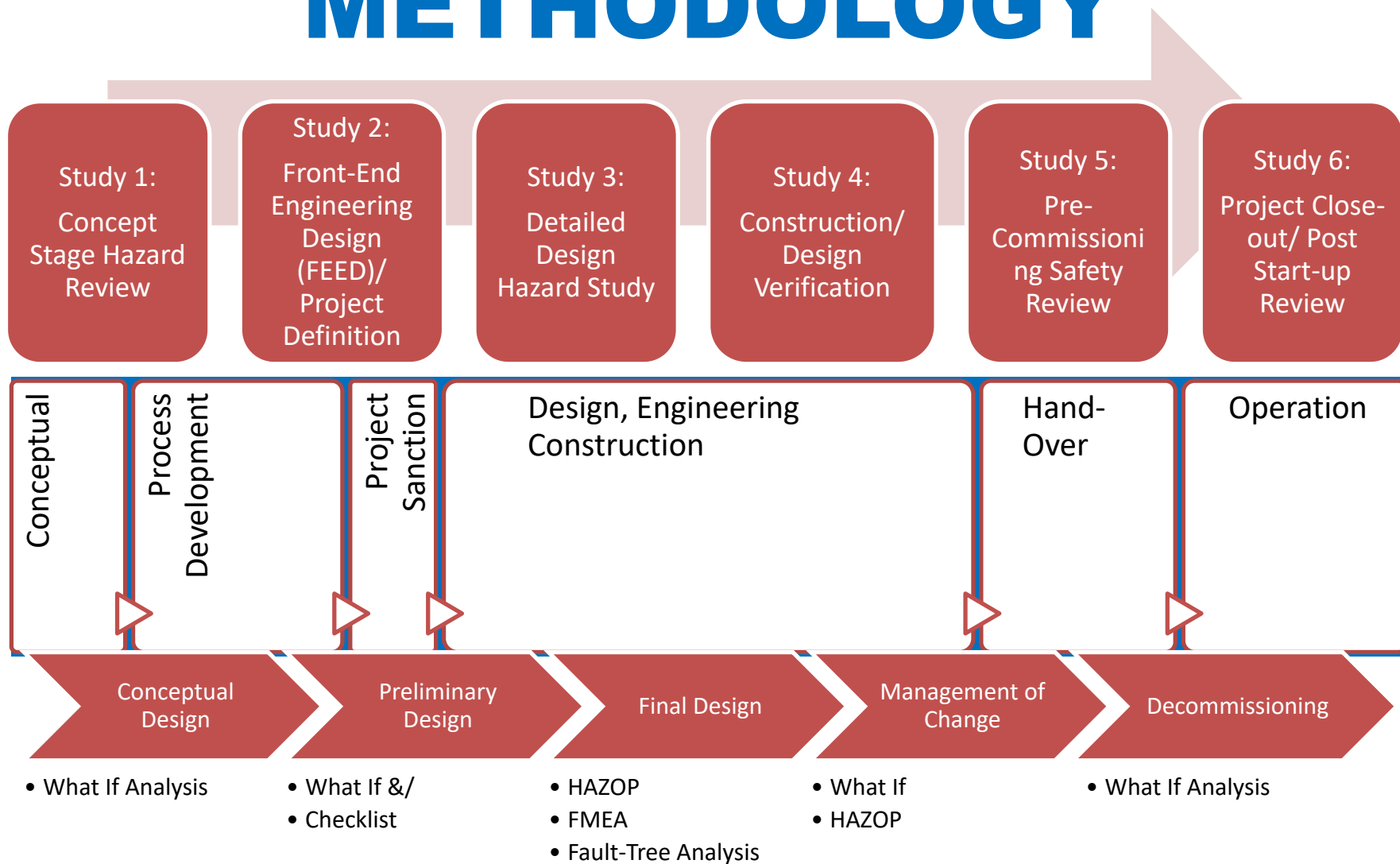
How to
Perform
HAZOPs?

HAZOP
Team

Examples

Reporting

HAZARD STUDY METHODOLOGY



WHEN TO DO HAZOPs?

- Initial Concept Stage – At the drawing board
- When the Final P&ID are available
- During Construction – Installation/ Revamp (Check HAZOP Recommendation Implementation)
- During Commissioning
- During Operations - Process Modifications – Changes in P&IDs, Equipment Design, Operating Windows, Layout, Capacity; Updation of Emergency Plans and Operating Procedures
- Whenever an Accident Occurs
- Decided by Safety Audit or a PHA Study
- There is Change of Management – Plant Hand-over/ Take-over
- **Review for existing facility between 18 months – 5 years**



CAUTION

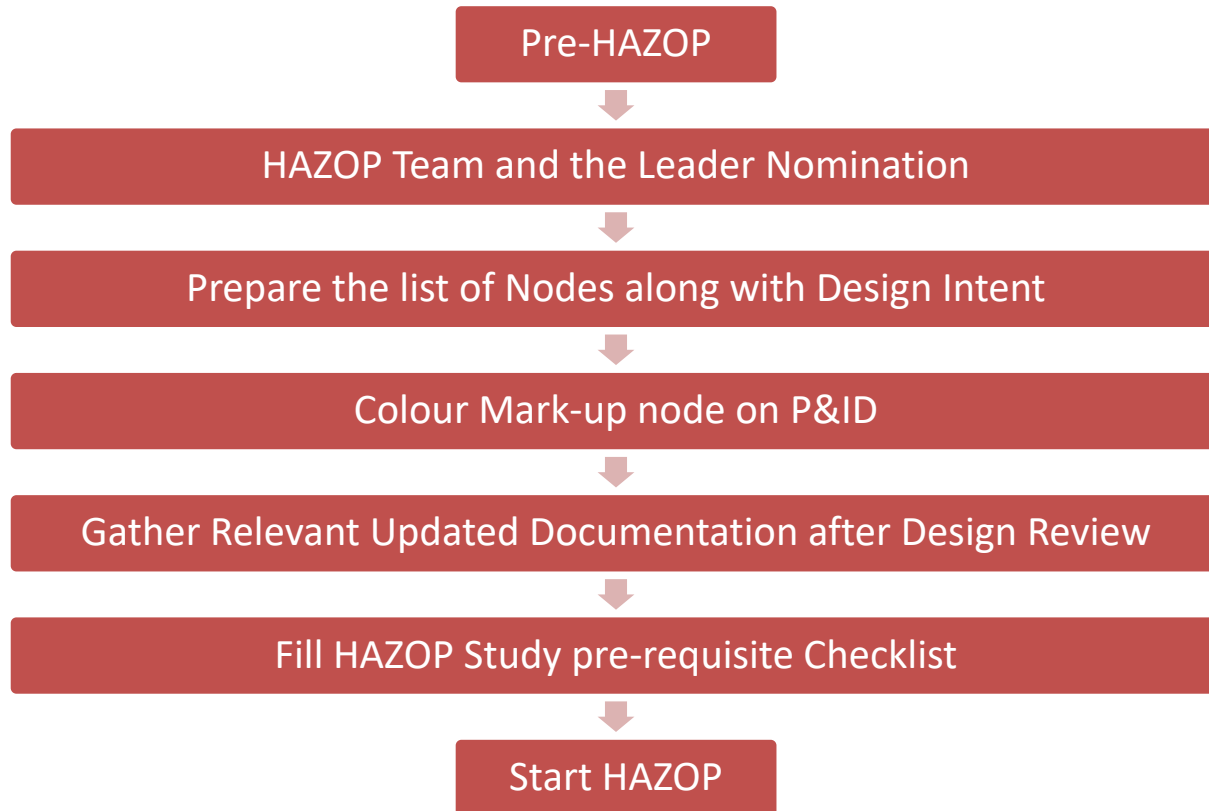


Performing a HAZOP is generally an assurance that if procedural and/or engineering modification is implemented to mitigate risk, the plant will then be operating at some lower level of risk.

It is not, however, a guarantee that no risk exists, nor does it guarantee that hazardous events or operating problems will not be encountered.

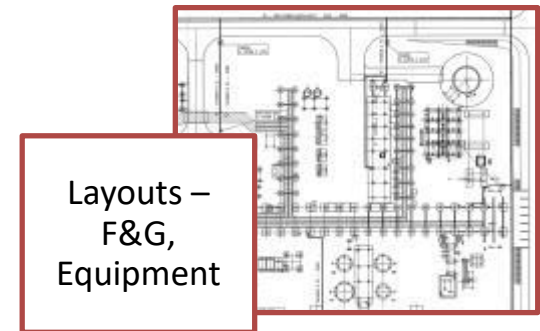
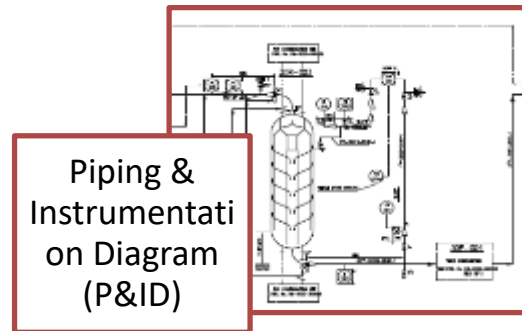
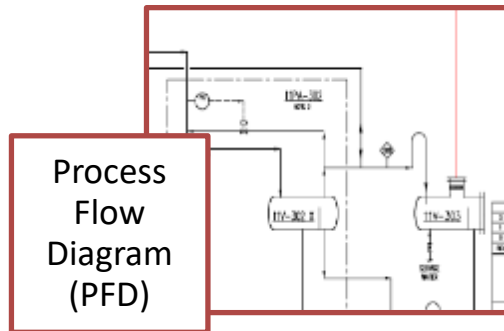
HOW TO DO HAZOP STUDY?

References BS IEC 61882: 2001



HAZOP PREREQUISITES

As a basis for the HAZOP study the following information should be available:

[illegible]

```

graph TD
    A[Fischer-Tropsch Process] --> B[2.1.1. SCOT SECTION: CHEMISTRY]
    A --> C[2.1.2. CATALYTIC HYDROGENATION STAGE]
    B --> D["In the reduction reactor virtually all sulfur compounds present in the non-oxidized Claus tail gas are converted to H2S by hydrogen (H2) over a cobalt molybdenum catalyst (on alumina support) at a reactor inlet temperature of 220 - 240 °C."]
    D --> E["
$$2\text{H}_2 + \text{SO}_2 \rightarrow \text{H}_2\text{S} + \text{H}_2\text{O} + \text{heat}$$
"]
    D --> F["
$$\text{H}_2 + \text{S}_8 \rightarrow \text{H}_2\text{S} + \text{heat}$$
"]
    C --> G["In the hydrogenation reactor sulfur dioxide (SO2) and elementary sulfur (S8) the respective reactions are"]
    G --> H["
$$2\text{H}_2 + \text{SO}_2 \rightarrow \text{H}_2\text{S} + \text{H}_2\text{O} + \text{heat}$$
"]
    G --> I["
$$\text{H}_2 + \text{S}_8 \rightarrow \text{H}_2\text{S} + \text{heat}$$
"]
    G --> J["a molybdenum (CO) which is also present in the Claus tail gas, is equivalent to H2, since with water vapor (H2O) present in the Claus tail gas to give CO and H2."]
    J --> K["
$$\text{H}_2\text{O} + \text{CO}_2 + \text{H}_2 + \text{heat}$$
"]
  
```

Fischer-Tropsch Process

2.1.1. SCOT SECTION: CHEMISTRY

In the reduction reactor virtually all sulfur compounds present in the non-oxidized Claus tail gas are converted to H₂S by hydrogen (H₂) over a cobalt molybdenum catalyst (on alumina support) at a reactor inlet temperature of 220 - 240 °C.

$$2\text{H}_2 + \text{SO}_2 \rightarrow \text{H}_2\text{S} + \text{H}_2\text{O} + \text{heat}$$

$$\text{H}_2 + \text{S}_8 \rightarrow \text{H}_2\text{S} + \text{heat}$$

2.1.2. CATALYTIC HYDROGENATION STAGE

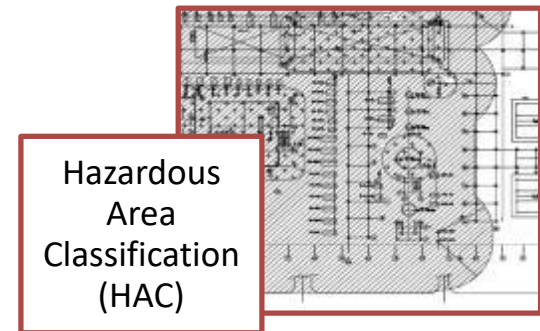
In the hydrogenation reactor sulfur dioxide (SO₂) and elementary sulfur (S₈) the respective reactions are

$$2\text{H}_2 + \text{SO}_2 \rightarrow \text{H}_2\text{S} + \text{H}_2\text{O} + \text{heat}$$

$$\text{H}_2 + \text{S}_8 \rightarrow \text{H}_2\text{S} + \text{heat}$$

a molybdenum (CO) which is also present in the Claus tail gas, is equivalent to H₂, since with water vapor (H₂O) present in the Claus tail gas to give CO and H₂.

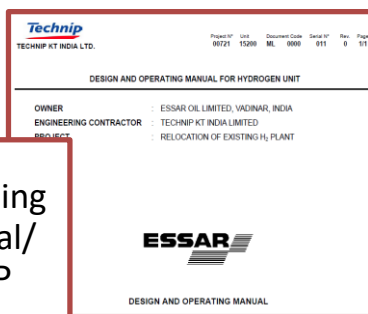
$$\text{H}_2\text{O} + \text{CO}_2 + \text{H}_2 + \text{heat}$$



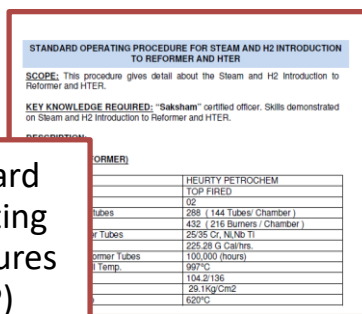
HAZOP PREREQUISITES

As a basis for the HAZOP study the following information should be available:

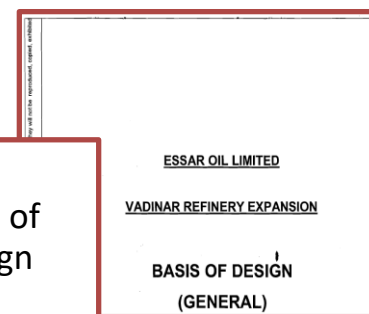
Operating Manual/
BDEP



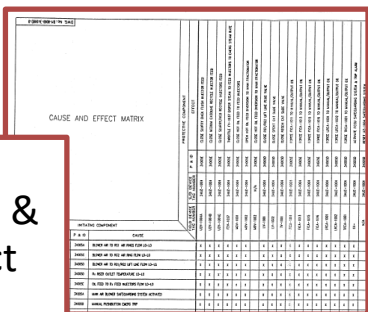
Standard Operating Procedures (SOP)



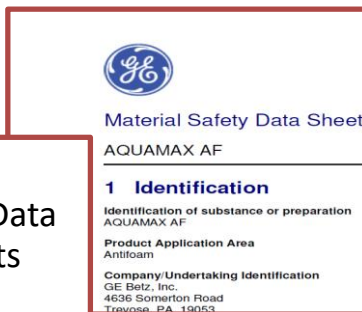
Basis of Design



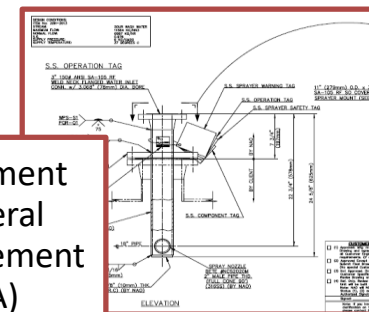
Cause & Effect



Safety Data Sheets



Equipment General Arrangement (GA)



What is HAZOP

When to do HAZOP?

How to Perform HAZOPs?

HAZOP Team

Examples

Reporting

HOW TO DO HAZOP STUDY?

1

2

3

4

5

6

7

8

Collect information	Identify Nodes (with maximum 2-3 activities)	Select a node and Specify its Design Intent	Identify meaningful Deviations using Guidewords	Identify Credible/ Likely Causes	Analyze all potential Consequences for each Cause without Safeguards	Identify existing and functional Safeguards	Rank Risk using the Risk Matrix and Give Recommendations

Start HAZOP

Repeat the above steps for each Node (A) assessing every Cause for every Deviation

What is HAZOP

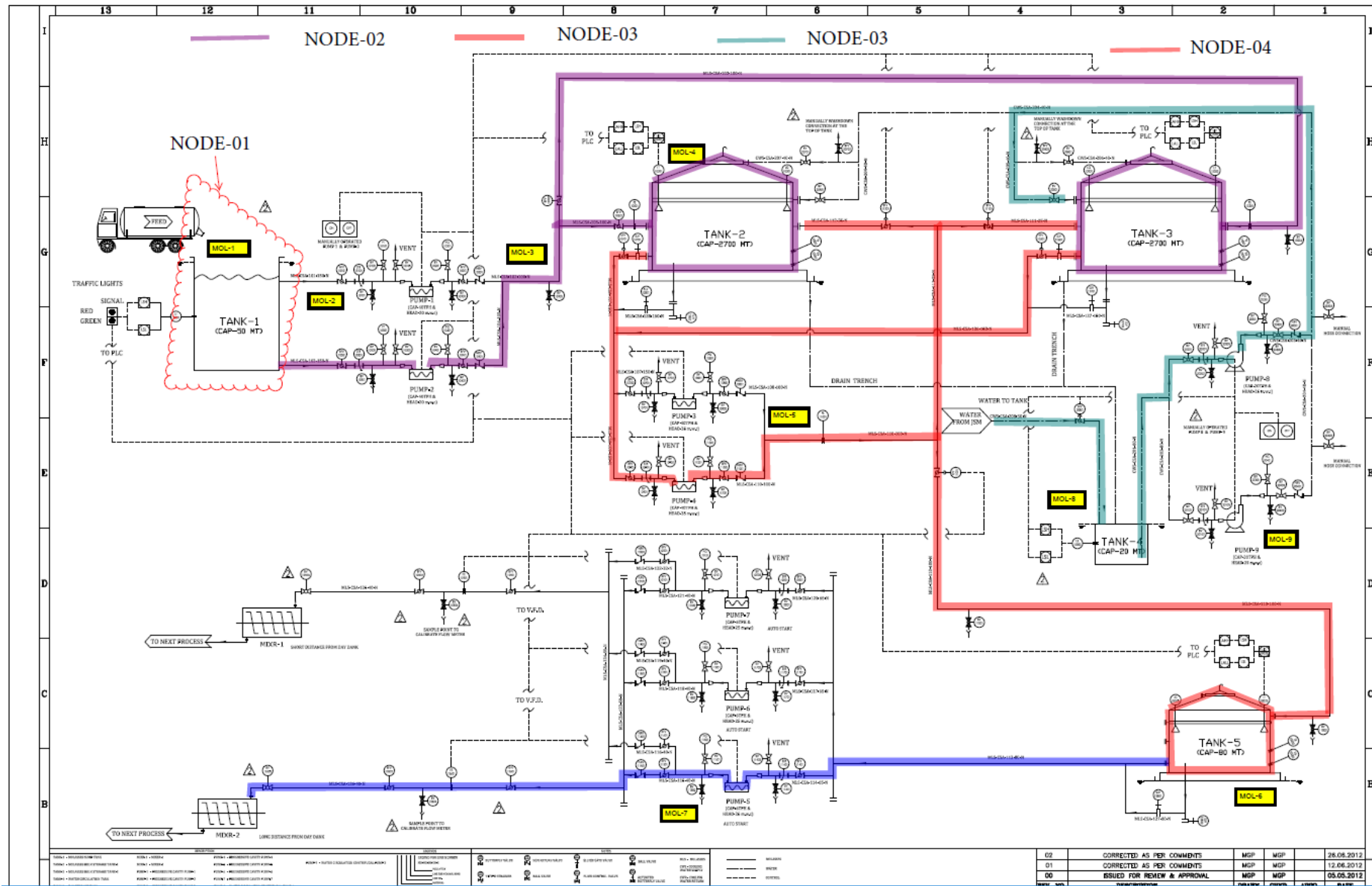
When to do HAZOP?

How to Perform HAZOPs?

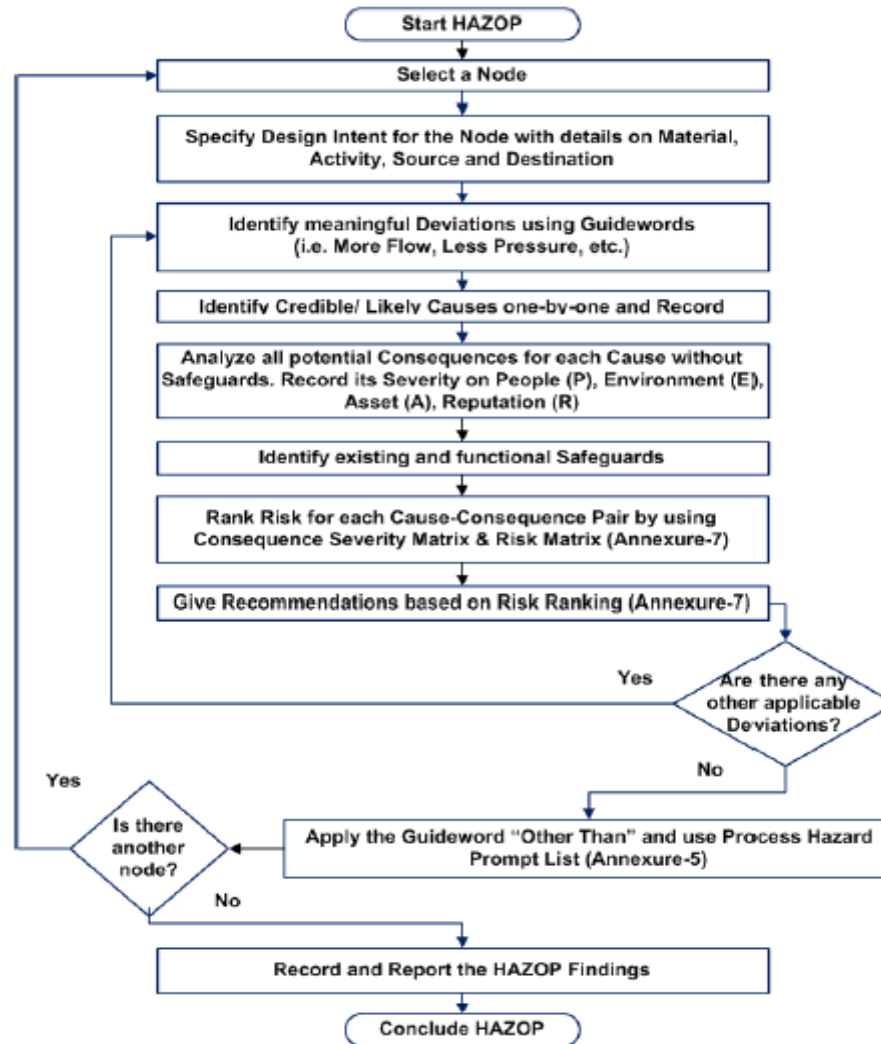
HAZOP Team

Examples

Reporting



HAZOP Methodology



HAZOP TERMINOLOGY

Nodes

- A node is a specific location in the process in which (the deviations of) the design/ process intent are evaluated.
- Mark the **end-point of the node** clearly for applying the deviations during the study.

Design Intent

- The design intent is a description of how the process is expected to behave at the node; this is qualitatively described as an activity (e.g., feed, reaction, sedimentation) and/or quantitatively in the process parameters, like temperature, flow rate, pressure, composition, etc.



DESIGN INTENT

- The “**design intent**” forms a **baseline** for the examination and should be correct and complete, as far as possible.
- The **Design Intent** should contain information on the following:



Material

Information on the materials handled in the node, their composition, phase, and any relevant properties (like density, viscosity, hazardous properties).



Activity

The activities involved in the node in detail including the design process parameter limits involved.



Source

The starting point from where the material comes (with the design values for process parameters, such as flow rate, pressure, temperature).



Destination

Where the material is sent to (with the design values for process parameters).

What is HAZOP

When to do
HAZOP?

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HAZOP
Team

Examples

Reporting

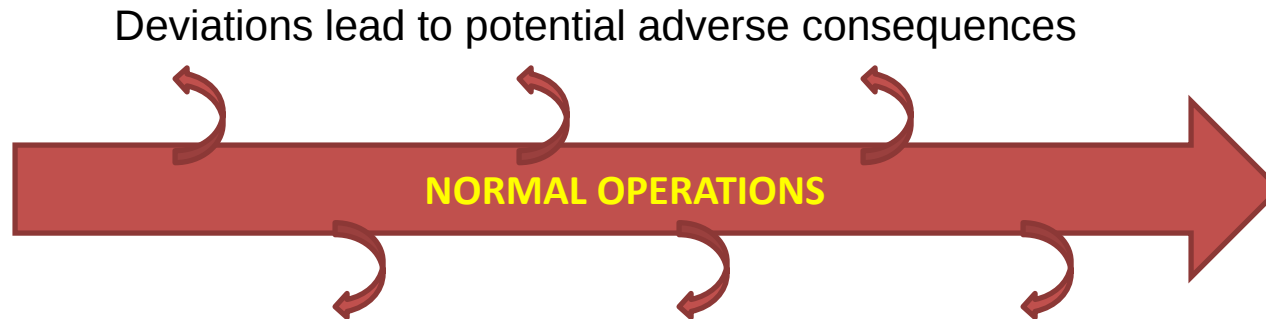
HAZOP

TERMINOLOGY

Parameter: The relevant parameter for the condition(s) of the process (e.g. pressure, temperature, composition).

Guideword: The guidewords are short words applied, in turn, to all the parameters, in order to identify unexpected and yet credible deviations from the design/process intent.

Deviation:



Guide-word + Parameter → Deviation



COMMON GUIDEWORDS

GUIDE WORD	MEANING
No (Not, None)	None of the design intent is achieved
More (High)	Quantitative increase in a parameter
Less (Low)	Quantitative decrease in a parameter
As Well As (In addition to)	An additional activity occurs - impurities or an extra phase is present, such as ingress of air, water, corrosion products etc.
Part Of	Only some of the design intention is achieved. A change in the composition of the stream i.e. the ratio of components making it up are different
Reverse	Logical opposite of the design intention occurs
Other Than	Complete substitution - another activity takes place. The Guideword "Other Than" should be used at the end of each node. Annexure-5 (Process Hazards) checklist can be used for this.

Guidewords relating to time/ sequence: Early / late; Before / after; Faster / slower; Where else

Deviations	Guide Word	Parameter
1. Low/No Flow	Low	Flow
2. More Flow	More	Flow
3. Reverse Flow	Reverse/ Misdirected	Flow
4. Low Pressure	Low	Pressure
5. High Pressure	More	Pressure
6. Low Temperature	Low	Temperature
7. High Temperature	High	Temperature
8. Low level	Low	Level
9. High Level	High	Level
10. Change in Composition	Others	Others
11. Impurities	Others	Others
12. Fire/ Explosion	Others	Others
13. Testing	Others	Others
14. Operability issues	Others	Others
15. Electricals (Area Classification/ Isolation/ Earthing)	Others	Others
16. Instruments (Sufficient for Control/ Too Many/ Correct Location)	Others	Others

HAZOP

TERMINOLOGY

Cause

- The reason(s) why the deviation could occur. “Local” to the node studied.
- All credible/ plausible scenarios leading to the deviations, including all operator/ human errors, should be considered when determining causes.
- Recommended to start with the causes that may result in the worst possible consequence. – *Can be Human Error/ Failure – Internal/ External*

Consequence

- The results of the deviation, in case it occurs. “Global” effects
- Consequences may both comprise process hazards and operability problems, like plant shut-down or reduced quality of the product.
- Several consequences may follow from one cause and, in turn, one consequence can have several causes.

What is HAZOP

When to do
HAZOP?

How to
Perform
HAZOPs?

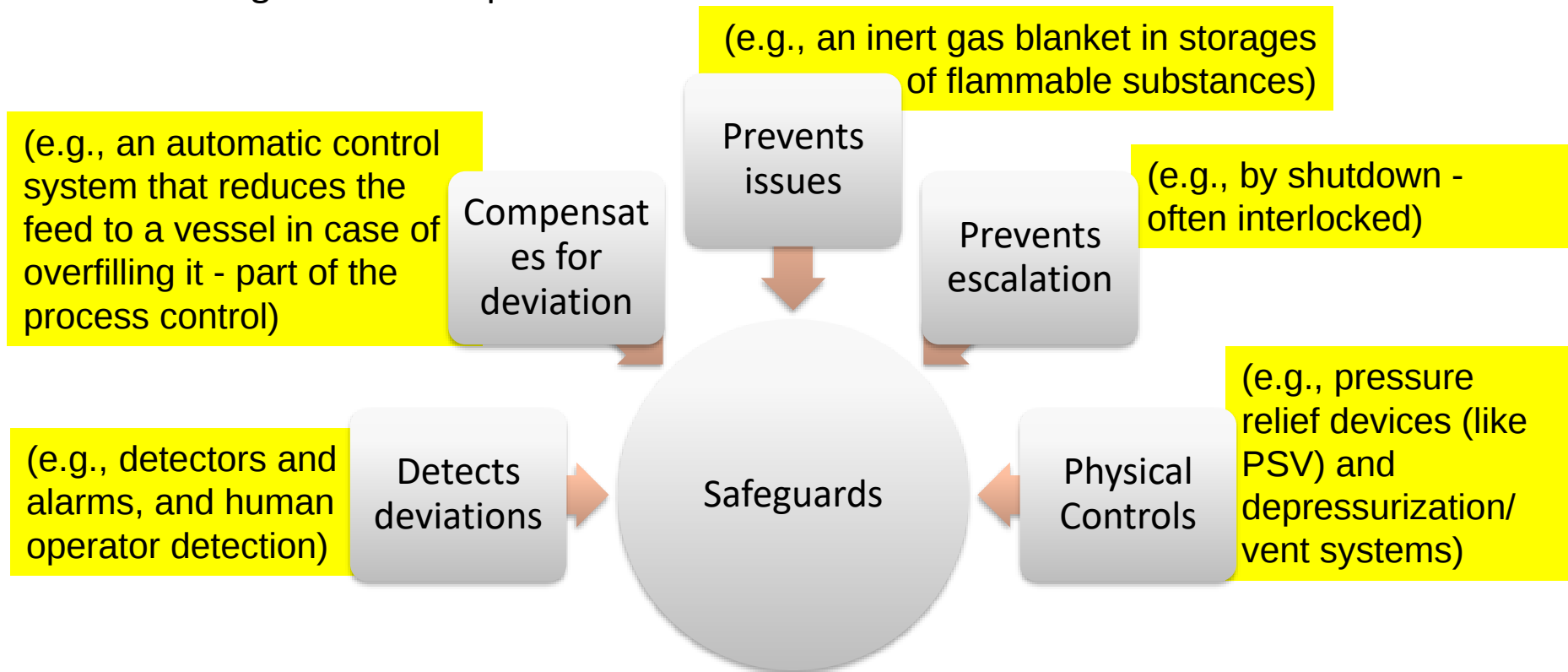
HAZOP
Team

Examples

Reporting

HAZOP TERMINOLOGY

Safeguards: Facilities that help to reduce the occurrence frequency of the deviation or to mitigate its consequences.



What is HAZOP

When to do
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Examples

Reporting

IMPORTANCE OF GUIDEWORDS

High/ More

More Flow/ High Level

- Tank Overflow
- Tank Over-pressurization
- PCV Failure
- No Relief – Atmospheric Vent
- Explosion

More Temperature

- Cooling Failure

Example



What is HAZOP

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Examples

Reporting

IMPORTANCE OF GUIDEWORDS

No/ Low

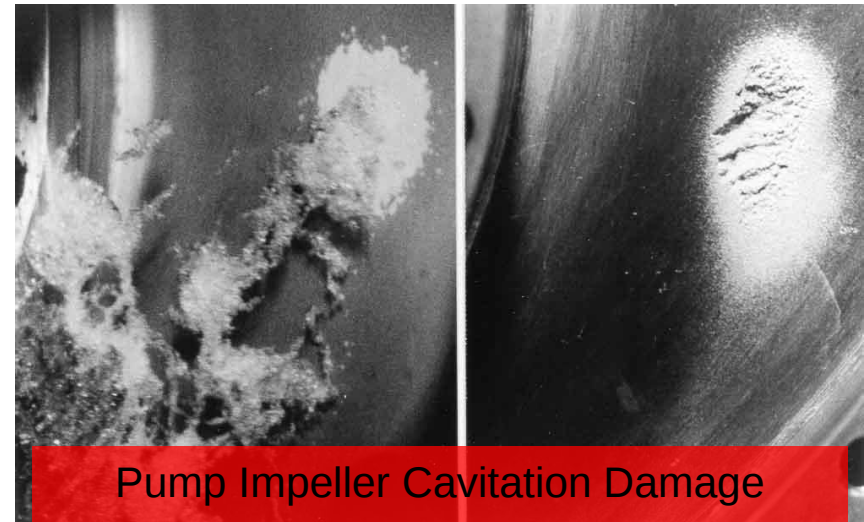
Example

Low Flow/ Low Level

- Pump Cavitation Damage
- Bearing Damage
- Gas Blow-by from Separator led to Tank Rim-Seal Failure and Damage

No Flow

- Wrong Path lined-up
- Blinded/ Valve Stem dropped
- Spurious Close
- NRV wrong direction
- Pipe Leak



What is HAZOP

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Examples

Reporting

IMPORTANCE OF GUIDEWORDS

As Well As

- Inclusion of Impurities.
- Water in unwanted areas, where it could pose different hazards. Ex: Water into heater/ furnace – Steam Explosions.
- Consider HE Tube leaks
- Remember Bhopal?

Example



What is HAZOP

When to do
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HAZOP
Team

Examples

Reporting

IMPORTANCE OF GUIDEWORDS

Other Than

- Some other material enters or displaces intended.
- Mixing of streams.
- **Human Error.** Wrong Valve Operation
- Water Hammer. Condensate in Steam Lines – Drains
- Order of addition of Reactants

Example



What is HAZOP

When to do
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How to
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HAZOPs?

HAZOP
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Examples

Reporting

IMPORTANCE OF GUIDEWORDS

Maintenance

- Isolation
- Drainage/ Venting
- Purging
- Clearing/ Drying
- Slip Plates/ Blinding – Spec/ Spade
- Access
- Rescue plan
- Training – Operators, Maint.
- Pressure Testing
- Condition/ Preventive Maint.
- Catalyst change and activation
- Relief Device, Polymerization

Example



Elbow Failure Caused by
Erosion-Corrosion

What is HAZOP

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HAZOPs?

HAZOP
Team

Examples

Reporting

IMPORTANCE OF GUIDEWORDS

Failure of Utilities

- What if there is a Power Failure?
- Nitrogen Supply Failure
- Steam Failure
- Temperature Drop
- Excess Steam – Pressure Rise
- Hammering, etc

Example



What is HAZOP

When to do
HAZOP?

**How to
Perform
HAZOPs?**

HAZOP
Team

Examples

Reporting

IMPORTANCE OF GUIDEWORDS

Loss of Containment

- LOPC – Leak/ Fire – Vapour Cloud formation – Dense Gas/ Frost Bite/ Burns
- Pump Seal Leak, Piping/ Component (Flange, Gasket, Dead Legs, etc) Leak, Compressor Seal Leak

Example



What is HAZOP

When to do
HAZOP?

**How to
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HAZOPs?**

HAZOP
Team

Examples

Reporting

SAFEGUARDS

Making Recommendations is not mandatory; these should be made only when necessary. The Objective is to “Flag” the issue.

Recommendations should be reported using action-based words (such as Check, Provide, etc.), and assigned to specific work groups. It should be verified whether three chief questions have been explained, viz.

- (1) What is to be done?
- (2) Where is it to be done?
- (3) Why is it to be done?

Check whether the existing safeguards are sufficient or more recommendations are required using a Risk Assessment Matrix.



ORDER OF PRECEDENCE

Eliminate

1. **Eliminate** the Hazard

Substitute

2. **Substitute:** Use Processes/ Methods with less Risk
(*Replace Manual by Auto*)

Moderate

3. **Isolate/ Segregate/ Moderate** Hazard and/ Targets
(*Guards*)

Simplify

4. **Engineered Safeguards:**

Prevention: Design to Prevent unwanted Event

Recovery: Design to Mitigate Consequences

Engineering Control

5. **Organizational Controls:** Training, Competency, Communication

Organizational Control

6. **Procedural Controls:** Operating Procedures, Work Instructions, Permits, SMP, ERP

Procedure

7. **Personal Protective Equipment**

PPE

What is HAZOP

When to do
HAZOP?

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Perform
HAZOPs?

HAZOP
Team

Examples

Reporting

RECORDING

The findings are recorded during the meeting(s) using a HAZOP work-sheet, either by filling in paper copies, or by using a computer connected to a projector (recommended). A sample worksheet is provided in the next slide.

The HAZOP Report is usually composed of the following Chapters and Appendices, viz.

- (1) Introduction;
- (2) A Brief Description of the Facility;
- (3) HAZOP Methodology;
- (4) HAZOP Team;
- (5) Summary of Recommendations;
- (6) Appendices
 - a) HAZOP Worksheet;
 - b) Recommendations made; and Marked-up P&IDs.

What is HAZOP

When to do
HAZOP?

**How to
Perform
HAZOPs?**

HAZOP
Team

Examples

Reporting

SAMPLE HAZOP SHEET

Node: 1. Molasses unloading to tank-1 Drawings: P&ID for Molasses bulk storage tank

Design Intent: To receive molasses in tank -1

Parameter	Deviation	Causes	Consequences	Safeguards	Risk Rating												Recommendations
					People			Env			Asset			Reputation			
					S	L	RR	S	L	RR	S	L	RR	S	L	RR	
Flow / Quantity	1.1. No/less Flow from tanker	1.1.1. No level in tanker	1.1.1.1. Time delay	1.1.1.1.1. inspection of weight and level	2	5	10	2	5	10	2	5	10	2	5	10	
Flow / Quantity	1.2. More Flow	1.2.1. Action is too fast(more opening in tank valve)	1.2.1.1. Level increase in tank 1 and possible overflow	1.2.1.1.1. Unloading Tank (Tank-1) is provided with Level Sensors (Ultrasonic type) with traffic lights system .Red Light should come if the level is high (about 85%)	2	5	10	6	5	30	6	5	30	2	5	10	
Flow / Quantity	1.3. Reverse Flow	1.3.1. NA															
Pressure	1.4. More Pressure	1.4.1. NA															
Pressure	1.5. Less Pressure	1.5.1. NA															
Temperature	1.6. More Temperature	1.6.1. NA															
Temperature	1.7. Less Temperature	1.7.1. NA															
Level / Interface	1.8. Low Level	1.8.1. level sensors malfunctioning	1.8.1.1. Possible Pump 1 and 2 damage														
Level / Interface	1.9. High Level	1.9.1. level sensors malfunctioning	1.9.1.1. Level increase in tank 1 and possible overflow	1.9.1.1.1.													
Part of (something missing)	1.10. Part of Composition (Molasses Physical properties check like Density, Viscosity, pH, Water content etc)	1.10.1. Poor quality material	1.10.1.1. High viscosity can lead to higher pressure drop / frictional drop in the piping system, need higher pump head and power.	1.10.1.1.1. quality check of molasses when purchased													
Others	1.11. maintenance	1.11.1. tank maintance	1.11.1.1. possible injury and fatality due to confined space operation														
		1.11.2. material handling in hose conection	1.11.2.1. spillage 1.11.2.2. Personal njury														
Others	1.12. Corrosiveness																
Others	1.13. Personal safety	1.13.1. vehicle movement during unloading operation	1.13.1.1. spillage														
			1.13.1.2. Personal njury														
Others	1.14. Noise																

What is HAZOP

When to do HAZOP?

How to Perform HAZOPs?

HAZOP Team

Examples

Reporting

HAZOP TEAM

HAZOP Team Leader

Responsibilities:

- Ideally, not closely associated with the design team and the project.
- Trained and experienced in leading HAZOP studies.
- Plans the study. Agrees study team composition.
- Chairs the HAZOP meetings
 - Triggers the discussion using guide-words and parameters
 - Follows up progress according to schedule/ agenda
 - Ensures completeness of the analysis
 - Ensures time-keeping
 - Resolves issues within the team

What is HAZOP

When to do
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HAZOPs?

**HAZOP
Team**

Examples

Reporting

HAZOP TEAM

HAZOP Coordinator

Responsibilities:

- Ensure the availability of information documents before a HAZOP session, and that they are updated copies, as built for the existing units.
- Arrange for a HAZOP Leader
- Arrange and convey session timings to the Team
- Fill the HAZOP Study Pre-requisites Checklist
- Prepare HAZOP worksheets
- Record the discussion in the HAZOP meetings
- Prepare draft report(s)

What is HAZOP

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**HAZOP
Team**

Examples

Reporting

HAZOP TEAM

HAZOP Team Members

Personnel having adequate experience in their field of activity:

DISCIPLINE	NOMINATED BY	FROM
Team Leader	Head – Process	Identified HAZOP Leaders
Operations	Area Manager	Sr. Operations personnel
Process (Coordinator)	Head – TS	Process Department
Instrumentation	Head – Instrumentation	
Mechanical	Head – Mechanical	
Inspection & Corrosion	Head – Inspection	
Safety	Head – Safety	
Optional Team Members		
Engineering (Design)	Head – Engineering Services	
Environmental Engineer	Head – Environment	
Electrical	Head – Electrical	
Fire/ Process Safety	Head – Fire & Safety	

What is HAZOP

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HAZOP?

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HAZOPs?

**HAZOP
Team**

Examples

Reporting

WHAT ELSE CAN BE CONSIDERED?

Modes of operation

The following modes of plant operation should be considered for each node:

- Normal operation
- Reduced throughput operation
- Routine start-up
- Routine shutdown
- Emergency shutdown
- Commissioning
- Special operating modes

What is HAZOP

When to do
HAZOP?

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Perform
HAZOPs?

HAZOP
Team

Examples

Reporting

REPORTING

Contents Summary

1. Introduction
 2. System definition and delimitation
 3. Documents (on which the analysis is based)
 4. Methodology
 5. Team members
 6. HAZOP results
 - ✓ Reporting principles
 - ✓ Classification of recordings
 - ✓ Main results
- ☐ Appendix 1: HAZOP work-sheets
 - ☐ Appendix 2: P&IDs (marked)

What is HAZOP

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HAZOP
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Reporting

REVIEW MEETINGS

Review meetings should be arranged to monitor completion of agreed actions that have been recorded. The review meeting should involve the whole HAZOP team. A summary of actions should be noted and classified as:

- Action is complete
- Action is in progress
- Action is incomplete, awaiting further information

What is HAZOP

When to do
HAZOP?

How to
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HAZOPs?

HAZOP
Team

Examples

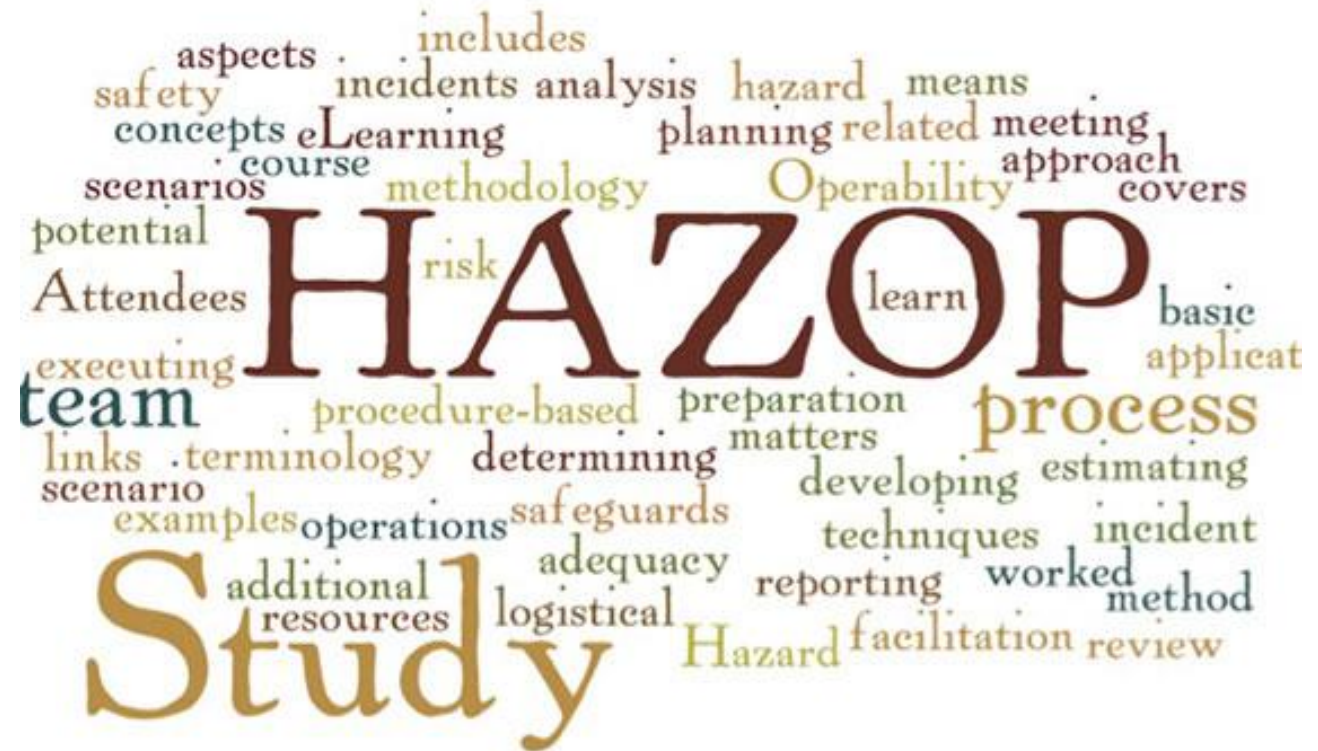
Reporting

HAZOP-BATCH PROCESS

- An examination of an existing or planned operation (work) procedure to identify hazards and causes for operational problems, quality problems, and delays.
- Focus on both human errors and failures of technical systems
- Best suited for detailed assessments, but can also be used for coarse preliminary assessments
- Flexible approach with respect to use of guide-words
- Breakdown of operation (work) procedure to suitable steps
- Define intention of each step
- Establish boundary conditions
- Continue as conventional Process HAZOP
- Apply guide-words to intention and boundary conditions for each step.

HAZOP RESULTS

- Improvement of system or operations
 - Reduced risk and better contingency
 - More efficient operations
- Improvement of procedures
 - Logical order
 - Completeness
- General awareness among involved parties
- Team building



HAZOP STUDY PRACTICE

ISSUES

HAZOP PROS & CONS



Systematically and thoroughly think hazards associated with the facilities

Cross-discipline Thinking: “Oh, I thought You Guys were taking care of that”

Utilizes Operational Experience

Covers Safety & Operational Issues

Economic Pay-off: Efficient process, Good Business

Process Training: Excellent forum – Process Integration

Development of PSI: Alarms, Set Limits, “As-Built” Drawings need updation

Considers Operational Procedures

Covers Human Errors

Structured way of presenting what Controls are needed

“Real Work” business

“No Time for Meetings”

Can’t bring everyone together at same time

Benefits in real-time? - Only visible for High Frequency Events

Dependent on Team Composition

Recreation of Discussion based on Reports is difficult



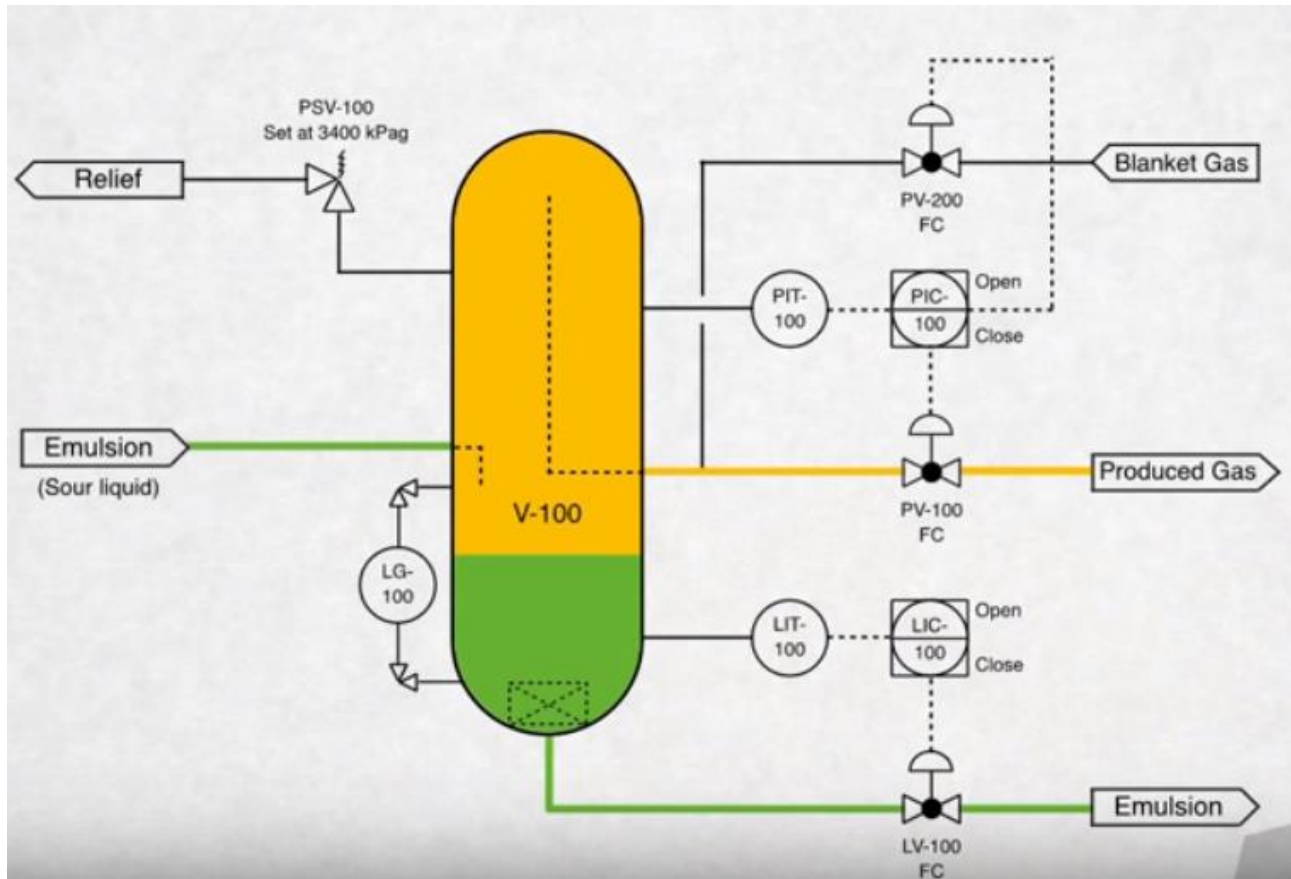
HAZOP ISSUES

- Each action must be relevant, clearly defined and worded with no ambiguity
- The persons who follow up the action may not have been at the meeting and could waste time and effort if there is a misunderstanding
- The study must accept a flexible approach to actions
- The team must be motivated and have adequate time to complete the examination
- The boundary of the study must be clearly analyzed and studied

HAZOP ISSUES

- Teams tend to quickly identify alarms, shutdown trips and controls as safeguards
- Alarms may not work, as they are not tested most often
- Alarms and Interlocks are most often bypassed due to Nuisance factor
- Operators may miss warning signals
- Auto-Controls may be switched over to Manual Mode (Remember Piper Alpha)
- Every action raised must be analyzed and answered accurately
- Those which require a positive change should be subject to a management of change process (which may require a new HAZOP of the change) and put into a tracking register

HAZOP-TRAINING EXAMPLE



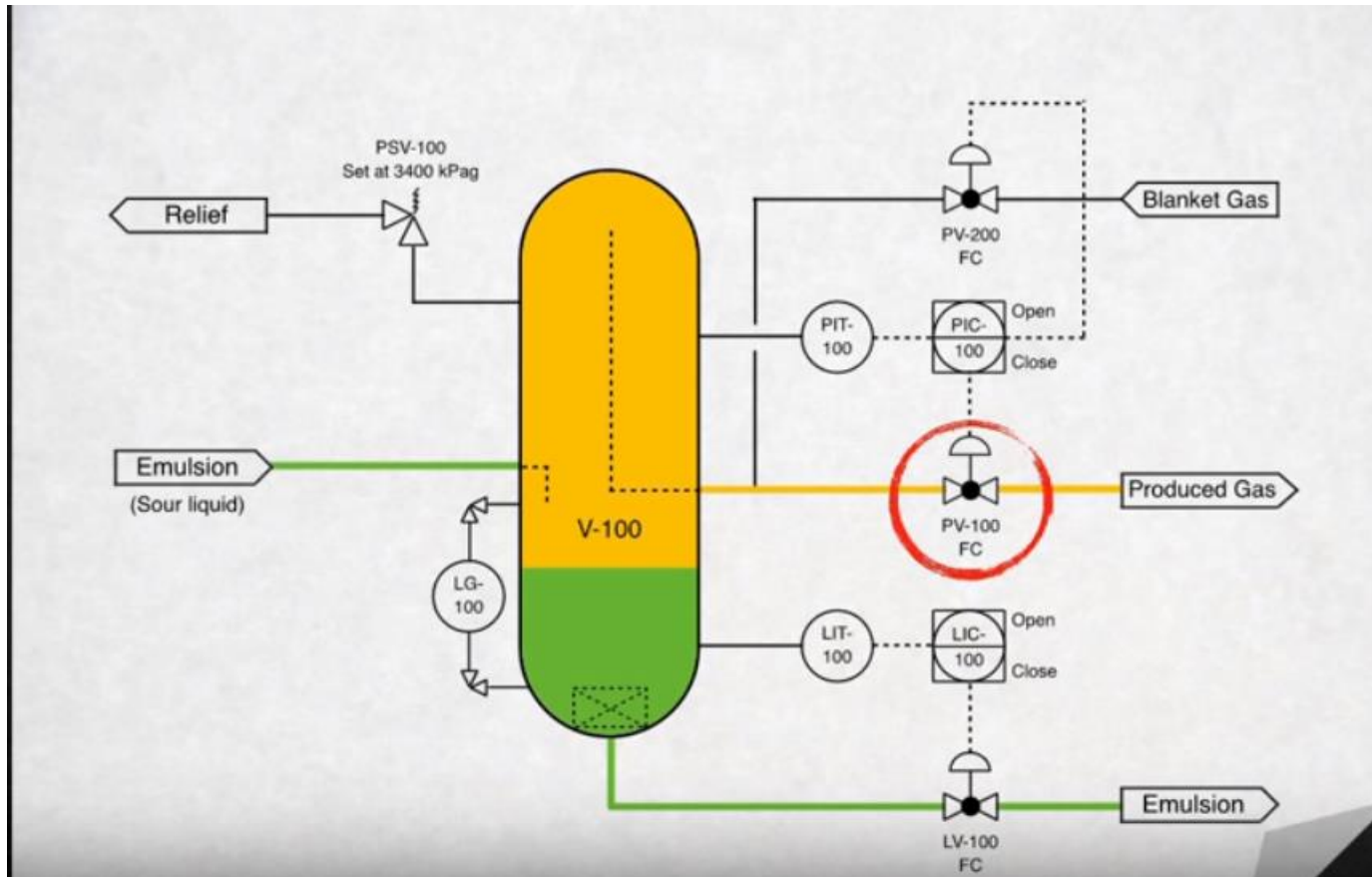
Identify the risk by asking:
What hazardous event...

... by thinking of specific process **deviations**

Here are some examples of process deviation...

- High Temperature
- High Pressure
- Low Level
- Misdirected Flow

What can **cause** high pressure in following process?



Step 2: Describe the **consequences** and
assign a severity level

What if the vessel V-100 were to
overpressure leading to **rupture**?

Can it kill someone?

Can it cause a public relations disaster?

Is it going to cost thousands of dollars to fix the equipment?

The consequence of vessel rupture can be a
fatality

Step 3: Assess the **probability** of the cause

What is the **probability** of the pressure control valve failing closed?

10% chance in a year?

1 % chance in a year?

20% chance in a year?

90% chance in a year?

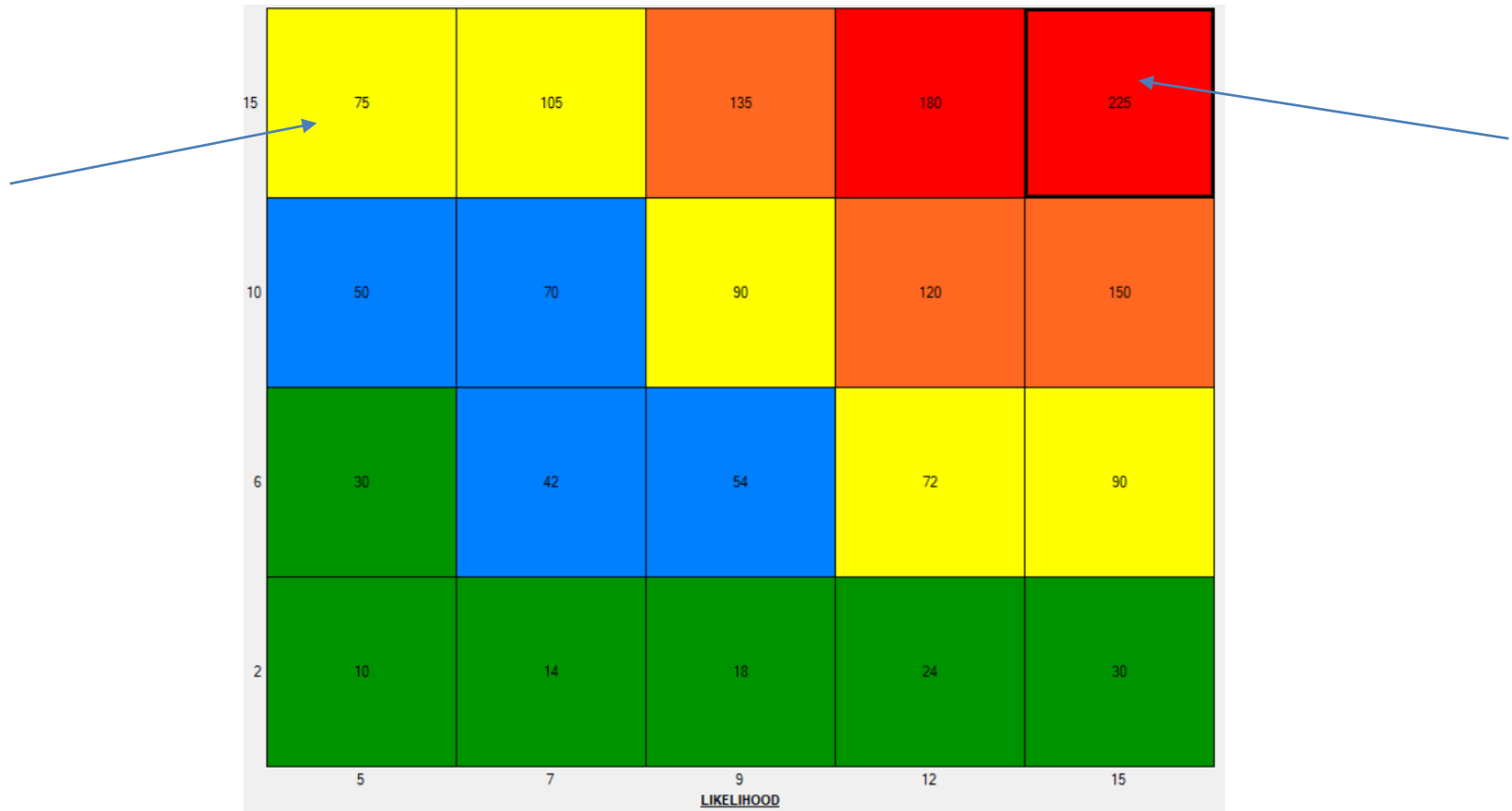
Step 4: Evaluate the risk based on the severity and probability **without** any safeguards

Let's say our scenario has a **high** probability
of a control valve failure and a **high**
severity due to possible fatality

Look up your **risk matrix** to categorize the risk...

... by locating the risk
based on the **probability**
and the **severity**



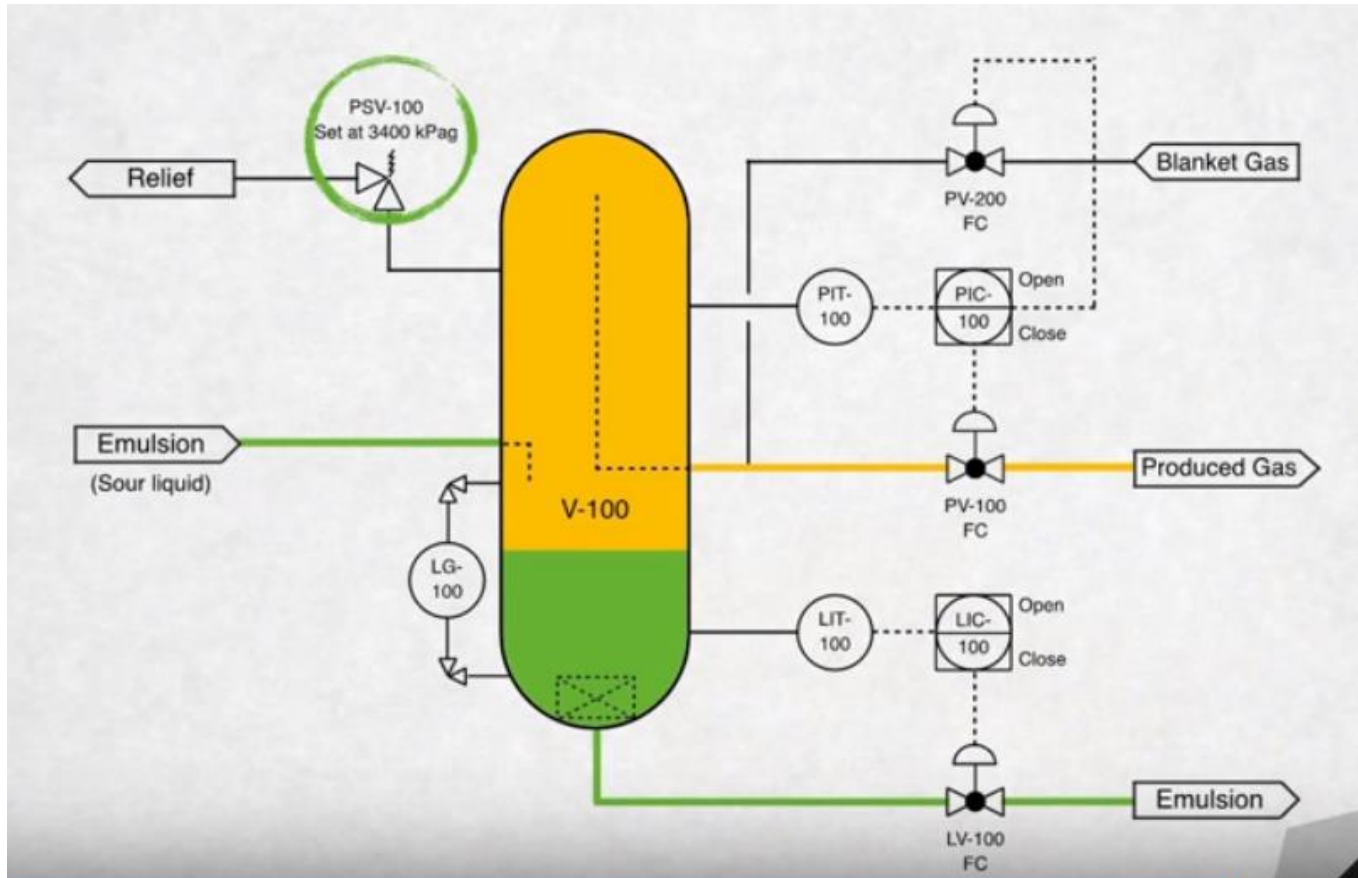


Step 5: Assess the risk with **safeguards**

Is there an alarm with operator intervention?

Is there a pressure safety valve on the vessel?

Is there an automatic safety shutdown on the high pressure alarm?



In our case the pressure safety valve will
reduce the likelihood of a vessel rupture

Step 6: Make a **decision** to accept the risk
or make a recommendation to further
reduce the risk

Your risk matrix defines
the risk acceptance
criteria



Make a **recommendation** when the risk is
not acceptable

Remember

There is no value in a recommendation
without **commitment** to action...

A HAZOP alone does not change your risks
exposure unless there are effective actions
sustainable for operation

Thank
You



“All birds find shelter during a rain. But an Eagle avoids rain by flying above the Clouds. Problems are common, but Attitude makes the difference !” - Dr. APJ Abdul Kalam

CONTACT US FOR YOUR TRAINING REQUIREMENTS TODAY!!!!