SAFETY SERVICES ORGANISATION

HAZ ID AND HAZOP

HAZOP

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[1,2]

REFERENCES AND USEFUL DOCUMENTS

Useful documentation and resources:

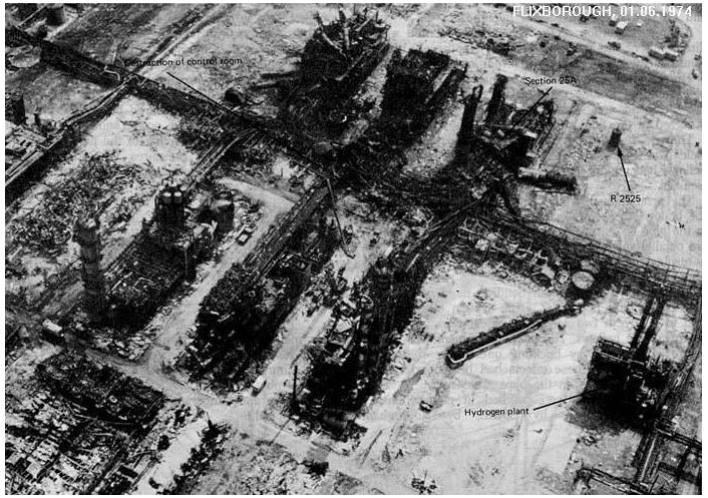
- **Def Stan 00-058**: Now withdrawn, although still useful.

[1,2]

FLIXBOROUGH DISASTER

The Flixborough disaster was an explosion at a chemical plant in 1974, it killed 28 people and seriously injured a further 36 on site. Beyond the site, a further 50 people were injured, and 2000 properties suffered damage.

- The disaster might have been caused by a hasty modification, although there are conflicting theories on the immediate cause.
- The Imperial Chemical Industries (ICI) instigated a review into how it controlled modifications. It found several issues in how safety was conducted...



The solution was HAZOP.

[5,6]

WHAT IS A HAZOP STUDY?

HAZOP is a technique for HAZ ID that involves looking at the entire process, step-by-step, and question every part of that process to establish how fault conditions or deviations can arise.

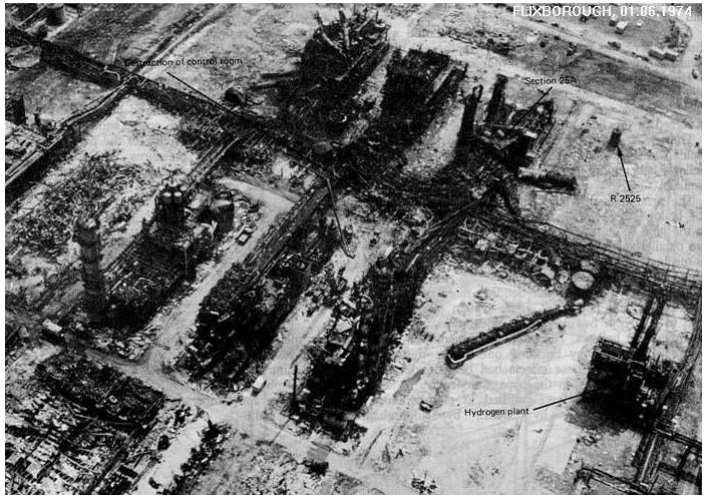
For each fault all the causes and subsequent effects and are identified.

Designed for continuous, plant type processes. With a bit more planning however, it can be applied to batch processes.

Works best for analysing process, procedures and sequential operations.

It is one of the most widely used HAZID techniques and is the standard in many industries.

As always: it should be used in conjunction with other techniques.



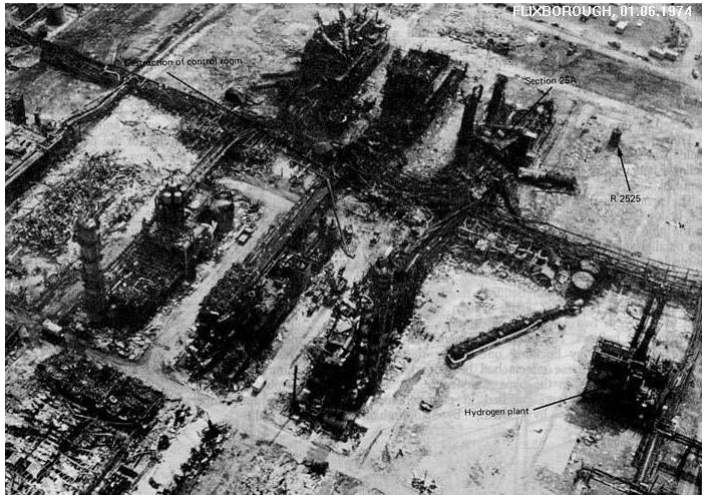
[5,6]

AIMS OF A HAZOP

Every HAZOP, will have these four basic aims:

- To identify all deviations from design intent; their causes, and all the hazards and associated with these deviations.
- To determine whether action is required to control the hazard, and/or identify additional mitigation or solutions.
- To identify and note cases where a decision cannot be made immediately and to determine follow up action.
- To ensure that said actions are decided upon and then completed.

HAZOPs may be applied to an entire system, individual sub-systems or even modifications to an existing system.



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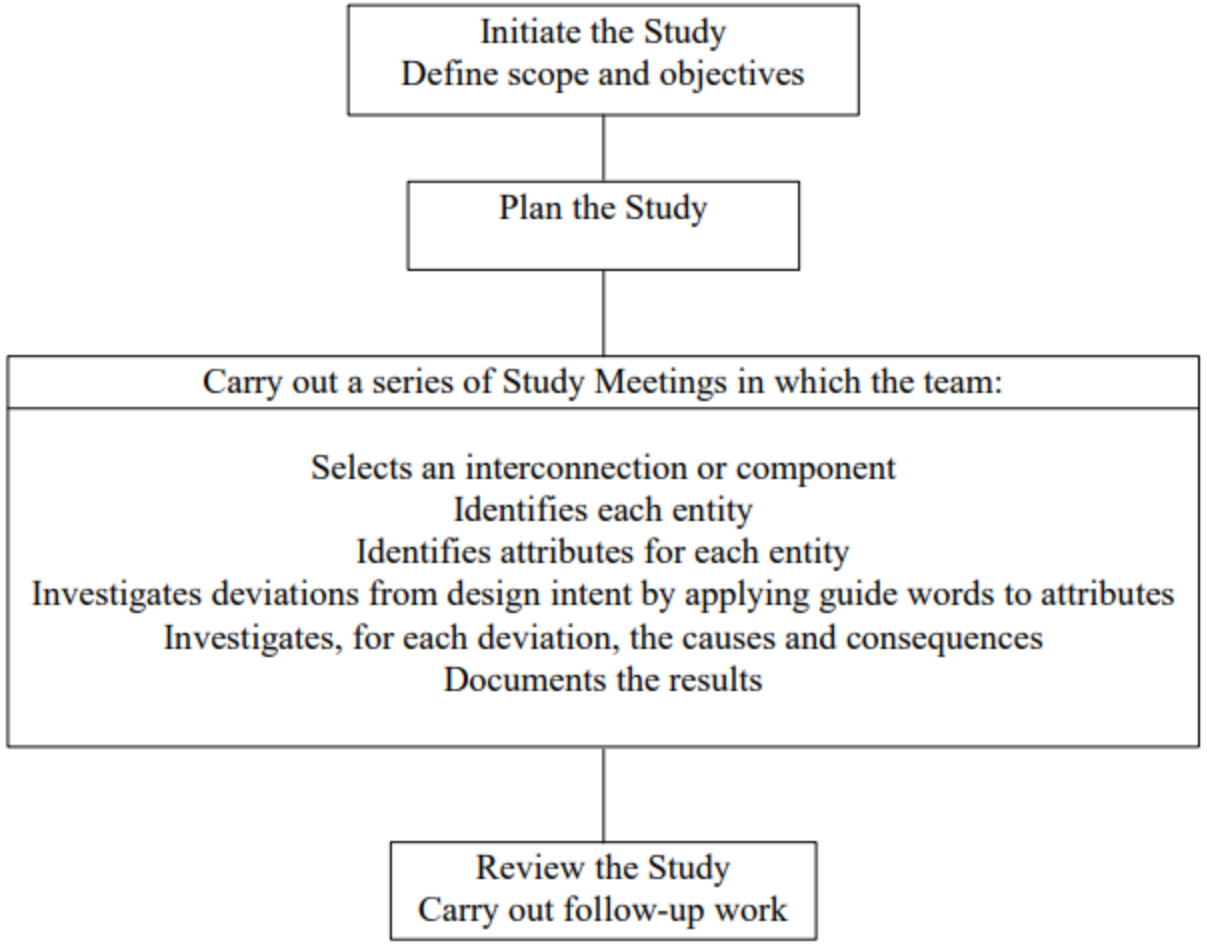
HAZOP PROCESS



[7]

PLAN THE HAZOP STUDY

Firstly, you must plan for the HAZOP:

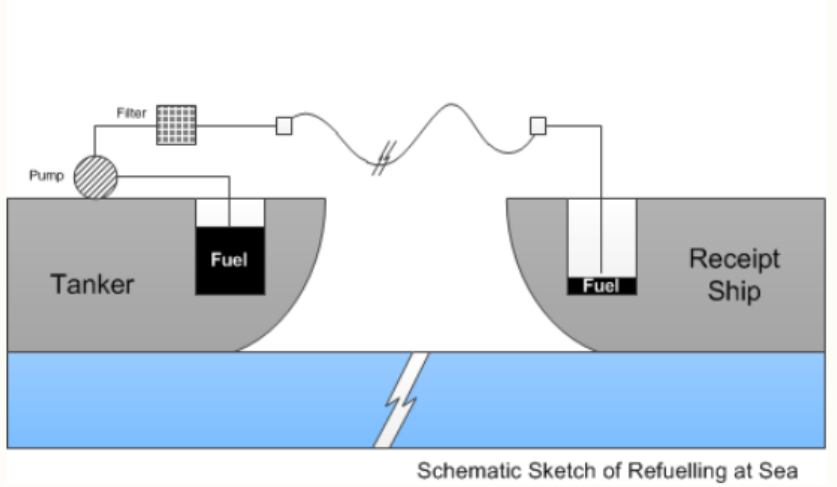
- The HAZOP should have a defined purpose and scope.
- You need to assemble the HAZOP team.
- You need to gather relevant documentation.

[8,9,10]

PROCESS REPRESENTATION

To begin a HAZOP you need a full representation of the process, design or procedure you are studying. It should detail accurately each component and the interconnection between each component.

This gives you a set of 'nodes' to study, with all nodes effectively representing the entire system or process.



Schematic Sketch of Refuelling at Sea

Node Description:

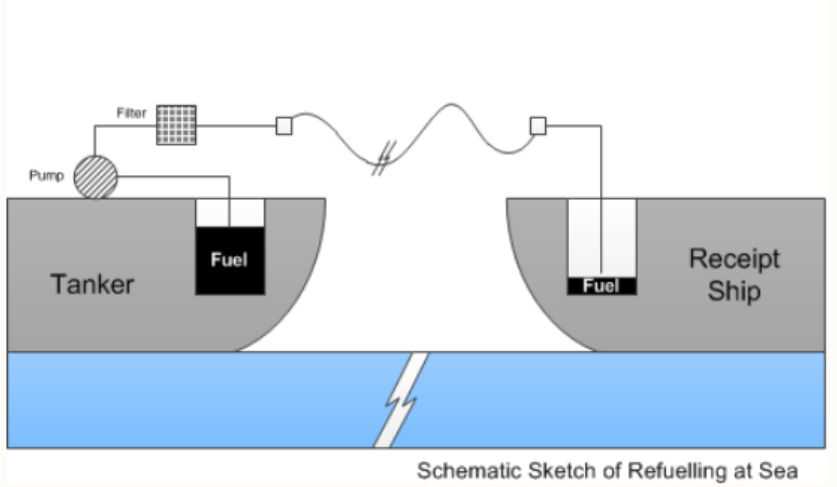
The hose connections from the tanker to the ship tank connection pipe including the pump, filter and manual valves on the pump inlet and outlet.

[6,7]

PROCESS REPRESENTATION

The representation must:

- Express the design intent and the relevant variables
- Represent interactions between components and systems.
- Represent the interaction between the user (humans) and the system.
- Represent any interactions between the system and the environment.



Schematic Sketch of Refuelling at Sea

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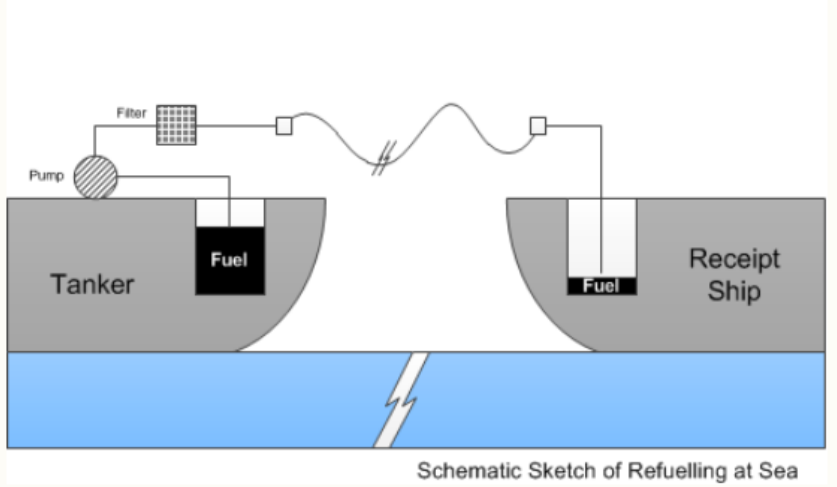
[6,7]

VARIABLES

The variables in the system must be understood.

This will be very dependent on the system or process you are studying.

- In the example below the following may be variables:
  - Fuel flow rate
  - Fuel temperature



Schematic Sketch of Refuelling at Sea

Node Description:

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[6,7]

GUIDE WORDS

The leader should generate the guide words prior to the meeting.

They should be specific… but not too specific

They need to be as complete as possible, but avoid overlong lists.

There is a standard set, however they can and should be adapted to best fit your analysis.

For guide word adaptions, see Ref [12].

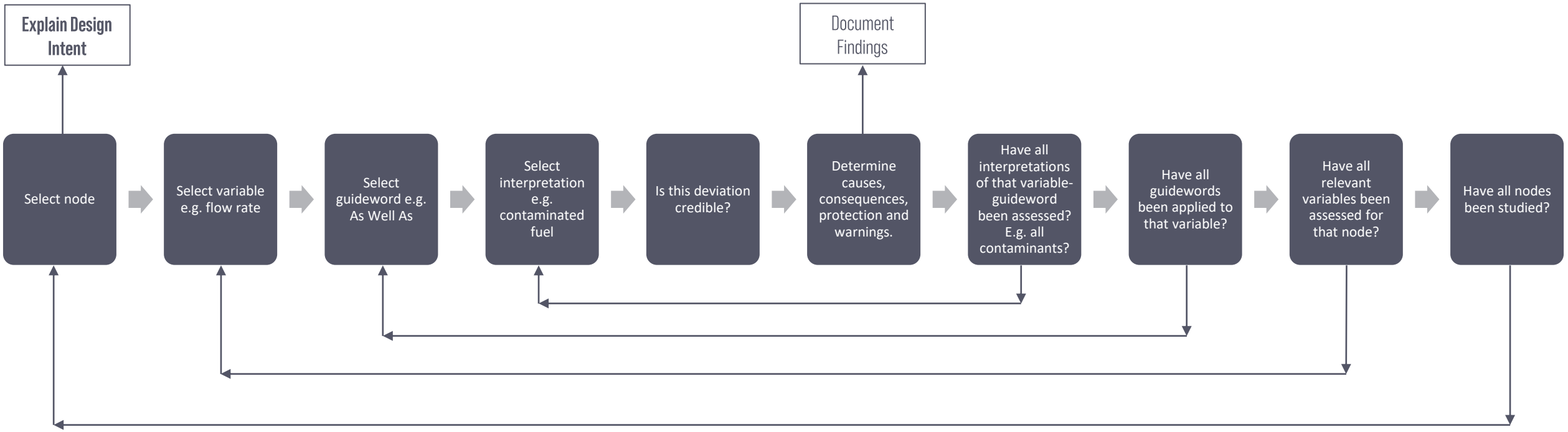
The team will be making variable-guide-word combinations. If several interpretations of such a variable-guide-word exist, they should all be used in the HAZOP.

[11,12,13,14]

GUIDE WORDS

Guide Words	Description	Deviation for Fuel Flow Rate Variable
No or Not	This is the complete negation of the design intention. No part of the intention is achieved and nothing else happens	No flow of fuel at all
More	This is a quantitative increase.	High flow
Less	This is a quantitative decrease.	Low flow
As Well As	All the design intention is achieved together with additions.	Correct amount of fuel, with additional contamination (will also be a high flow)
Part Of or Partial	Only some of the design intention is achieved.	Correct flow, but fuel is contaminated (leading to less fuel)
Reverse	The logical opposite of the intention is achieved.	Flow in opposite direction
Other Than or Instead	Complete substitution, where no part of the original intention is achieved but something quite different happens.	Flow of water instead of fuel
Early	Something happens earlier than expected relative to clock time.	Flow begins before hose is connected
Late	Something happens later than expected relative to clock time.	Delay to fuel flow
Before	Something happens before it is expected, relating to order or sequence.	Flow begins before hose is connected
After	Something happens after it is expected, relating to order or sequence.	Delay to fuel flow

CONDUCTING THE HAZOP – STEP BY STEP



CONDUCTING THE HAZOP

At the start of the meeting:

- Discuss generic failures e.g. lightning strike.
- Be cognisant of previous accident/hazard data.

The leader needs to:

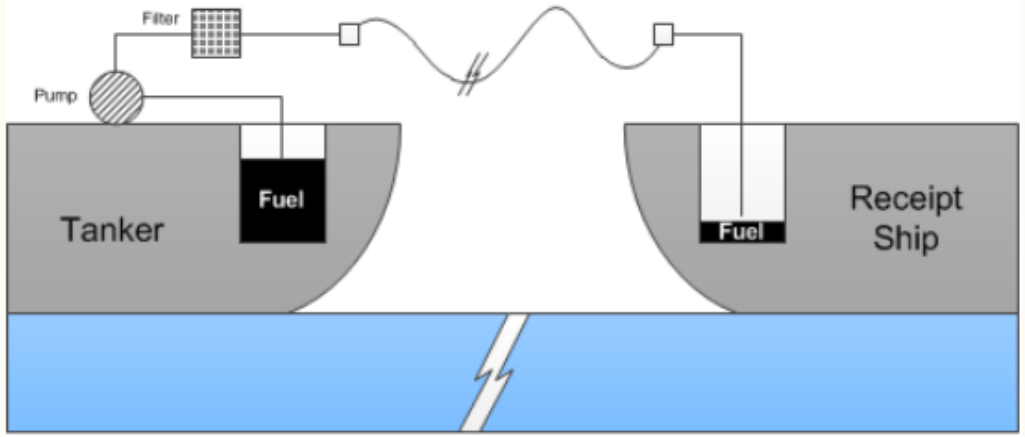
- Ensure the team goes through the process systematically.
- Lead the discussion. The leader should moderate and not be directly involved.
- Ensure the HAZOP is correctly recorded.

The HAZOP will generally not:

- Assess risk, this should be a separate activity.
- Control the design.

[7,15,16]

HAZOP EXAMPLE (ASEMS) - DESIGN



Schematic Sketch of Refuelling at Sea

Fuel oil is transferred from a tanker to a ship as shown in Figure 1. A simple sketch describing part of the system is shown in Figure 2. In this example we shall apply the HAZOP technique to the equipment shown. We are interested in safety hazards and environmental aspects.

Fuel is removed from one of the fuel storage tanks on the supply vessel by pump and transferred to the fuel storage tank on the receiving ship via permanent pipework and a flexible hose connection. There are manual valves on the suction and discharge to the transfer pump and also a filter to prevent solids from being transferred. There is also a manual valve at the delivery on the receiving ship. Couplings are provided at each end of the hose to enable quick connection.

The fuel is at ambient temperature; the pressure is negative static head at the pump suction and 3 barg maximum at pump discharge. The storage tanks are at atmospheric pressure with capacities of 50 and 20 m3 respectively for the tanker and receiving ship. Fuel flow rate is 500 litres per minute. It is assumed that level measurement in the tanks is by manual dipping and that the pump is started and stopped using a local pushbutton. A procedure is in place for correct configuration of the pipework and equipment and subsequent transfer of the fuel.

An example of the completed logsheet for this HAZOP study is shown in the Table below.

HAZOP EXAMPLE (ASEMS) - NODE

Project: Fuel Transfer System	**Revision:** 0	**Node:** 001	**Page:** 1
	Date:	**Time:**	
	Session: 0	**Team:**	
Node Description: The hose connections from the tanker to the ship tank connection pipe including the pump, filter and manual valves on the pump inlet and outlet.	**Leader:**	**Recorder:**	
	Organisation: XYZ		
	Location: Various		
Design Intention: To transfer fuel from the tanker to the ship tank via the installed pump.	**P&ID's**	**Rev #'s**	
Normal Process Conditions (Range): Temperature: Ambient Pressure: Negative static head from tanker, 3 barg maximum at pump discharge Flow rate: 500 litres per minute			
Team Members:			

HAZOP EXAMPLE (ASEMS) - CONDUCT

Project: Fuel Transfer System			**Node:** 001		**Page:** 2
Node Description: The hose connection from the tanker to the ship tank including the pump and manual valves on the pump inlet and outlet.					
Guideword/Deviation	**Causes**	**Consequences**	**Safeguards**	**Rec#**	**Recommendation**
No Flow	Manual valve on pump inlet closed	No transfer of fuel. Pump starved of liquid, which could cause mechanical damage and possible leakage from the pump to sea. Possible fire if there is an ignition source.	Operators knowledge and training. Local stop which will be used by operator if pump leaks or is noisy.	R1	Provide low level / dry running cut out for the pump to prevent pump damage on loss of suction.
	Manual valve on pump outlet closed	No transfer of fuel. Pumps runs against a closed discharge, which could cause overheating, mechanical damage and leakage if left for too long.	As before. Also this valve is normally kept open.	R2	Develop a checklist for use by the operator when carrying out tanker transfers. Ensure checks of manual valve positions are included in this checklist for all stages of fuel delivery.
	Line or filter blocked.	As above.	As above. Line or filter blockage is unlikely since fuel delivered is clean.		
Reverse Flow	Backflow of fuel when disconnecting tanker hose at ship due to siphoning.	Spillage of fuel on ship with potential spillage to sea and fire hazard.	Operator closes manual valve before disconnecting hose.	R3	Install a non-return valve in the line to the ship fuel tank.
		Operator could be splashed with fuel when disconnecting hose.	Operator wears gloves and goggles.		
More Flow	Tanker hose or transfer pipe rupture.	Discharge of fuel from hose or pipe to sea causing environmental pollution. Potential for fire if there is a source of ignition.	Hoses and pipework are rated for 7 barg pressure. Maximum pump pressure is 3 barg.	R4	Develop oil spill containment response procedures and check suitability of hardware for spillage cleanup.
				R5	Review adequacy of the fire fighting equipment on the ship.

ADVANTAGES OF HAZOP

Advantages of HAZOP:

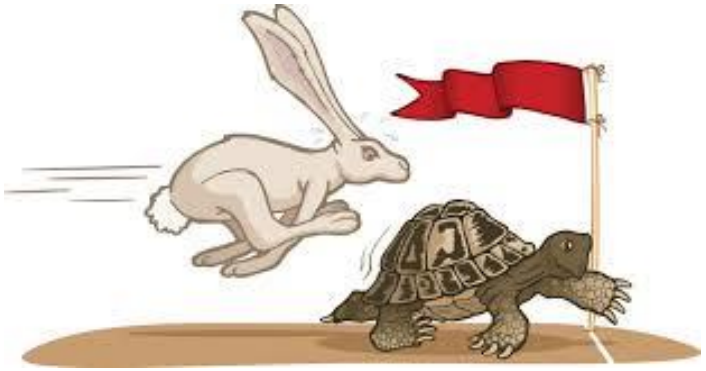
- Very widely used and understood in many industries.
- Users, maintainers and operators can easily be included in the team.
- It is systematic and comprehensive.
- It is useful for technical and human errors.
- Flexible.
- Allows for identification of corrective and preventative measures.

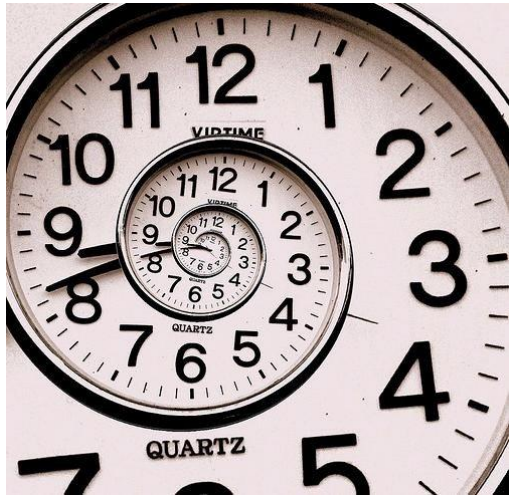
[6,17,18]

DISADVANTAGES OF HAZOP

Disadvantages of HAZOP:

- Its success depends on the facilitation of the leader and the knowledge of the team.
- Optimised for process hazards, needs some modification for others.
- Can be very repetitive for batch processes.
- Requires detailed procedural descriptions, designs and operational information.
- The resulting documentation is lengthy.
- The method is labour intensive and time consuming.
- The method may not be able to provide adequate design solutions to the human error problems it highlights.
- It focuses on identifying single failures.





[6,19,20]

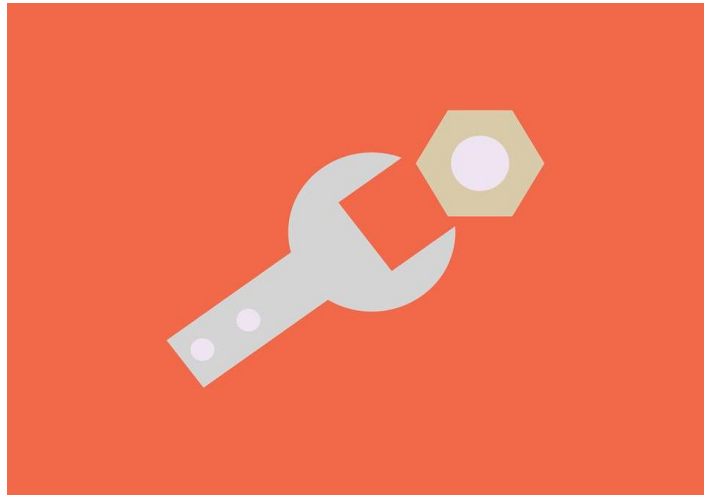
FLEXIBILITY OF HAZOP

What we have spoken about so far is the ‘formal’ method of HAZOP.

- This may be more suitable for new plant in the detailed design phase.
- Or when more detail is required.

In some situations, to negate some of the disadvantages, the method of HAZOP can be adjusted.

We are going to talk about one potential method for adjusted HAZOP studies based on a real implementation of HAZOP.



IMPLEMENTATION - TWO STAGE HAZOP

A two stage HAZOP process consists of a less detailed first stage (HAZOP 1) which uses '**Keywords**', similar to SWIFT, but runs through a nodal HAZOP process.

- This may be more suitable for early phases of design or for well-understood existing plant

This, if necessary, may be followed by a 2nd stage (HAZOP 2) which uses **Guidewords and Parameters** and is essentially the same as the 'formal' HAZOP process described in the majority of this lecture.

- This may be more suitable for new plant in the detailed design stage

[24,25]

KEYWORDS

Keyword	Keyword	Keyword	Keyword
Access	Drop/ Impact	Extreme Weather	Residues
Adjacent Facilities / Ops	Dust	Fire	Noise
Biological	Effluents / Washing	Human Error	Seismic
Chemical	Electrical	Humidity	Toxicity
Degradation / Ageing	Electrocution	Laser	Vehicles
Detonation	Explosion	Mechanical	Ventilation
Sympathetic Detonation	External Factors	Method of Operating	Waste

HAZOP EXERCISE

- Access
- Drop/ Impact
- Extreme Weather
- Residues
- Adjacent Facilities / Ops
- Dust
- Fire
- Noise
- Biological
- Effluents / Washing
- Human Error
- Seismic
- Chemical
- Electrical
- Humidity
- Toxicity
- Degradation / Ageing
- Electrocution
- Laser
- Vehicles
- Detonation
- Explosion
- Mechanical
- Ventilation
- Sympathetic Detonation
- External Factors
- Method of Operating
- Waste

HAZOP EXERCISE

Facility:					Session:					
Node:										
Intention										
ID	Key-word	Cause	Consequence	Controls	Recommendations	S	L	R	Action	Comments

NEXT STEPS…

I will hand you over to Austin who will talk you through the Hazard and Risk Assessment process.

I will then return to talk you through Hazard Logs and Safety Cases.

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THANK YOU FOR LISTENING

ANY QUESTIONS?

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