HAZARD & OPERABILITY STUDY

HAZOP

Standards/Referefrences followed

International Standard : IEC61882 (International Electrotechnical Commission);lkiujhytgrfedwsqa
Hazard and Operability Studies (HAZOP) Application Guide
Edition 2.0
2016 -03

PQRI HAZOP Training Guide
(Product Quality Research Institute, is USA based non-profit consortium of organizations working for Quality and Regulations)
Manufacturing Technology Committee – Risk Management Working Group
Risk Management Training Guides

Definition & Concept

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•A Hazard and Operability (HAZOP) study is a 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.

•The HAZOP technique was initially developed to analyze chemical process systems, but has later been extended to other types of systems and also to complex operations and to software systems.

As a risk assessment tool, HAZOP is often described as:

❖A brainstorming technique
❖A qualitative risk assessment tool
❖An inductive risk assessment tool,

meaning that it is a "bottom-up" risk identification approach, where success relies on the ability of the team to predict deviations based on past experiences and general subject matter expertise, but no discussion is missed as it is systematic guide word based approach.

Key Benefits

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- It is a quality assurance tool. It gives assurance to the management, process owners as well as regulatory authorities that "structured safety analysis" is carried out of the processes.

- Early identification of hazards which helps in taking proactive actions thus reducing potential losses.

- Mistakes and omissions during design stage are discovered and for every identified deviation, recommendations for improvement given form better design, operational controls and management systems.

- Team approach brings wider set of views and experience into consideration and actions recommended by the team, reflect those wider views rather than criticism of original design.

Specific Application

HAZOP is best suited for assessing hazards in facilities, equipment, and processes and is capable of assessing systems from multiple perspectives:

Design Stage:

- Assessing system design capability to meet user specifications and safety standards
- Identifying weaknesses in systems

Physical and Operational Environments :

- Assessing environment to ensure system is appropriately situated, supported, serviced, contained, etc.

Pre-commissioning / Commissioning Stage. :

- Assessing engineered controls (ex: automation), sequences of operations, procedural controls (ex: human interactions) etc.
- Assessing different operational modes – start-up, standby, normal

After Modification:

Any MOC/ revamp / de-bottlenecking / expansion / modernization / alterations – addition or deletion in processes / plants / systems

HAZOP Process

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1. Definition:
- Define scope and objectives
- Define responsibilities
- Select Team

2. Preparation :
- Plan the study
- Collect data
- Agree style of recording
- Estimate the time
- Arrange a schedule

3. Examination :
- Divide the system into parts
- Select a part and define design intent
- Identify deviation by using guide words on each element
- Identify consequences and causes
- Identify whether a significant problem exists
- Identify protection, detection, and indicating mechanisms
- Identify possible remedial/mitigating measures (optional)
- Agree actions
- Repeat for each element and then each part

4. Documentation and follow-up :
- Record the examination
- Sign off the documentation •Produce the report of the study
- Follow up that actions are implemented
- Re-study any parts of system if necessary
- Produce final output report

HAZOP Team

- **HAZOP team members:**
  - The basic team for a process plant will be:
    - Team Leader
    - Scribe or Secretary
    - Project engineer / Manager
    - Process engineer / Production / Technical Services
    - Instrumentation Engineer
    - Electrical engineer
    - Mechanical Engineer
    - HSE Engineer / Practitioner
    - Operating Staff / technicians from specific disciplines / area of department
- Depending on the actual process the team may be enhanced by:
    - Operating team leader
    - Maintenance engineer
    - Suppliers representative
    - Other specialists as appropriate

HAZOP Team Responsibilities

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HAZOP team all member - Responsibilities:

- Be active ! Everyone's contribution is important.
- Do not compete with each other.
- Be an active listener.
- Be critical in a positive way – be constructive.
- Do not put anyone on defensive.
- Be to the point – Avoid endless discussion of details.
- Be focused on "Hazard identification, cause-consequence analysis" not necessarily on finding an immediate solutions.
- Give due consideration to each activity. Avoid extremes that all the activities are extremely hazardous or having no hazard at all !!
- Stick to the overall discipline – time, schedule, agenda etc. of the meetings / sessions.

HAZOP Team Responsibilities

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HAZOP team leader - Responsibilities:

Define the scope for the analysis.

Select HAZOP team members in consultation with senior management.

Plan and prepare the study

Chair the HAZOP meetings :

Trigger the discussion using guide-words and parameters

Follow up progress according to schedule/agenda

Ensure completeness of the analysis.

HAZOP secretary- Responsibilities:

Prepare HAZOP worksheets

Record the discussion in the HAZOP meetings

Prepare draft report(s)

Consequences & Safeguards

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- While recommending the safeguards – follow typical hierarchy of risk control. (OHSAS 18001 & ISO 45001 Standards)
- In case of operational error / deviation – training and procedural solutions may not be useful, explore possibility of design solution.
- Risk assessment of all the recommendations prior to its implementation. Consider all consequences and recommended actions in relation to each other.

SEVERITY					LIKELIHOOD				
					Very Unlikely	Unlikely	Possible	Likely	Very Likely
					1	2	3	4	5
Severity	**People**	**Assets**	**Environment**	**Cost**	**Over 100 Years**	**Between 10 Year to 100 Year**	**Between 10 Year to 1 Year**	**Between 1 Month to 1 Year**	**Less than 1 Month**
Negligible (1)	First aid	Negligible damage	Negligible damage	<USD 1000	L	L	L	L	M
Slight (2)	Minor cuts or bruises First aid	Slight damage	Slight damage	USD-1,000 to 10,000	L	L	M	M	M
Moderate (3)	Serious injury	Moderate damage	Moderate damage	USD-10,000 to 1,00,000	L	M	M	H	H
High (4)	Serious Injury causing long time disability	High damage	High damage	USD-1,00,000 to 1,000,000	L	M	H	H	H
Very high (5)	One or more Fatality	Very high damage	Very high damage	USD-1 Million or above	M	H	H	H	H

	Safeguards
L	Administrative control
M	Administrative / Design control (1 layer)
H	Design control – 2 layers of protection

Sr. No.	Severity & Likelihood Combination	Risk Category
1.	1-4	Low
2.	5-12	Medium
3.	13-25	High

Consequences: 3 categories – impact on people, environment and financial loss

HAZOP Terminology

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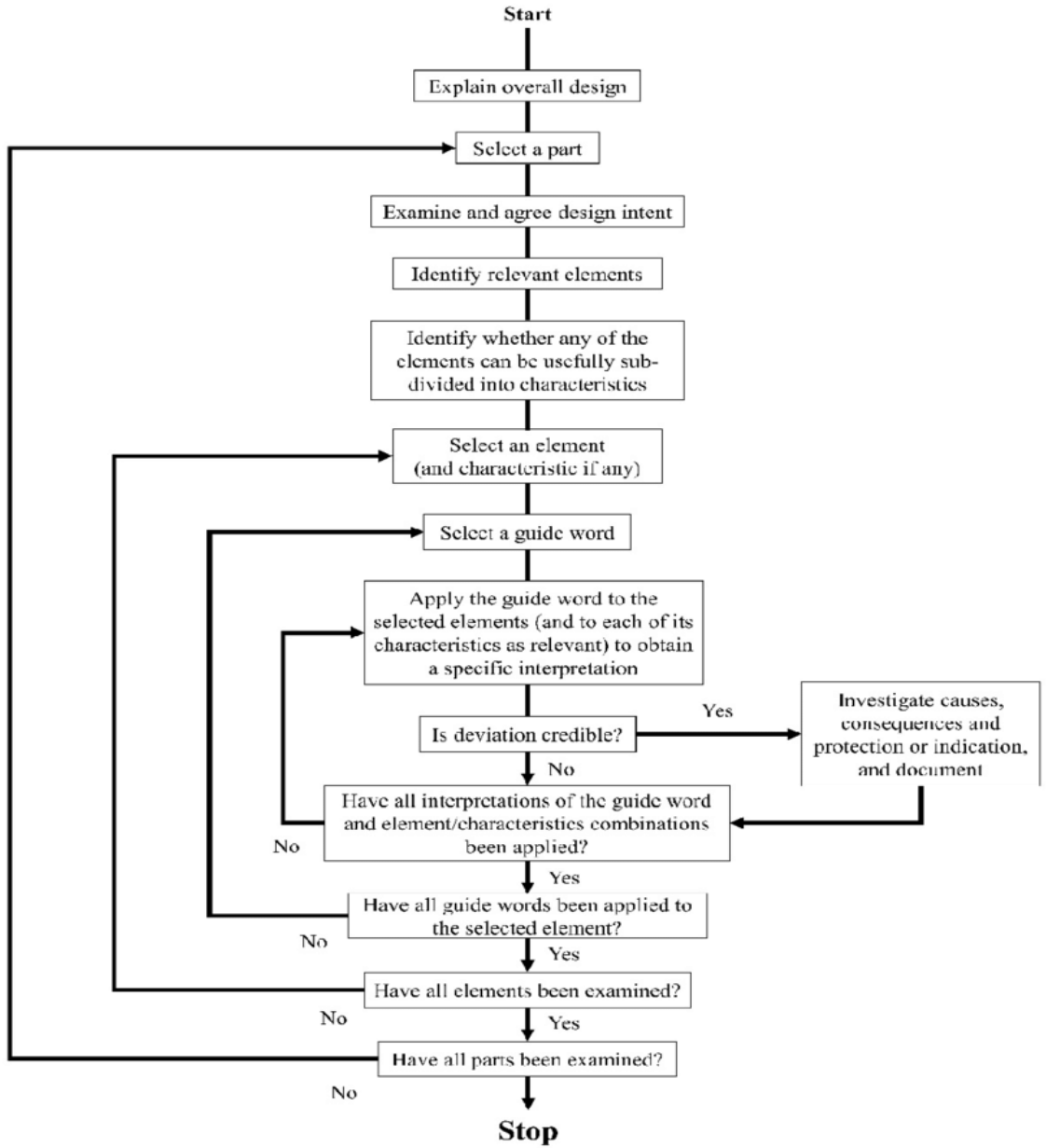
- **Characteristic -** Qualitative or quantitative property
- **Consequence -** Outcome of an event affecting objectives
- **Control -** Measure that is modifying *risk*
- **Design intent -** Designer's desired, or specified range of behaviour for properties which ensure that the item fulfills its requirements

Deviations - Variation from the intention found by applying the guide words (Guide word + Parameter = Deviation, e.g., "no flow")

- **Element -** Smaller part of a node or part under consideration study
- **Guide word -** Word or phrase which expresses and defines a specific type of deviation from a property's design intent
- **Harm -** Physical injury or damage to the health of people or damage to assets or the environment
- **Hazard -** Source of potential *harm*
- **Level of risk -** Magnitude of a *risk or combination of risks, expressed in terms of the combination of consequences and their likelihood*
- **Node or part -** Section of P & ID/Drawing/Procedure at which the process parameters are Investigated for deviations
- **Risk -** Effect of uncertainty on objectives

HAZOP Process



HAZOP Process

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1. Divide the system into sections (i.e., reactor, storage)
2. Choose a study node (i.e., line, vessel, pump, with similar process conditions)
3. Describe the design intent
4. Select a process parameter
5. Apply a guide-word
6. Determine cause(s)
7. Evaluate consequences/problems
8. Recommend action: What? When? Who?
9. Record information
10. Repeat procedure (from step 2)

If you are not sure of any causes or consequences – Get Additional Information !

HAZOP Process

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1.1 Node Name							
Deviation	Causes	Consequences	Existing Safeguards in Design	Risk Rating = Severity x Likelihood	Recommendations, if any	Action by & Target Date	Risk Rating after Recommendations = Severity x Likelihood

HAZOP Parameters

Process parameters may generally be classified into the following groups:

- Physical parameters related to input medium properties
- Physical parameters related to input medium conditions
- Physical parameters related to system dynamics
- Non-physical tangible parameters related to batch type processes

- Parameters related to system operations These parameters are not necessarily used in conjunction with guide-words:
  - Instrumentation
  - Relief
  - Start-up / shutdown
  - Maintenance
  - Safety / contingency
  - Sampling
  - Draining / venting

HAZOP Parameters

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Flow	Composition	pH
Pressure	Addition	Sequence
Temperature	Separation	Signal
Mixing	Time	Start/stop
Stirring	Phase	Operate
Transfer	Speed	Maintain
Level	Particle size	Services
Viscosity	Measure	Communication
Reaction	Control	

HAZOP Guide-words

No or not – no or zero
More - high or too much
Less – low or too low
As Well As – this and other parameter
Part of – this and partially other or partly this and other
Reverse – in opposite direction
Other than – wrong or something else out of group
Early – before time
Late – after given time
Before – in advance to given activity
After – subsequent to given activity

Example guide word interpretations for data flow and state transition diagrams

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	No	More	Less	As well as	Part of	Reverse	Other than	Early	Late	Before	After
Generic meanings	no part of the intention is achieved	a quantitative increase	a quantitative decrease	all design intent but with additional results	only some of the intention is achieved	the logical opposite of the intention	result other than original intention is achieved	relative to clock time	relative to clock time	related to order or sequence	related to order or sequence
For PES attributes of data flow and control flow	no data or control signal passed	more data is passed than expected			the information passed is incomplete (for group flows)	generally not credible	information complete but incorrect	flow of information occurs before it was intended	flow of information occurs after it was intended		
Attribute of data value for data flow diagram		value too high (within or out of bounds)	value is too low (within or out of bounds)								
Attribute of data rate for data flow diagram		the data rate is too high	the data rate is too low								
Attributes of events / actions and their timings for state transition diagrams	event does not happen or no action takes place			another event or an additional (unwanted) action takes place as well	an incomplete action is performed (not usually credible for events)		unexpected event instead of that anticipated or an incorrect action takes place	event / action takes place before it is expected	event / action takes place after it is expected	happens before another event or action that is expected to precede it	happens after another event or action that is expected to come after it
Attribute of response time (with timing diagram)	never happens (time infinite)	time longer than required	time shorter than required	synchronisation with other I/O gives problems			time is variable				

Review Meeting

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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

HAZOP Results

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- **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 Process KPIs

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During HAZOP:

Number of key processes covered.
Completion of HAZOP Study as per schedule.
Number of hazards identified and validated for corrective action and preventive action.
Number of validated recommendations.

After Conducting HAZOP:

Number of validated recommendations implemented as targeted.
Number of process safety related incident / work injury / abnormality after conducting Hazop and implementing recommendations.

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Questions?

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Thank You!

xZxxxxxxxxxxx