

HAZARD AND OPERABILITY (HAZOP) REVIEW PROCEDURE

Approved By:
Planning & Development Director



ADWEA HSE PROCEDURE MANUAL

**HAZARD AND OPERABILITY (HAZOP)
REVIEW PROCEDURE**

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HAZARD AND OPERABILITY (HAZOP) REVIEW PROCEDURE

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1. OBJECTIVE

The objective of the HAZOP Review Procedure is to provide guidelines for carrying out rigorous and systematic evaluation of associated process system with respect to safety of operations, potential hazards with foreseeable upsetting conditions, and operability and conformity with codes of practices in designing process plant/modifications.

2. SCOPE

This procedure is applicable to all studies, projects and engineering modifications (of existing facilities to a plant) where a HAZOP has been identified as a requirement.

The Company project execution strategy for engineering shall address whether HAZOP is required for a particular project/study. However, the following general guide lines may be considered while establishing of HAZOP:

- HAZOP for new grass root project.
- HAZOP for Engineering major modification.
- Project Engineer or Study Coordinator in consultation with ADWEA HSE SPECIALIST (for projects/modifications handled by ADWEA Project Directorate) or the HSE Department in the Group Companies (if the project/modification is handled directly by the Group Company) shall judge the requirement of HAZOP/Process Safety Review prior to commencement of project.
- Company Project Management shall define within the HAZOP requirement, its schedule and the requirement of third party HAZOP Team Chairman, etc.

It is of prime importance that information/drawings used during the HAZOP reflect actual facilities (as built) and that the new facility drawings represent a high level of accurate/checked details.

3. TERMINOLOGY :

- **Hazard:** Source, situations or act with a potential for harm in terms of human injury or ill health, or combination of these
- **Policy:** Overall intentions and direction of an organization related to its HSE Performance as formally expressed by top management.
- **Procedure:** Specified way to carry out an activity or a process.
- **Record:** Document stating results achieved or providing evidence of activity performed
- **Document:** Information and its supporting medium (paper, magnetic, electronic or optical computer disc, photograph or master sample, or combination thereof).

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4. POLICY

It is ADWEA's and its Group Companies policy to:

- Carry out the HAZOP review in accordance with agreed documented procedure.
- Ensure a consistent application of HAZOP technique, which will result in a fully documented and repeatable review.
- Ensure that designs originating from in-house engineering or external Engineer are safe to commission, start up, operate, shut down and risks are reduced to minimum and well controlled.
- Ensure that Process and Instrumentation Diagrams (P&IDs) reflect the requirements of a safe operation, prior to completion of detailed design.

5. PROCEDURE

5.1 Responsibilities Of HAZOP Review Team:

The role of the HAZOP Team is to identify faults as "findings" and not to attempt to design solutions on the spot, see section 4.6.5. Minor drafting errors may be noted (marked on the master copy of the P&ID for drafting correction) during the HAZOP rather than raised as an action item.

To be effective, the HAZOP review must involve the Design Engineers responsible for P&IDs input and development. The Team needs to be multi-disciplined with authority to make on-the-spot decisions with regard to the acceptability of the design and the category of actions.

The Chairman is responsible for seeing that a thorough study report is produced, and guiding the Team to their decisions, based on his experience of similar systems on other projects. However, the Chairman's involvement does not alter the Design Engineers responsibility for safe design and operability of the plant.

5.2 Number Of Reviews:

The number of HAZOP reviews may depend on the scope and content of each project. However, the following general guide lines may be considered for the number of HAZOP reviews:

- At least two times HAZOP (during basic and detailed engineering) for new grass root project.
- Engineering major modification wherever potential hazards are involved either normal or upsetting condition.

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5.3 Team Composition:

HAZOP Review Chairman

The HAZOP Chairman should preferably be either independent of the project design team or third party consultant (for EPC project), should be expert in HAZOP techniques, be Senior engineer either already chaired for at least one similar type of HAZOP or active member for at least 4 times for similar type of HAZOP review, shall be capable and skilled in leading the team.

HAZOP Review Team

The core of the Review Team is normally consists of the following discipline Engineers:

- Process or Water Desalination engineer (as applicable and available)
- HSE engineer
- Mechanical engineer
- Electrical/Instrument engineer
- Representation from the Operations
- Secretary

Other personnel like Corrosion Specialist, Maintenance engineer may be required to attend on an on-call basis.

Attendance by Licenser/Equipment Supplier

Where third party technology is used, Company shall invite a suitably qualified and experienced engineer from the Licenser and/or Equipment Supplier and advise them of the schedule and place of the review four weeks in advance of the meetings.

5.4 Roles and Responsibilities of Team Members

The roles and responsibilities of HAZOP Chairman, Project Engineer/Study Coordinator, Secretary and other Team Members are as follows:

HAZOP Chairman:

- To plan the detailed HAZOP schedule and agenda.
- To select line systems, vessels and units as study nodes and define their scopes on the master P&IDs as detailed in section 4.6.3.
- To define the scope of interfaces which are to be reviewed in liaison with the Project Engineer.
- To instruct the HAZOP secretary for preparing HAZOP review Node Lists.
- To lead and facilitate HAZOP review meetings using guide words.
- To manage the progress of HAZOP reviews.

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- To instruct the HAZOP secretary for recording the review findings in the HAZOP meetings and preparing HAZOP action sheets.
- To lead review meetings for HAZOP worksheets and returned HAZOP action sheets.
- To instruct secretary for the preparation of HAZOP review report after HAZOP review.
- To maintain HAZOP review reports recording and reviewing responses to HAZOP actions up to the completion of the project.
- To describe HAZOP guide words to Team Members.

Project Engineer/Study Coordinator

- To organize HAZOP review Team.
- To interface with Design Engineers to decide the scope of work for review Team.
- To plan schedules of HAZOP reviews and inform concerned parties to attend.
- To invite Licensor's and/or Equipment Supplier's Representative to the HAZOP reviews, as necessary.
- To prepare facilities for HAZOP reviews such as meeting rooms, personal computer, stationary etc.
- To prepare P&IDs drawings and reference documents in advance to be used by the team members.
- To explain purpose, function, major operating conditions, etc. of the unit and process systems under review.
- To follow up implementation of agreed HAZOP actions.
- To maintain HAZOP review reports.
- To distribute HAZOP action sheets to concerned parties for taking actions and receive them for review.
- To prepare and issue for the concerned parties approval, a list of design changes after HAZOP reviews are complete.

HAZOP Secretary

- To prepare HAZOP review Node Lists.
- To record HAZOP review findings by using HAZOP software if available.
- To prepare HAZOP review action sheets for action items which require separate study or investigation outside the review meeting.
- To prepare prints of HAZOP worksheets and returned HAZOP action sheets for daily review.
- To prepare and maintain HAZOP review reports.

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5.5 Pre-Review Meeting

If required, Chairman shall hold a pre-review meeting in advance of commencing the HAZOP review to make sure that there is consistency in the review techniques, procedures and resultant review reports among review team. An overview of the HAZOP procedure indicating scope and purpose of the HAZOP, Node design intentions, administrative arrangements etc. This meeting to be attended by the Chairman, Project Engineer and Secretary.

5.6 Review Technique

5.6.1 HAZOP Guide Words

The HAZOP technique relies on the systematic application of guide words, to the various systems comprising the P&IDs. The list of guide words is contained in (Attachment 1). For electrical distribution and electronic control systems, reference can be made to attachment -2 as a proposed deviation guidelines.

The guide words list is in two parts. The first set of guide words is applied to the P&IDs line system. The second set based on "Other Than" is applied at the end of the unit or facility review to assess the overall unit or specific vessel as appropriate. The selection of vessel or unit approach will be determined by the HAZOP Chairman on a unit by unit basis.

5.6.2 Study Nodes

The type of study Nodes for a unit or a facility are basically as follows:

- Line Systems
- Major Vessels
- Unit or Facility as a whole

A line system does not include the upstream and/or downstream vessel but may include pump, filter, heat exchanger, control valve, etc. and its scope may be basically defined as a line from a vessel to another vessel.

In cases where two or more lines join together, there may be two ways for review as shown below, this also applies on cases where a line branches into two or more lines:

- To review each line separately from its upstream vessel to the downstream vessel.
- To review all lines as a whole from their upstream vessels to the downstream vessel.

The scope of study Node will be decided by the HAZOP Chairman on a case by case basis at or in advance of the meeting. The following is a reference criteria for the decision:

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- Line system to be selected as a study node in which a fluid is flowing continuously or intermittently under normal operation.
- Line system in which no fluid is flowing under normal operation, such as vents, drains, purge connections, sampling connections, etc., are not regarded as study nodes but are included in the relevant major line specified as a study node.
- Interconnecting lines and utility distribution headers are not regarded as an independent study node but are included in the relevant process line or utility line considered as study node.
- Each study node shall be identified by a unique reference number to be consistent with unit number and listed in the HAZOP review node list (see Attachment 3).

5.6.3 Use of HAZOP Master P&IDs

The HAZOP Master P&IDs are to be utilized in the following manner:

- The particular system under review (study node) shall be identified by marking the P&ID with a series of colored dashes. Different colors may be used for each node.
- Each study node shall be cross referenced to the HAZOP worksheet by clearly marking the HAZOP table number on the P&ID in the most appropriate location.
- Once the system review is completed, the colored dashes shall be made continuous.
- Agreed modifications to the P&ID which do not form part of the HAZOP record shall be identified by clearly marking the P&ID, e.g. drafting errors as noted in section 4.1; minor modifications not impinging on design, etc.

The marked-up HAZOP Master P&ID form a part of the HAZOP Review Report (refer to section 5).

5.6.4 Recording of Review Results

Either a PC based HAZOP software or manual filling of worksheet (Attachment 4) will be used to record the review findings.

To avoid the production of excessive documentation and loss of time during the review meeting, the HAZOP review worksheet need only be filled when actions are to be recorded. Where the review team is satisfied that no problem exists under a particular parameter, then no record of the decision is required.

If there are no actions on a particular node, then "no action required" shall be entered on the worksheet.

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5.6.5 Review Session Procedure

In general, Chairman will give an introduction for the purpose of the meeting, members introduction, HAZOP procedure, administration, etc., Project engineer shall explain the brief scope of the project/review.

HAZOP reviews are to be scheduled on a Node by Node basis. Consequently, team composition may change for each separate Node.

- At the start of the review sessions, (assisted by the Licensor representative, as applicable) the project engineer shall describe the process function briefly to the review team. Thereafter, during each new session he should also describe the specific system being reviewed.
- The Chairman leads the review by applying individual guide words for each system.
- Where a potential hazard identified, remedial action may be required depending on the likelihood of the event and its consequences.
- If remedial action is required and an immediate solution is available and acceptable to the team, the P&ID shall be marked up accordingly and a set of the review findings, i.e. Guide word, Process deviation, Possible cause, Consequences, Existing safeguard, Action required, Action number and Action By shall be recorded in the HAZOP worksheet.
- Where solutions are unlikely to be derived without a technical evaluation, the Chairman shall refer the problem for a separate assessment. Discussion of problems in the meeting should be kept to a minimum. A set of the review findings including the problem to be solved shall also be recorded in the worksheet.
- Where a system is reviewed and no actions have been generated, a statement to the effect shall be recorded.

5.6.6 Response to Recommended Actions

For each recommended action which is required to be separately solved outside the meeting, a HAZOP review action sheet (see Attachment 5) shall be prepared by the secretary and distributed to the responsible person for action.

5.6.7 Timing of the HAZOP Review

HAZOP should be held when P&IDs have attained a status (applicable to both basic or detailed engineering) where:

- P&IDs are well developed
- Vendor's drawings/data are available

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- Major equipment is well defined
- Major process lines have been sized and specified
- Control and Emergency Shutdown (ESD) philosophy is specified

5.6.8 Facilities For HAZOP Review

A dedicated room which can take about 10 persons shall be available for the review team during the scheduled period.

A personal computer shall be allocated for the review room, for recording actions, etc. in case customized software is used.

The HAZOP Chairman should use full size (A1) prints as the Master P&IDs. A set of A3 size P&IDs should be issued to each team member in advance.

To assist in the review, reference documentation should be available. Typically this should include:

- Plot Plans
- Process Flow Diagrams (PFDs)
- Material balance
- Process specifications/equipment process data sheets
- Material hazards data sheet
- Process control philosophy document
- Cause and effect charts
- Instrumentation schedule of alarms and trips
- Line Lists
- Material of construction
- Area classification documents
- Isolation philosophy
- Electrical line diagrams

Note: If full details of instrumentation and control systems cannot be shown on P&IDs, then additional documentation such as Trip descriptions, ESD Logic Diagrams, etc., shall be generated to show this information.

6. HAZOP REVIEW REPORT

It is important to realize that a HAZOP review is not complete until all actions have been resolved and the final report is issued.

A HAZOP review report (draft) in which the following documents are compiled shall be issued for team members review as soon as the review is complete:

- HAZOP review report front sheet.
- Introduction
- HAZOP review scope



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- Chairman's report
- Review summary
- References
- HAZOP Review Worksheets (Attachment 4)
- HAZOP Review Action Sheets (Attachment 5)
- HAZOP Master P&IDs

In the event of major design changes, it may be necessary to schedule a "re-HAZOP" to ensure that the design change has not introduced new hazards.

Once all actions have been completed, or decisions finalized, a Final Review Report will be compiled by the Project Engineer, and approved by the HAZOP Chairman, prior issuing to the concerned parties.

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Attachment 1

LIST OF GUIDE WORDS

Parameter	Approved List	Example Causes	Application
FLOW	No Flow	Wrong routing, incorrect slip plate, incorrectly fitted non return valves, burst pipes, large leak, equipment failure (control valve or isolation valve, pump, vessel, etc.), incorrect pressure differential, isolation in error, etc.	System
	Reverse Flow	Defective non return valve, siphon effect, incorrect differential pressure, two way flow, emergency venting, incorrect routing, pump reversed, etc.	System
	More Flow	Increased pumping capacity, increased suction pressure, reduced delivery head, exchanger tube leak, restriction orifice plates deleted, control faults, surging, valve failed open, pump gland leaks, etc.	System
	Less Flow	Line blockage, filter blockage, fouling of vessels, valves, defective pump, etc.	System
Temperature	More Temperature	Higher than normal ambient temperature, fouled or failed exchanger tube, fire situation, cooling water failure, heater control failure, etc.	System
	Less Temperature	Ambient conditions, reducing pressure, fouled or failed exchanger tubes, loss of heating, etc.	System
Pressure	More Pressure	Surge problems, leakage from connected higher pressure system, thermal overpressure, positive displacement pump, failed open PCV, etc.	System
	Less pressure	Generation of vacuum conditions, operation with reduced pressure, condensation, restricted pump/compressor suction line, undetected leak, vessel drainage, etc.	System

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Attachment 1

LIST OF GUIDE WORDS

Parameter	Approved List	Example Causes	Application
Level	More	Outlet isolated or blocked, inflow greater than outflow, control failure, faulty level measurement, etc.	Vessel
	Less	Inlet flow stops, leak, outflow is greater than inflow, control failure, faulty level measurement, draining of vessel, etc.	Vessel
Viscosity	More viscosity	Incorrect material specification, incorrect temperature, etc.	System
	Less viscosity	Incorrect material specification, incorrect temperature, etc.	System
System Composition	Part of	Passing isolation valve, leaking exchanger tube, phase change, incorrect feed stock/specification, inadequate quality control, etc.	System
	More than	Leaking exchanger tube or isolation valve, incorrect operation of system, interconnected systems, effect of corrosion, wrong additives, wrong material, ingress of air, shutdown and start-up conditions, etc.	System
Other	Activities or conditions other than or additional to the design intent or normal operation	Start-up and shut down of plant, testing and inspection, commissioning, decommissioning, weather, physical impact, containment loss and consequences, purging, washing out, toxicity, etc.	System
	Relief	Relief philosophy, type of relief device and reliability, relief valve discharge location, pollution implications, etc.	System

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Attachment 1

LIST OF GUIDE WORDS

Parameter	Approved List	Example Causes	Application
Other	Control	Control philosophy, location of instruments, response time, set points of alarms & trips, time available for operator intervention, alarm & trip testing, fire protection, panel arrangement and location, auto/manual facility & human errors, etc.	System
	Sampling	Sampling procedure, time for analysis result, calibration of automatic samplers and reliability, accuracy of representative sample, etc.	System/unit
	Corrosion / erosion	Cathodic protection arrangements, internal/external corrosion protection, engineering specifications, stress corrosion cracking, fluid velocities, etc.	Vessel/unit
	Service failure	Failure of instrument air, steam, nitrogen, cooling water, hydraulic power, electric power, heating and venting systems, computers, etc.	Vessel/unit
	Maintenance	System drainage, isolate of equipment, purging, cleaning, access, pressure testing, work permit system, condition monitoring, etc.	Vessel/unit
	Leakage	Tube rupture	Vessel/unit
	Ignition / static	Earthing arrangements, insulated vessels/equipment, low conductance fluids, splash filling of vessels, static electricity, hot surface, auto ignition, etc.	Vessel/unit
	Spare equipment	Installed/non-installed spare equipment, availability of spares, modified specification, storage of spares, etc.	Vessel/unit
	HSE	Fire & gas detection system/alarm, emergency shutdown arrangements, fire fighting response, emergency plans, security arrangements, knowledge of hazard of process and materials, first aid and medical resources, effluent/discharge disposal, emissions, waste, noise, etc.	Vessel/unit

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Attachment 2

**PROPOSED HAZOP DEVIATIONS FOR ELECTRICAL
DISTRIBUTION SYSTEMS**

DEVIATION	TYPICAL PROBLEM
No Current	Distribution board component failure; connection failure between components; faults in overload trip system; isolation in error (human error); lighting failure
Reverse Current	Wrong connection
Increased Current	Short circuit; leakage to ground; required load in excess of supply capacity or in excess of design requirement; overload settings too high; Plant being operated in excess of design parameters
Reduced Current	Faulty load shedding arrangements; reduced generator capacity
Increased Voltage	Variable loading; electrical storms (lightning); defective transformer or voltage control
Reduced Voltage	Voltage dip; defective contacts
Increased Temperature	Resistance to the fire situation; effect of ambient temperature changes; overheating of distribution board components; detection of electrical fires; cable routing; smoke detection
Reduced Temperature	Winter conditions; failure of HVAC equipment
Contamination	Ingress of flammable atmosphere into electrical distribution rooms; internal damage, by insect, corrosive material,
Instrument	Set points for maximum overload condition (flow tested and adjusted); load shedding arrangements (flow control); ground leakage detection; effect of temperature change on electrical components
Corrosion	Corrosion resistance of equipment
Abnormal Operation	Emergency power distribution arrangements
Service Failure	Electrical supply failure; failure of any associated services
Maintenance	Maintenance isolation procedures; work permit system
Safety	Fire protection system; fire fighting; personnel protection; area classification

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Attachment 2

**PROPOSED HAZOP DEVIATIONS FOR ELECTRONIC
CONTROL SYSTEMS**

DEVIATION	TYPICAL PROBLEM
Design Basis	Reasons for proposed (or existing) control arrangements; system philosophy and capacity; etc
No Current	Electronic component failure; connection failure between components; failure of control signal (not received); control switched to manual; failure of power source; mechanical damage to cables; failed fuse or overload trip; etc
Reverse Current	Loop connections not correct; reverse intention achieved (high reading transmits signal for low reading etc); etc
Increased Current	Short circuit; leakage to earth; Location of excess current protection (fuse or fusible link); control valves operates without initiating signal; control switched to manual; etc
Reduced Current	Feed back of control valve "status" defective (limit switch faults); initiating signal transmitted at wrong time (faulty limit switch or set incorrectly); etc
Increased Voltage	Increased voltage (defective voltage control unit); electrical overload protection philosophy; location of equipment and cables; etc
Reduced Voltage	Reduced voltage; voltage "dip" protection and consequences; corroded contacts; etc
Increased Temperature	Resistance to the fire situation; overload electrical components; etc
Reduced Temperature	Winter conditions; reliability of HVAC system; etc
Contamination	External magnetic fields; external signals from communication transmitters received b electronic trip amplifiers; ingress of moisture, dust, liquids, etc;
High Current Protecton	Overload protection (location and type of fuse); explosion vents to prevent over-pressure damage to electronic equipment;
Instruments	Control philosophy; software error detection; trip and alarm testing; etc
Sampling	Calibration of analysis instrumentation; operator action in "off spec" situation; etc
Corrosion	Resistance of electronic components to internal, external, galvanic corrosion;

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Abnormal Operation	Start-up; normal shutdown; abnormal shutdown; etc
Service Failure	Failure of electrical power to instruments; HVAC failure; fail safe mode of control loops due to electronic component failures; etc
Maintenance	Fault diagnosis; manual control arrangement during maintenance, circuit testing; calibration; etc
Spares	Availability
Static	Earthing (grounding arrangements); area classification of electronic components and wiring; grounding of equipment and test frequencies;
Safety	Passive/active fire protection of electronic equipment; fire detection systems; etc



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Attachment 3

HAZOP REVIEW NODE LIST

Project Name:.....
Project No. :.....
Date :.....

Node No.	Description	Drawing No.	From	To	Notes

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Attachment 4

HAZOP REVIEW WORK SHEET

HAZOP REVIEW WORKSHEET

Project :
 Project No. :
 Node No. :
 Location :
 Drawing No. :
 Line / Equipment No. :

Design Intention :
 Date :
 Time :
 Revision :

Design Temperature :
 Design Pressure :
 Design Flowrate :

Guide Word	Process Deviation	Possible Causes of Deviation	Possible Consequences	Existing Safeguards	Recommended Action	Action Number	Action By



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Attachment 5

HAZOP REVIEW ACTION SHEET

Project Name :

Unit :

Report No. :

Action Sheet Ref. No. :

Date of Issue :

Revision No. :

Study Node No. :	Recommendation No. :
Responder :	Due Date :
Recommendations:	
Response:	
Date:	Signature:
Comment By Project Engineer:	
Date:	Signature:
Comment By Chairman:	
Date:	Signature:
Action Complete Yes <input type="checkbox"/> No <input type="checkbox"/>	