HAZOP Parameters, Deviations, and Possible Causes

The following are typical guide-word parameter, deviations, and possible causes that are used in HAZOP reviews. They are based on the standard HAZOP deviation matrix shown below.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>More</th>
<th>Less</th>
<th>None</th>
<th>Reverse</th>
<th>Partial</th>
<th>As well as</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>High flow</td>
<td>Low flow</td>
<td>No flow</td>
<td>Back flow</td>
<td>Wrong concentration</td>
<td>Contaminants</td>
<td>Wrong material</td>
</tr>
<tr>
<td>Temperature</td>
<td>High temperature</td>
<td>Low temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>High pressure</td>
<td>Low pressure</td>
<td>No level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>High level</td>
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<td>No level</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

This listing is by no means exhaustive and each review should be supplemented or tailored to meet the needs of a particular facility.

PARAMETERS, DEVIATION, AND POSSIBLE CAUSES

Flow

High
- Increased pumping capacity
- Increased suction pressure
- Reduced delivery head
- Greater fluid density
- Exchanger tube leaks
- Restriction orifice plates not installed
- Cross connection of systems
- Control faults
- Control valve trim changed
- Running multiple pumps
Less
- Restriction
- Wrong routing
- Filter blockage
- Defective pump(s)
- Fouling of vessel(s), valves, orifice plates
- Density or viscosity changes
- Cavitation
- Drain leaking
- Valve not fully open

None
- Wrong routing
- Blockage
- Incorrect slip plate
- One-way (check) valve in backwards
- Pipe or vessel rupture
- Large leak
- Equipment failure
- Isolation in error
- Incorrect pressure differential
- Gas locking

Reverse
- Defective one-way (check) valve
- Siphon effect
- Incorrect pressure differential
- Two-way flow
- Emergency venting
- Incorrect operation
- Inline spare equipment
- Pump failure
- Pump reversed

Level

High
- Outlet isolated or blocked
- Inflow greater than outflow control failure
- Faulty level measurement
HAZOP Parameters, Deviations, and Possible Causes

- Gravity liquid balancing
- Flooding
- Pressure surges
- Corrosion
- Sludge

Low
- Inlet flow stops
- Leak
- Outflow greater than inflow
- Control failure
- Faulty level measurement
- Draining of vessel
- Flooding
- Pressure surges
- Corrosion
- Sludge

Pressure

High
- Surge problems
- Connection to high pressure
- Gas (surge) breakthrough
- Inadequate volume of vents
- Incorrect vent set pressure for vents
- Relief valves isolated
- Thermal overpressure
- Positive displacement pumps
- Failed open PCV
- Boiling
- Freezing
- Chemical breakdown
- Scaling
- Foaming
- Condensation
- Sedimentation
- Gas release
- Priming
- Exploding
• Imploding
• External fire
• Weather conditions
• Hammer
• Changes in viscosity/density

Low
• Generation of vacuum conditions
• Condensation
• Gas dissolving in liquid
• Restricted pump/compressor line
• Undetected leakage
• Vessel drainage
• Blockage of blanket gas regulating valve
• Boiling
• Cavitation
• Freezing
• Chemical breakdown
• Flashing
• Sedimentation
• Scaling
• Foaming
• Gas release
• Priming
• Exploding
• Imploding
• Fire conditions
• Weather conditions
• Changes in viscosity/density

Temperature

High
• Ambient conditions
• Fouled or failed exchanger tubes
• Fire situation
• Cooling water failure
• Defective control valve
• Heater control failure
• Internal fires
• Reaction control failures
• Heating medium leak into process
• Faulty instrumentation and control

*Low*
• Ambient conditions
• Reducing pressure
• Fouled or failed exchanger tubes
• Loss of heating
• Depressurization of liquefied gas—Joule Thompson effect
• Faulty instrumentation and control

*Part of*

*Concentration wrong*
• Leaking isolation valves
• Leaking exchanger tubes
• Phase change
• Incorrect feedstock specification
• Process control upset
• Reaction byproducts
• Ingress of water, steam, fuel, lubricants, corrosion products from high-pressure system
• Gas entrainment

*As well as*

*Contaminants*
• Leaking exchanger tubes
• Leaking isolation valves
• Incorrect operation of system
• Interconnected systems
• Wrong additives
• Ingress of air: shutdown and start-up conditions
• Elevation changes and fluid velocities
• Ingress of water, steam, fuel, lubricants, corrosion
• Products from high-pressure system
• Gas entrainment
• Feed stream impurities (e.g., mercury, \( \text{H}_2\text{S}, \text{CO}_2 \))
Other than

Wrong material
• Incorrect or off-specification feedstock
• Incorrect operation
• Wrong material delivered

Viscosity

More
• Incorrect material or composition
• Incorrect temperature
• High solids concentration
• Settling of slurries

Less
• Incorrect material or composition
• Incorrect temperature
• Solvent flushing

Relief system

• Relief philosophy (process and fire)
• Type of relief device and reliability
• Relief valve discharge location
• Pollution implications
• Two-phase flow
• Low capacity (inlet and outlet)

Corrosion/erosion

• Cathodic protection arrangements (internal and external)
• Coating applications
• Corrosion monitoring methods and frequencies
• Materials specification
• Zinc embrittlement
• Stress corrosion cracking
• Fluid velocities
• Sour service (e.g., H₂S, mercury)
• Riser splash zone

Service failures

• Instrument air
• Steam
HAZOP Parameters, Deviations, and Possible Causes

- Nitrogen
- Cooling water
- Hydraulic power
- Electric power
- Water supply
- Telecommunications
- PLCs/computers
- HVAC
- Fire protection (detection and suppression)

**Abnormal operation**
- Purging
- Flushing
- Start-up
- Normal shutdown
- Emergency shutdown
- Emergency operations
- Inspection of operating machines
- Guarding of machinery

**Maintenance/procedures**
- Isolation philosophy
- Drainage
- Purging
- Cleaning
- Drying
- Access
- Rescue plan
- Training
- Pressure testing
- Work permit system
- Condition monitoring
- Lift and manual handling

**Static**
- Grounding arrangements
- Insulated vessels
- Low conductance fluids
- Splash filling of vessels
• Insulated strainers and valve components
• Dust generation
• Powder handling
• Electrical classification
• Flame arrestors
• Hot work
• Hot surfaces
• Auto-ignition or pyrophoric materials

Spare equipment
• Installed or not installed
• Availability of spares
• Modified specifications
• Storage of spares
• Catalog of spares

Sampling/procedures
• Sampling procedure
• Time for analysis results
• Calibration of automatic samplers
• Reliability and accuracy of representative sample
• Diagnosis of results

Time
• Too long
• Too short
• Wrong time

Action
• Overkill
• Underestimated
• None
• Reverse
• Incomplete
• Knock-on
• Wrong action

Information
• Confusing
• Inadequate
HAZOP Parameters, Deviations, and Possible Causes

- Missing
- Misinterpreted
- Partial
- Stress
- Wrong information

**Sequence**
- Operation too early
- Operation too late
- Operation left out
- Operation performed backwards
- Operation not completed
- Supplemental action taken
- Wrong action in operation

**Safety systems**
- Fire and gas detection and alarms
- Emergency shutdown (ESD) arrangements
- Fire fighting response
- Emergency training
- TLVs of process materials and method of detection
- First aid/medical resources
- Vapor and effluent disposal
- Testing of safety equipment
- Compliance with local and national regulations

**Global**
- Layout and arrangement
- Weather (temperature, humidity, flooding, winds, sandstorm, blizzards, and so on)
- Geological or seismic
- Human factors (labeling, identification, access, instructions, training, qualifications, and so on)
- Fire and explosion
- Adjacent facility exposures