CHEMICAL ENGINEERING DESIGN & SAFETY

CHE 4253

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HAZOP Studies

HAZOP

Hazard and Operability Studies

- Identifies Hazards Systematically (based on malfunctions)
- Does not address Risk (probability can be high or very low)
- Addresses Consequences (harmless or harmful).
- Proposes Actions (Design and/or Operational)

HAZOP

Hazard and Operability Studies

- Based on analyzing one equipment at a time.
- Describes Consequences of malfunction and proposes Action(s) to be taken by identifying Deviations and their Causes.
- Based on using guide words applied to parameters.

HAZOP

Hazard and Operability Studies

Guide Word
NO OR NOT
MORE
LESS
AS WELL AS
PART OF
REVERSE
OTHER THAN / INSTEAD
EARLY
LATE
BEFORE
AFTER

HAZOP

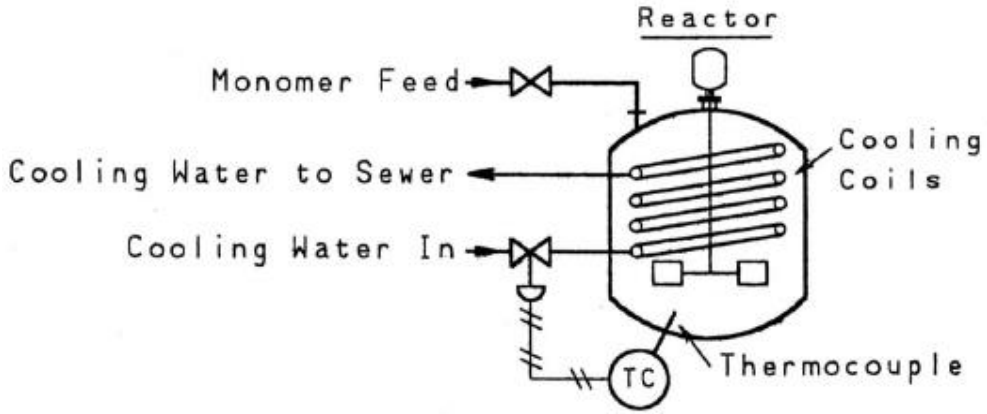
Hazard and Operability Studies

Parameter
Flow
Pressure
Temperature
Level
Time
Agitation
Reaction
Start-up / Shut-down
Draining / Venting
Inertising
Utility failure (instrument air, power)
DCS failure [b]
Maintenance
Vibrations

HAZOP

EXAMPLE

- Consider a batch reactor. We will show the HAZOP Analysis for the cooling system only.



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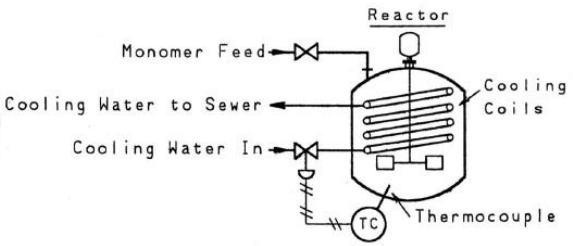
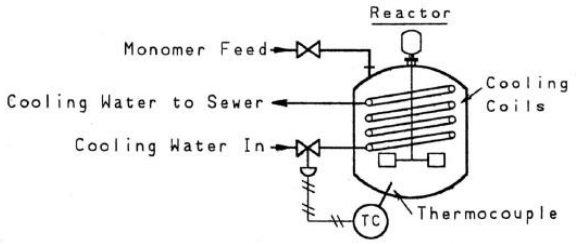
EXAMPLE

Guide word	Deviation	Possible causes	Consequences	Action
NO	No cooling	1. Control valve fails closed 2. Plugged cooling line 3. Cooling water service failure 4. Controller fails and closes valve. 5. Air pressure to drive valve fails, closing valve	1. Temperature increase in reactor 2. Possible thermal runaway	1. Install back-up control valves, or manual bypass valve. 2. Install filters to prevent debris from entering line 3. Install back-up cooling water source 4. Install back-up controller 5. Install control valve that fails open 6. Install high temperature alarm to alert operator 7. Install high temperature emergency shutdown 8. Install cooling water flow meter and low flow alarm



HAZOP

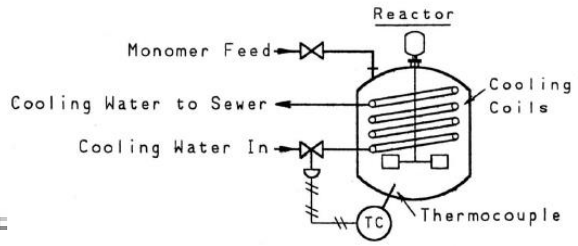
EXAMPLE



MORE	More cooling flow	1. Control valve fails to open 2. Controller fails and opens valve	1. Reactor cools, reactant builds-up, possible runaway on heating	1. Instruct operato on procedure
LESS	Less cooling flow	1. Control valve fails to respond 2. Partially plugged cooling line 3. Partial water source failure	1. Covered under "NO"	1. Covered under "NO"
AS WELL AS	Cooling water in reactor	Leak in cooling coils, pressure in reactor less than pressure in coils	1. Dilution of contents 2. Product ruined 3. Overfilling of reactor	1. Install high level and/or pressure alarm 2. Install proper relief 3. Check maintenance procedure and schedule
AS WELL AS	Reactor product in coils	Leak in coils with reactor pressure greater than coil pressure	1. Product lost thru coils 2. Loss of product yield 3. Reduction in cooling function 4. Possible contamination of water	1. Check maintenance procedure and schedules 2. Install upstream check valve in cooling water source

HAZOP

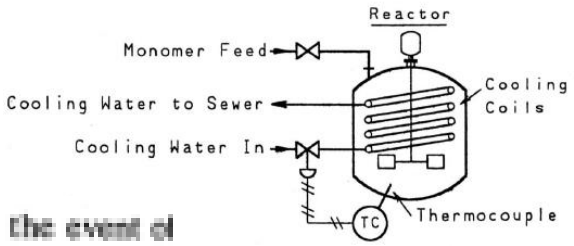
EXAMPLE



PART OF	Partial cooling flow	Covered under "LESS COOLING FLOW"		
REVERSE	Reverse cooling flow	1. Failure of water source resulting in backward flow 2. Backflow due to backpressure	1. Improper cooling, possible runaway	1. Install check valve in cooling water line 2. Install high temperature alarm to alert operator
OTHER THAN	Another material besides cooling water	1. Water source contaminated 2. Backflow from sewer	1. Possible loss of cooling with possible runaway	1. Isolation of cooling water source 2. Install check valve to prevent reverse flow 3. Install high temperature alarm

HAZOP

EXAMPLE



- Installation of a high temperature alarm to alert the operator in the event of cooling function loss.
- Installation of a high temperature shutdown system. This system would automatically shutdown the process in the event of a high reactor temperature. The shutdown temperature would be higher than the alarm temperature to provide the operator with the opportunity to restore cooling before the reactor is shutdown.
- Installation of a check valve in the cooling line to prevent reverse flow. A check valve could be installed both before and after the reactor to prevent the reactor contents from flowing upstream and to prevent the backflow in the event of a leak in the coils.
- Periodically inspect the cooling coil to insure its integrity.
- Study of the cooling water source to consider possible contamination and interruption of supply.
- Installation of a cooling water flow meter and low flow alarm. This will provide an immediate indication of cooling loss.