Effective HAZOP execution & HAZOP Typicals

Antwerp Sept 2022 – Tijs Koerts (EPSC)

EPSC Work Group
HAZOP Efficiency

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THE PROCESS SAFETY NETWORK

HAZOP remains important
HAZOP execution is a competency
Gaining 50% time

- Team
- Rhythm
- Node
- Consequence
- Recommendation
- Knowledge
- Documentation

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HAZOP Team

- HAZOP execution is a skill

- Experience & Competency (HAZOP is not a training)
- Small team: Operation, Process & Design, Maintenance

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Rhythm in the HAZOP process

- Only talk about: cause – consequence – barriers
- Stick together as team while discussing these

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Consequence

- Nobody knows what will happen

- Do not discuss process upset details
- Focus on LOPC.

- Consequence of an LOC are often difficult to estimate, just mention the event class (C, D or E event). (LWC, Fatality, Catastrophe)
- Eventually be conservative and do a calculation later (e.g. in cases where the measures become very expensive).

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Nodes

- What is a node?
- Cause is in the node; Consequence can be anywhere

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Guidewords

- Effective checklists – suitable for the unit

Recommendation

- Do we lack safety? → Yes/No
- Not Designing the solution

Knowledge increases efficiency

- Reading the P&ID
- Understand main scenarios of equipment → HAZOP Typicals
- Failure frequencies (likelihood , LOPA)

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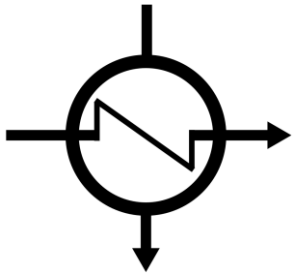
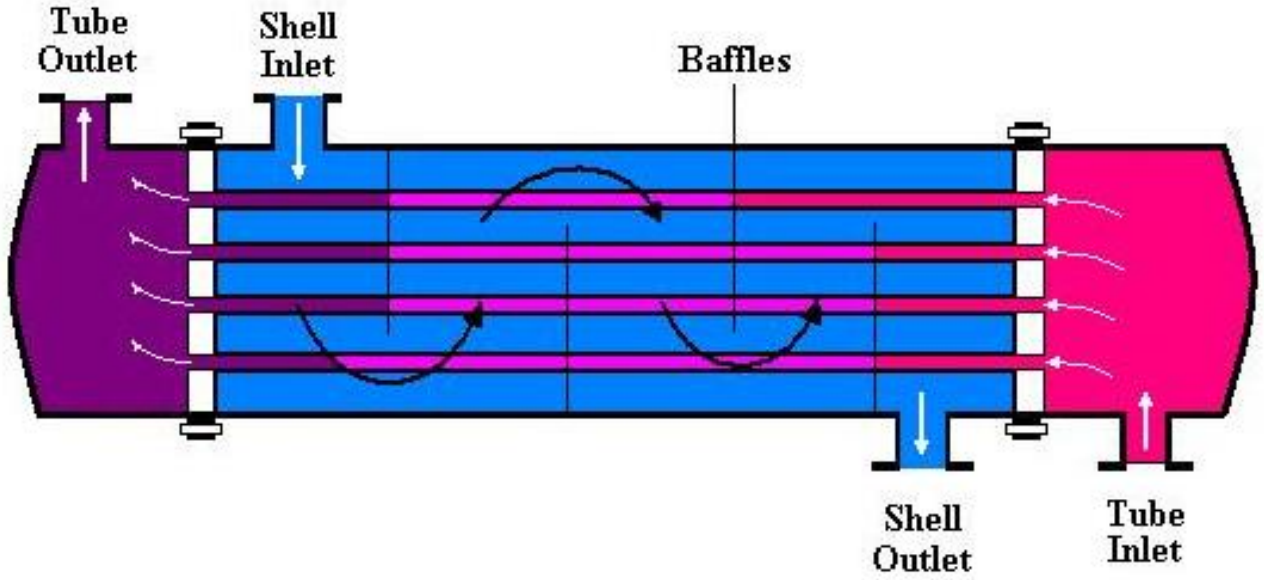
Heat Exchanger





Scenarios to consider

- Tube leak small (corrosion pinhole) → contamination → …
- Full tube rupture (low probability [1]) → Pressure exchange
- "Blocked in" at start-up → high pressure
- Fouling & corrosion
- Large temperature exceedance due to control loop failure

Measures to consider

Detection (e.g. HC detector at the cooling tower)

Pressure protection low pressure side (PSV)

TRV to release liquid

Cooling water / Boiler water control

Robust design allowing temperature deviations

[1] This is a low frequency scenario when leak before rupture with detection, or good design

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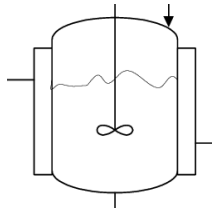
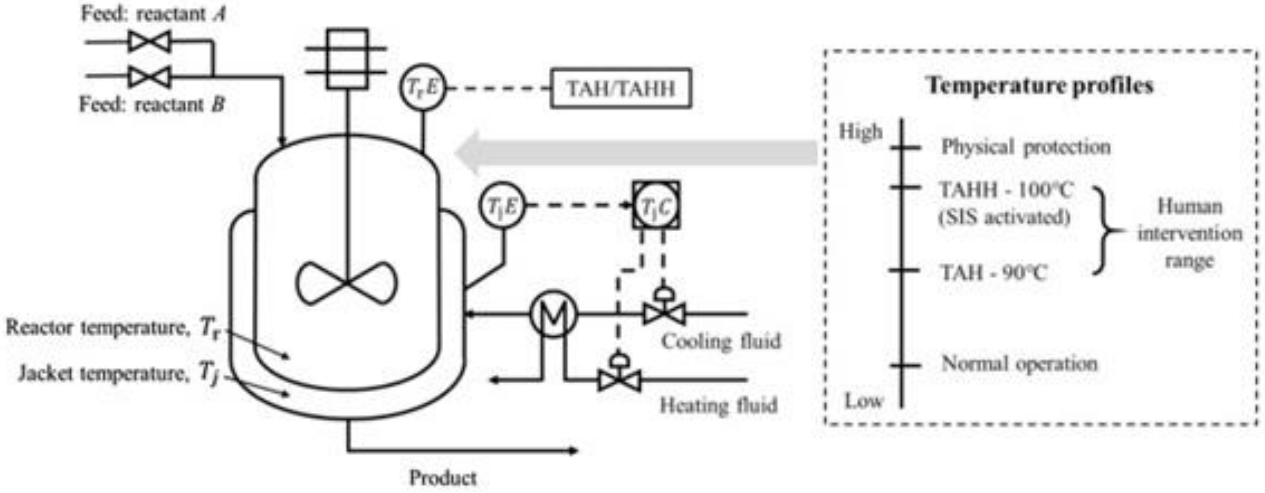
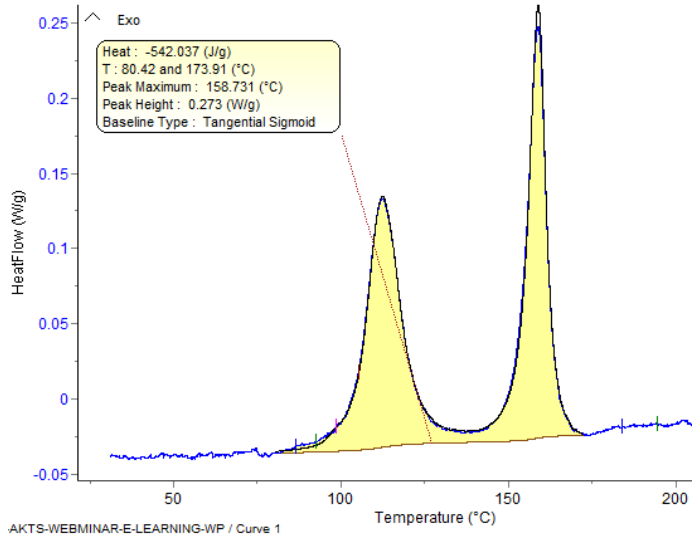
Batch Reactor







DSC caloric data

Scenarios to consider

- Reaction heat not absorbed → run away → explosion (know the energy balance / DSC data)
- Wrong chemical added → severe unexpected reaction
- Mixing not working → stratification → sudden reaction
- Temperature deviation → unknown exothermic reaction
- Fouling of cooling system

Measures to consider

Temp control, back-up cooling, depressurization, over pressure protection e.g. rupture disc, eventually a bunker

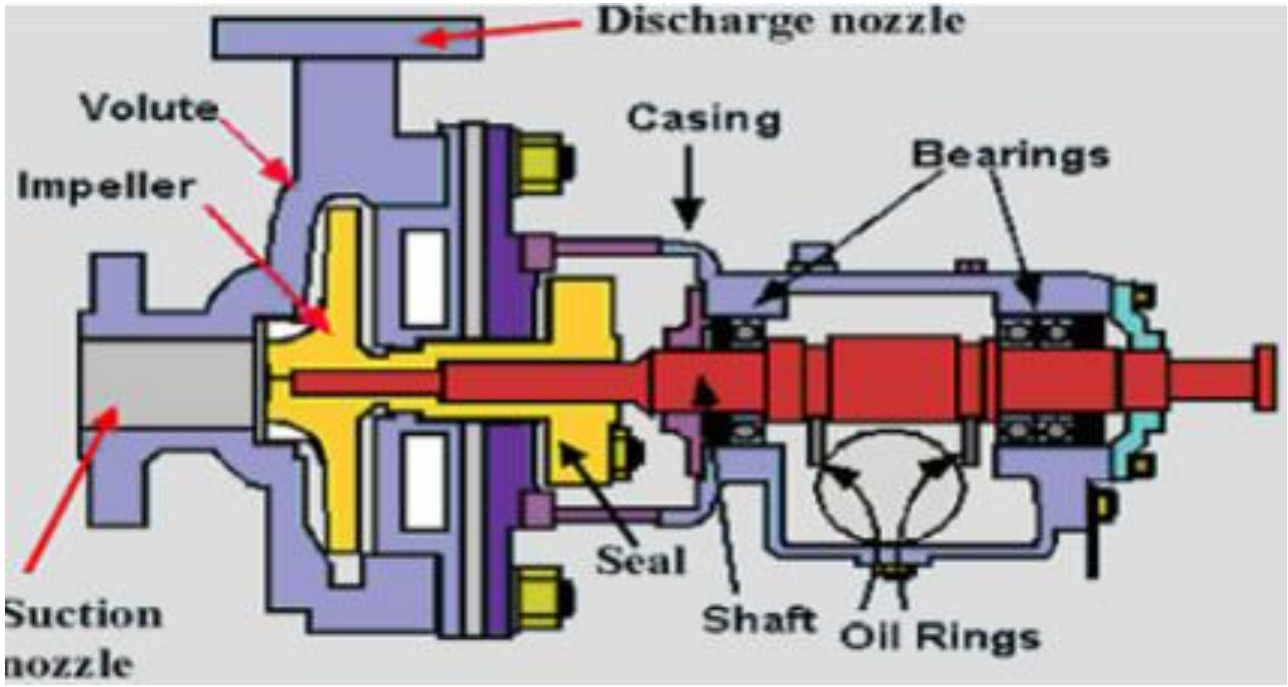
Chemical matrix, Materials identification

Alarm & procedures (see also above)

Chemical analysis, including DSC (see picture)

Temperature alarm / trip, emergency procedure, back-up cooling

Centrifugal pump



Scenarios to consider

- Low flow / suction blocked → Cavitation → Seal damage & leak
- Bearing damage → vibrations → seal leakage and worse
- Discharge blocked → overheated product → leakage → fire

Measures to consider

Low flow alarm, second containment, gas detection

Shaft position control, vibration analysis, operator rounds

second containment, gas detection

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Package Unit – Vendor package

Some Examples

- Nitrogen storage and gas supply
- Ammonia cooling unit
- Compressor
- Dosing system
- Auxiliaries: hot oil / steam
- Water treatment
- Boiler / Heater

Aspects

- Is the potential hazard identified (chemical releases)?
- Is a Recognized Design applied (e.g. according a standard)?
- Has a HAZOP been performed by the vendor?
- Are the IPL's identified and maintained?
- Is a P&ID available, is maintenance responsibility defined, are SOP available for operation?
- Is the vendor a recognized specialist?

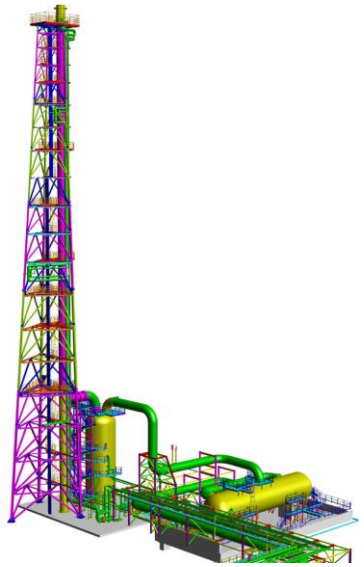
➢ Validate interface: flow, pressure, temperature exchanges bringing equipment out of design

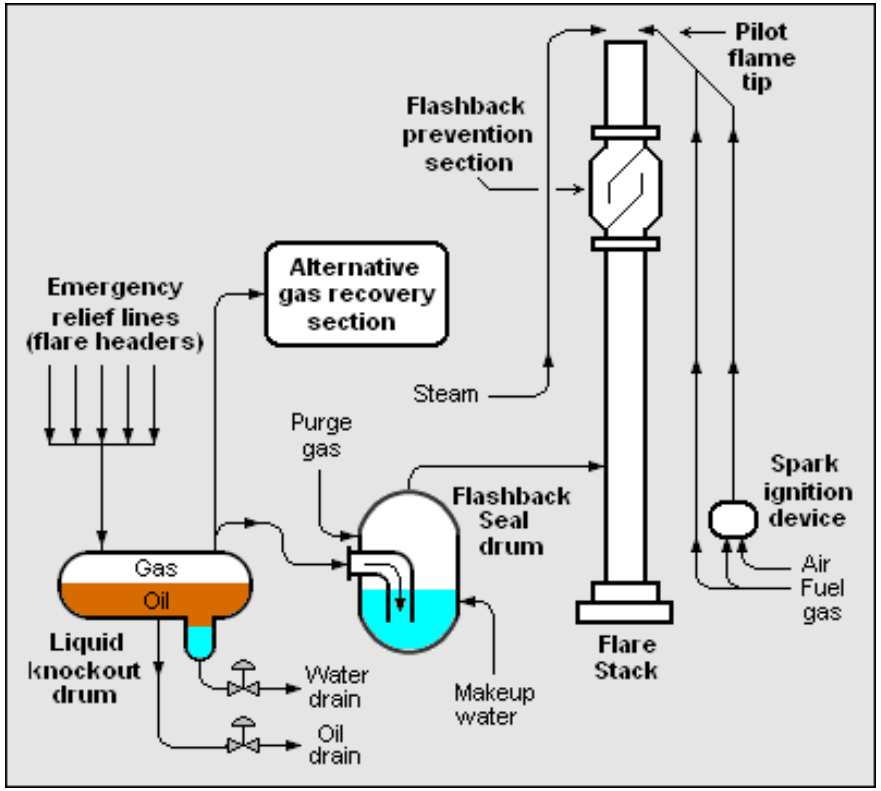
➢ Consider to invite the vendor to do a joined HAZOP to clarify residual hazards (depending on complexity and severity of potential consequence)

➢ Spot check on HAZOP of the vendor

➢ Is the protection of the Package Unit appropriate vs the hazard of the process unit

Flare System





Rust can block the pilot burner

Tip damage due to internal explosion

Tip damage due to flame inside of the tip

Scenarios to consider

- No flame in pilots → unburned gases released
- Flame burning inside the tip → loss/failure of tip
- Blocked flow to flare (high level in the drum, flare lines)
- Internal explosion
- Liquid carry over → Burning liquid falling from flare

Measures to consider

Have a redundant pilot gas feed (e.g. gas bottles), Multiple flame detection to validate the pilot

Verify the purge gas feed

Level control in KO drum and seal drum, Pressure alarm blockage in in the flare line; inspection and cleaning of flare line; keep flare piping free from valves etc.

Purge gas to avoid backflow of air; water lock to avoid back flow

Level control in KO drum and seal drum

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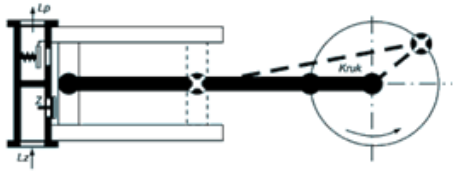
Compressor



<u>Scenarios to consider</u>

- Liquid in compressor due to high level in separators or KO drum down the compressor
- Loss of cooling (between stages) → overheating
- Vibration → moving equipment → fatigue
- Loss of purge gas → High concentration in vent lines Nitrogen

<u>Topics to consider</u>

KO drums level switch to detect liquid; Vibration monitoring to shut

Temperature switches to stop the compressor

Pulsation dampeners; Compensators; fixation of piping; Operator checks

Flow switch that stops the compressor; backflow protection to the

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Storage tank

Tank type depends on the product

Scenarios to consider

- Overflow → Fire or explosion
- Low level → no outlet flow
- Low level → roof landing on legs → air in the tank
- Rim seal damage → Gas feed to floating roof → fire
- Over/under pressure
- High temp → evaporation of the product → release
- Low conductive liquids generate a static spark

Measures to consider

Automatic overfill protection (for hazardous materials)

Protection of mixers, heating coils and pumps

Alarms & Procedures

Leakage detection (IR/gas); Tank preventive maintenance

PVV, see https://www.icheme.org/media/9850/xix-paper-63.pdf

Temperature alarm; Emergency cooling

Grounding; Filling at low speed

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Distillation Column

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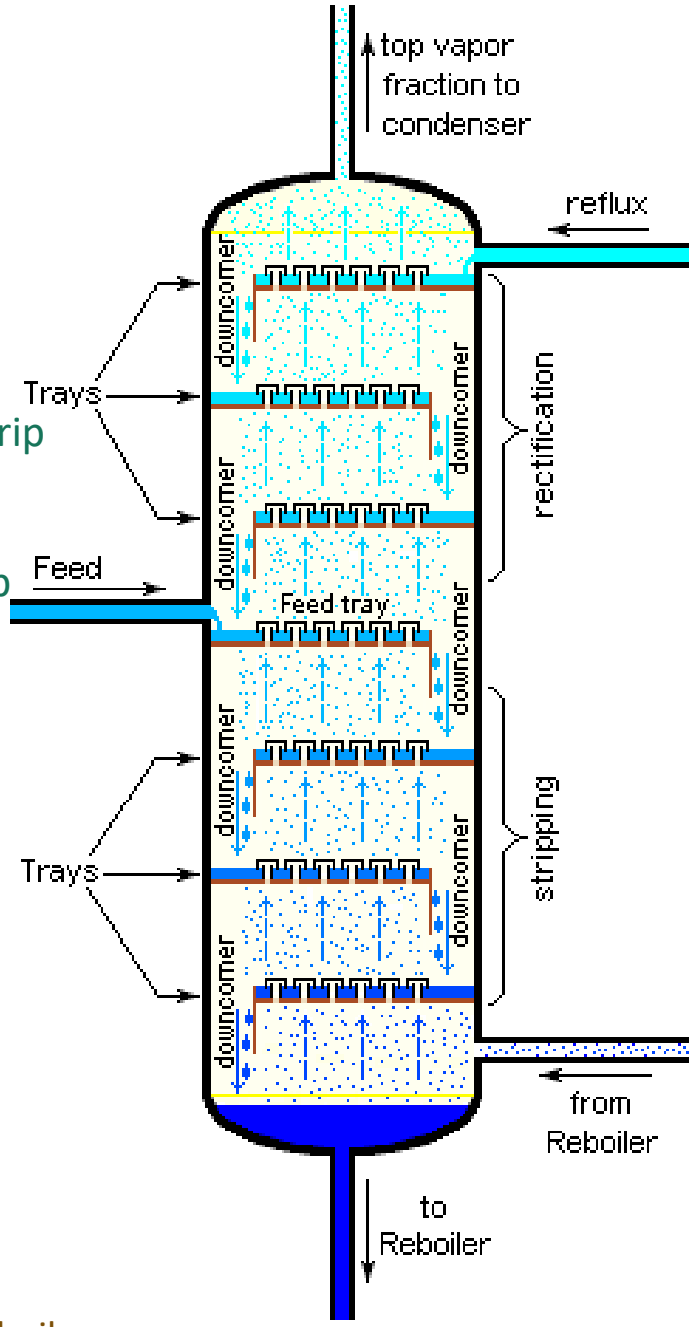
HAZOP typical

Scenarios to consider (generic, mandatory)	Measures to consider
➢ Overfilling	High level alarm / trip
➢ Loss of Reflux e. g. due to reflux drum overfill, condenser failure	Relief valve[(1)], Pressure trip
➢ Light components in bottoms sent to (floating roof) tank	Low temperature trip
➢ Feed composition (too light) → High flow / pressure in the top	Relief valve, Pressure trip
➢ Low level in the bottoms, i.e. vapor breakthrough to tank	Low level alarm / trip

Scenarios to consider (special, optional if appropriate)	
➢ Water ingress into hot columns (steam explosion)	thorough draining
➢ Formation of popcorn polymer (1,3-Butadiene)	design precautions
➢ Vacuum after steam out / upsets	procedural
➢ Caustic stress corrosion cracking	take samples, control pH
➢ Hydrate formation (LNG, C2) in cold columns	drying, take samples
➢ High temperature → decomposition / detonation	design precautions



[(1)] Relief Valve size calculation based on energy balance of column, condenser & reboiler

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Thank you for your attention

Questions?