



# 10 FUNDAMENTALS FOR EFFECTIVE PROCESS SAFETY

INTEGRITY SAVES LIVES!

## CAMPAIGN GUIDANCE

WITH PRACTICAL EXAMPLES

to be used for

OBSERVE

**HSELIFE NL**

Management system for a safer and healthier workplace



# 1

## Respect hazards

improve your understanding of process safety hazards

### MONITOR AN OPEN DRAIN

#### Hazards

- Unintended product release can occur during draining from a storage tank or other equipment to atmosphere.

#### When important

- When draining water from a tank that contains hydrocarbons to a sewer.
- When removing liquid from process equipment.

#### Challenges in the field

- Distracted by other things that need attention.
- Long draining time.
- Bad weather.
- Under estimation of the potential consequence of the product being released.
- Drain valve does not fully close.

#### Options to get it right

- Identify the critical draining operations on site.
- Limit drain size (typical to 1 inch) to limit the release rate of the hazardous chemical.
- Spring Loaded valves can help to assure that an operator remains present when drain time is short.
- Understand the draining time necessary when starting the draining process.
- Ensure the drain-valve can be closed from a safe location.
- Avoid doing something else while monitoring a draining task.
- In a critical situation, first stop the draining process before leaving the drain Stop draining during shift handover.



# 1

## Respect hazards

improve your understanding of process safety hazards

### CONTROL UTILITY SYSTEMS CONNECTED TO A PROCESS

#### Hazards

- When utility systems are temporarily connected with a flexible hose to a process, hazardous substances can flow back into the utility system.

#### When important

- During inerting, cleaning and unplugging operational equipment using utilities.
- When taking a sample a utility is needed to purge a system.

#### Challenges in the field

- Lack of knowledge.
- Easy availability of utility stations & hoses.
- Hazard studies did not identify the hazard.

#### Options to get it right

- Awareness of the hazard that utilities can be contaminated with process gasses or liquids.
- Understand the pressures in the systems and how they can deviate during operation.
- Define suitable safeguards against backflow, at least one non-return valve must be present.
- Remove the utility hoses from the process directly when the task is completed.
- Ensure that the hoses applied have the same pressure rating and chemical compatibility as the process when used in normal operation.
- Evaluate backflow during MoC and HAZOP studies when fixed connections exist between utilities and process units.



# 2

## Apply procedures

use operating and maintenance procedures

### VERIFY LEAK TIGHTNESS AFTER MAINTENANCE WORK

#### Hazards

- When a flange or other equipment is closed, it can still leak, when hazardous chemicals are introduced.

#### When important

- After work where equipment and flanges have been opened.
- Temperature change can influence bolt tension and create leakages.

#### Challenges in the field

- Competent people when bolting.
- Verification competency or procedures are missing.

#### Options to get it right

- Perform a leak test before introducing hazardous chemicals.
- Leak test can be done by introducing a less hazardous gas and perform a pressure hold test; put soap bubbles on all flanges that have been opened; ultrasound measurements can detect leakages.
- Develop criteria for acceptance of leak test results.
- Develop a special procedure for the flange that was used in the leak-tightness test (the flange to be closed after the leak test).
- Verify proper torqueing.
- Validate and adjust bolt tension after heating-up the equipment.
- Record Leak Test results.



# 3

## Sustain barriers

discuss the purpose of hardware and human barriers

### REPORT DEFICIENCIES ON SAFETY CRITICAL EQUIPMENT

#### Hazards

- Safety Critical Equipment provides a barrier to prevent or limit the effect of a major incident.

#### When important

- When Safety Critical Equipment is not working properly.

#### Challenges in the field

- A shutdown might be needed to repair the broken equipment.
- Not aware of the criticality.
- Unawareness of the failure – no testing.
- Unreadable equipment, like a fouled sight glass.

#### Options to get it right

- Determine which equipment is safety critical.
- Ensure workers know what equipment is Safety Critical, and understand the potential hazard.
- Safety Critical Equipment must have a testing protocol and frequency.
- Report failures or deviations on safety critical systems (also from testing).
- Decide what action is appropriate, if necessary stop the operation.
- Implement interim mitigating measures that are approved, in case of continuing operation.
- Repair or replace safety critical equipment with highest priority.
- Analyse why equipment failed
- Keeping a log on critical equipment out of service.



# 4

## Stay within operating limits

discuss and use the approved operating limits

### OPERATE WITHIN SAFE LIMITS

#### Hazards

- Hazardous reactions and releases or equipment damage can be caused when safe operating limits are exceeded.

#### When important

- Deviations from normal operation Transient operations, batch process , start-up / shut-down.
- At design changes.

#### Challenges in the field

- Limits not well known or identified.
- MOC process not followed.
- Pushing production.

#### Options to get it right

- Establish safe operating limits for key process variables and for all operating phases, and make them visible for operators.
- Validate that instruments are working well.
- Understand the critical process parameters that can result in equipment damage and loss of containment due to deviations.
- Install alarms and interlocks for critical process variables.
- Define actions to bring the process variable back within the operation limit.
- Report and discuss the cause when operating limits are exceeded.
- Understand the chemical hazards at non-standard conditions and have a chemical compatibility matrix available.



# 4

## Stay within operating limits

discuss and use the approved operating limits

### STAY OUT OF THE LINE OF FIRE

#### Hazards

- Exposure in case of unexpected release of energy or chemicals or unexpected movement of objects like a manhole, also vacuum can form a hazard.

#### When important

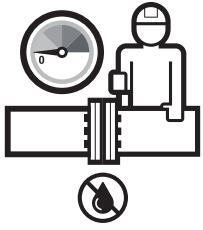
- When being in processing units that do not work at ambient pressure.

#### Challenges in the field

- Release points not designed well: e.g. PSV release points that end in a pathway.
- Manholes (or manway) that are stuck.
- Heat releases from flare.

#### Options to get it right

- Identify hazardous location around release points or below hoisted objects in the field, e.g. by lines or colours on the floor.
- Understand release locations and remove yourself from the potential energy discharge path from release points like PSV's, explosion panels and plugs under pressure.
- Keep people out of the heat radiation zone around a flare.
- Protect yourself (location of your body) when opening installations.
- Add physical barriers to prevent people from accidentally entering the paths.
- Verify that PSV's are designed to always vent to a safe location.
- At flange opening, first untighten the bolts that are far away from you.



# 5

## Maintain safe isolation

use isolation plans for the specific task

### APPLY DOUBLE ISOLATION

#### Hazards

- Spill of (hazardous) material can occur when a barrier (like a valve) fails and no second barrier is in place.

#### When important

- During routine and special operations: draining & sampling, (un-)loading activities, utility connections.

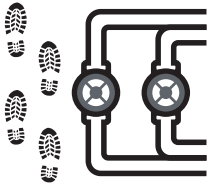
#### Challenges in the field

- Older plant design often do not provide a double barrier.
- Blind flanges not put back after maintenance work.
- Blind flanges not installed with bolts & missing end-caps.
- Importance of "primary containment" not understood.
- Valve handles that can be opened accidentally.

#### Options to get it right

- Do not rely on a single valve for positive isolation.
- Execute regular audits to check that drains are having an end-cap (blind flange or screw cap) conform pipe-spec.
- Do not accept missing blind flanges or missing bolts on blind flanges.
- Report and investigate all incidents from leaking drains.
- Valve handles can be locked to avoid accidentally opening.





# 6

## Walk the line

use up-to-date documentation that accurately reflect installed systems and equipment

### WALK THE LINE

#### Hazards

- Spills or inadvertent mixing might occur when the transfer line is not ready for operation due to open ended lines or drains, wrong valve or tank line-up.

#### When important

- After each change in set-up of a transfer line, e.g. start-up after shut-down, isolating equipment, change of equipment, maintenance work, draining.

#### Challenges in the field

- Transfers occurring around shift change-over.
- Long transfer lines, not fully accessible.
- Distracted by other things.
- Bad weather, low visibility at night.
- Pipelines or valve position that are not easy to see.

#### Options to get it right

- Validate a correct line-up (all valves, tanks, pumps), before starting the pump / transfer.
- Perform a check, after pump start, to detect leaking drains, hoses, flanges or pump seals.
- Use P&IDs or better isometrics during line check.
- Label equipment in the field, like valves, pipelines and pumps to help with the field check.
- Tag all the bleeds and drains.
- Validate the transfer regularly by checking the levels of the tanks versus the calculated level from the pump flow speed. Take actions upon deviation.



# 7

## Control ignition sources

identify, eliminate, or control the full range of potential ignition sources

### CHECK ATMOSPHERE IN FIRE BOX BEFORE IGNITING THE BURNERS

#### Hazards

- When the firebox of a furnace or boiler has an explosive mixture by accumulation of large amounts of flammable gases, this will explode when igniting the burners.

#### When important

- Upon start and restart.
- Cold start.
- After a furnace trip.

#### Challenges in the field

- Reliability of instruments.
- No good procedure / practices.
- Fast restart required to avoid shut down.

#### Options to get it right

- Furnaces/boilers need to be purged well with air to remove all gasses and to avoid an explosive atmosphere, before igniting the burners.
- Procedures for start of furnaces and boilers must be available and up-to-date.
- Report problems with fully automated systems (burner management systems) or deviation from start-up procedure immediately.
- Limit the number of attempts to ignite a furnace/boiler (and keep sufficient time between attempts).
- Perform a leak test on the gas supply before igniting a furnace/boiler.
- Check atmosphere in the fire box before igniting the burners with a LEL meter
- Bypassing of safety. Instrumentation (flame eyes, gas detection, sensors) must be managed carefully.
- Limit the number of people in the vicinity when starting furnaces/boilers to those necessary for the start-up operation.
- Avoid time pressure when starting or restarting furnaces or boilers.



# 7

## Control ignition sources

identify, eliminate, or control the full range of potential ignition sources

### AVOID SPLASH LOADING

#### Hazards

- When loading non conductive flammable liquids, an explosive atmosphere will be created in the tank, that can ignite when electrically charged droplets generate a spark.

#### When important

- When transferring flammable liquids.
- When liquids fall down and form droplets.

#### Challenges in the field

- Lack of knowledge.
- Design issues, e.g. on pump or loading dip-pipe.
- Communication (ship - shore).

#### Options to get it right

- Assure that the loading speed in the drop-down pipe in the vessel is below 1 m/s when start filling! This assures droplets are only little loaded and can not form sparks.
- When loading ships this is arranged in a ship-shore agreement, that should include the pipe diameter and pump speed.
- Ensure that pipelines, tanks, vessels are grounded.
- When the filling pipe is submerged below the liquid level inside the vessel or tank, the risk for splashing has gone and pump speed can be increased.
- Inertisation can eliminate an explosive atmosphere.
- Understand which chemicals are flammable liquids with low conductivity (like benzene, kerosene, butane – heptane).
- These are highly hazardous as they form an explosive mixture with air and dissipate static electricity slowly.



# 8

## Recognise change

discuss changes and involve others to identify the need for management of change

### VERIFY THE CONDITION OF FLEXIBLE HOSES

#### Hazards

- Hazardous fluid release due to hoses failures.
- Wildly moving hoses at pressure release when coupling gets loose.

#### When important

- When using flexible hoses.
- When disconnecting hoses that still contain pressure or toxic material.

#### Challenges in the field

- Connections are not properly made, requiring bended or stretched hoses.
- No good storage location available.

#### Options to get it right

- Make sure you use the correct hose: correct material of construction and temperature & pressure rating.
- Visually inspect hoses before using them and check for defects like corrosion, wear or mechanical damage.
- Hoses (including the connections) with hazardous fluids should be inspected periodically by an approved body and certified.
- Avoid hoses for very toxic chemicals (like phosgene).
- Hoses should be tagged and included in the maintenance schedule.
- When not in use, hoses must be properly stored, with the appropriate bend radius, hanging straight down, or laying straight.
- Hoses must not be twisted or forced when connected.
- Connect hoses well, follow-up on possible vibrations.
- If required replace hoses preventively and remove old hoses from the site.
- Check correct depressurization of hoses before disconnecting.



# 8

## Recognise change

discuss changes and involve others to identify the need for management of change

### REPORT PROCESS SAFETY INCIDENTS

#### Hazards

- Acceptance of small leakages, near misses or substandard practices.

#### When important

- When related to Safety Critical Equipment.
- Small leakages & Activation of barriers.

#### Challenges in the field

- No open learning culture that stimulates intervention by all on safety.
- Production pressure.
- Bad follow-up and feedback on reported items.
- Difficult reporting tools.

#### Options to get it right

- Create a culture where reporting nasty items is considered valuable feedback to improve safety. Have time available for that.
- Report all spills: have an easy database to do so.
- Follow-up on reported items and provide feed-back.
- Classify LOPC according to a standard and have a KPI with a target.
- Ensure workers recognise and report on TIER 3 & 4 incidents, that is weak signals or leading indicators, that should include:
  - Small leakages.
  - Failures of safety critical systems.
  - Activation of a last line of defence like a safety interlock.
  - Fires; liquid hammering; vibrations; corrosion.
  - Pressure or temperature outside design: like Auto-refrigeration.
  - Locked or car-sealed valves not in the right position.
  - Long standing or nuisance alarms.
  - Ignition sources in zoned area's; ATEX deficiencies.
  - Deviation of critical procedures.



9

## Stop if the unexpected occurs

pause and ask questions when signals and conditions are not as expected

### EMPTY AND DE-ENERGIZE BEFORE LINE-BREAKING

#### Hazards

- Uncontrolled release of energy or a hazardous material during the opening of piping or equipment.

#### When important

- When unbolting, unscrewing, drilling or cutting of process equipment.
- While working on live equipment.

#### Challenges in the field

- Working at the wrong location.
- Complexity of piping or break points arrangements.
- Double block and bleed not possible.
- Plugging of vents or drains / leaking valves.
- Installing blinds.
- Drains at the wrong location.

#### Options to get it right

- Have a validated isolation plan available, that indicates numbered isolation points in the right sequence on a P&ID.
- Apply LOTO to avoid that equipment can be reenergised: that is providing locks and labels.
- Empty and clean equipment properly.
- Check the completion of the isolation plan by an independent operator, before signing the permit to work.
- Wear selected PPE for residual chemicals that might not be purged or drained and provide absorbents for leaking fluids.
- Perform a Last Minute Risk Analysis by the mechanic or contractor, before opening, to validate that the pressure indicator is zero, the drain is open, the system is at ambient temperature, there is no flow and assure you are at the right equipment.
- Use blinds according pipe spec, that is indicated on the isolation list.
- Upon changes, validate that isolation remains intact.



**9**

## Stop if the unexpected occurs

pause and ask questions when signals and conditions are not as expected

### UNPLUGGING OF EQUIPMENT

#### Hazards

- Unplugging might require opening of installations that can unexpectedly result in a release of hazardous substances.

#### When important

- When process equipment is blocked, eg by fouling, polymer, corrosion, objects after maintenance etc.

#### Challenges in the field

- Unexpected severe flow restrictions.
- No unplugging procedure or good options.
- Not wanting to stop production.

#### Options to get it right

- Consider to stop production before unplugging.
- Do not start unplugging without an approved plan that includes a hazard analysis.
- Understand the source and reason of plugging.
- Understand the hazards while unplugged and have a mitigation plan for unexpected releases.
- Understand that instrumentation might give misreading or that safety valves do not operate properly.
- Understand that opened equipment can still have pressurized hazardous material inside behind the plug.
- Apply isolation and First Line Break principles in the unplugging procedure.
- Do not use hazardous gas to blow out pipelines / equipment.



**10**

## Watch for weak signals

proactively look for indicators or signals that suggest future problems

### MANAGE OVERRIDES OF SAFETY CRITICAL SYSTEMS LINE-BREAKING INCIDENTS

#### Hazards

- Insufficient safeguards are in place when a safety critical system is not working properly or is bypassed.

#### When important

- Failure of or unreliable safety systems.
- Testing of interlocks.
- Turnaround or maintenance work.
- Commissioning, start-up & shutdown.

#### Challenges in the field

- Consequences are unknown.
- Safety systems that prevent start-up.
- Lack of knowledge of procedure.
- Absence of authorizers.

#### Options to get it right

- Understand the safety critical systems and identify them in the field.
- Every bypass/override needs a formal authorization based on a risk assessment (a special permit to work for bypass can help).
- Define the criticality of the system to bypass like the SIL level.
- Authorisation level needs to be inline with criticality.
- Identify solid interim protection measures and put them in action.
- The bypasses must be registered in a bypass log accessible in the control room.
- Discuss active bypasses during shift handover.
- Determine process units that require shutdown when safety critical systems are unavailable.
- Limit bypass duration, initiate a formal MOC for long term bypasses.
- Protect safety interlocks against easy bypassing in the field.
- Review bypassed functions daily (typically in the morning meeting).
- Review statistics on bypassed equipment.





# 10

## Watch for weak signals

proactively look for indicators or signals that suggest future problems

### AVOID WORKING BEHIND A SINGLE VALVE

#### Hazards

- Single valves can leak because they are not fully closed, are fouled or just leak.
- During working behind a single valve the valve might be accidentally opened or start leaking, releasing chemicals.

#### When important

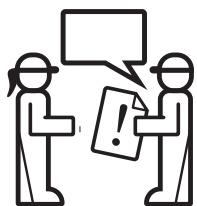
- During and after line breaking due to a repair or maintenance activity.
- When the plant is not fully deenergized.

#### Challenges in the field

- Older plant design often might not provide a second barrier or full block and bleed option to isolate equipment.
- Placing a blind, turning a spectacle flange.

#### Options to get it right

- Realize when it is not possible to work behind double isolation.
- Try to remove the substance or energy in the system before start working behind a single valve.
- If isolation by a single valve cannot be avoided:
  - Validate that the single valve is not leaking e.g. at a drain point downstream of the isolation, or by a pressure gauge.
  - Mechanically lock the isolation valve handle to avoid accidental knocking open during the task, deactivate the actuator for automated valves after checking the valve fail-safe position.
  - Mount a spade or blind flange after the single valve directly after the line break.
  - Consider if emergency responders should be in place during the line break, until the blind-flange is placed.
  - Wear appropriate personal protective equipment (PPE) during the task.
  - Keep working time short and avoid critical process conditions during.



# 10

## Watch for weak signals

proactively look for indicators or signals that suggest future problems

### CONTROL (UN)LOADING

#### Hazards

- Unexpected run away reaction.
- Formation of toxic chemicals.
- Overfilling or loss of containment.

#### When important

- Receiving of chemicals at your site.
- Loading chemicals to a tank or reactor.
- Waste handling operation.

#### Challenges in the field

- Lack of knowledge & guidance of the contractor or operator involved.
- Line up.
- Chemical identification.

#### Options to get it right

- Validate that the right chemical is loaded by a positive identification: analysis of a sample, inline analysis (density), certificate, barcode, clear label.
- Have a good procedure in place with check points.
- Provide unique coupling for hazardous chemicals (e.g. Chlorine, Ammonium, Ethylene oxide) to avoid wrong line-up.
- Use colour codes (or bar codes that can be scanned) on pipelines, tubing and connection point.
- Use professional firms for transporting the chemicals (that are ADR, ADN & RID compliant).
- Guide contractors well that are involved in (un)loading.
- Assure that receiving equipment has sufficient volume available.
- Have a compatibility matrix available to understand the hazards.