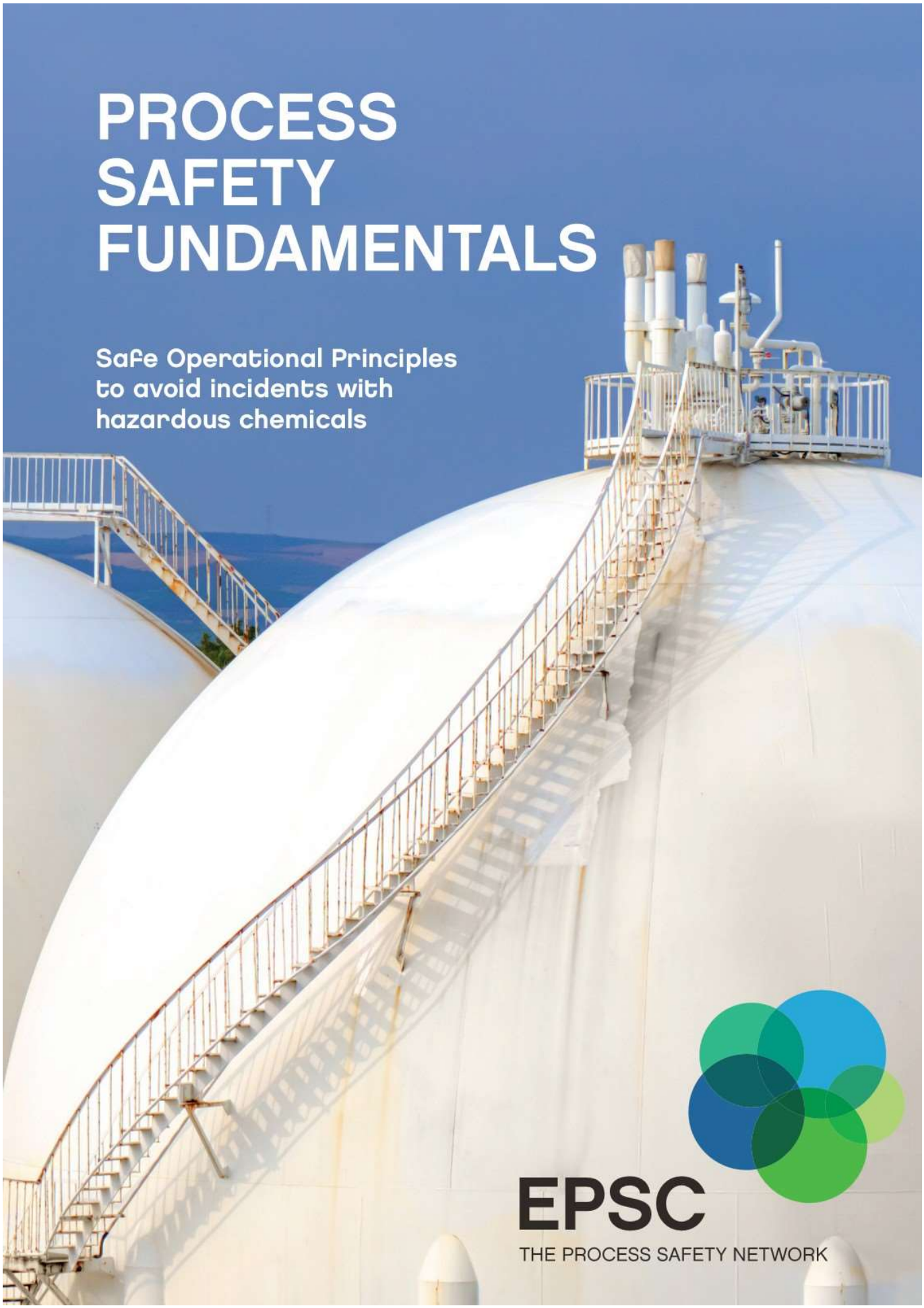
PROCESS SAFETY FUNDAMENTALS

Safe Operational Principles to avoid incidents with hazardous chemicals



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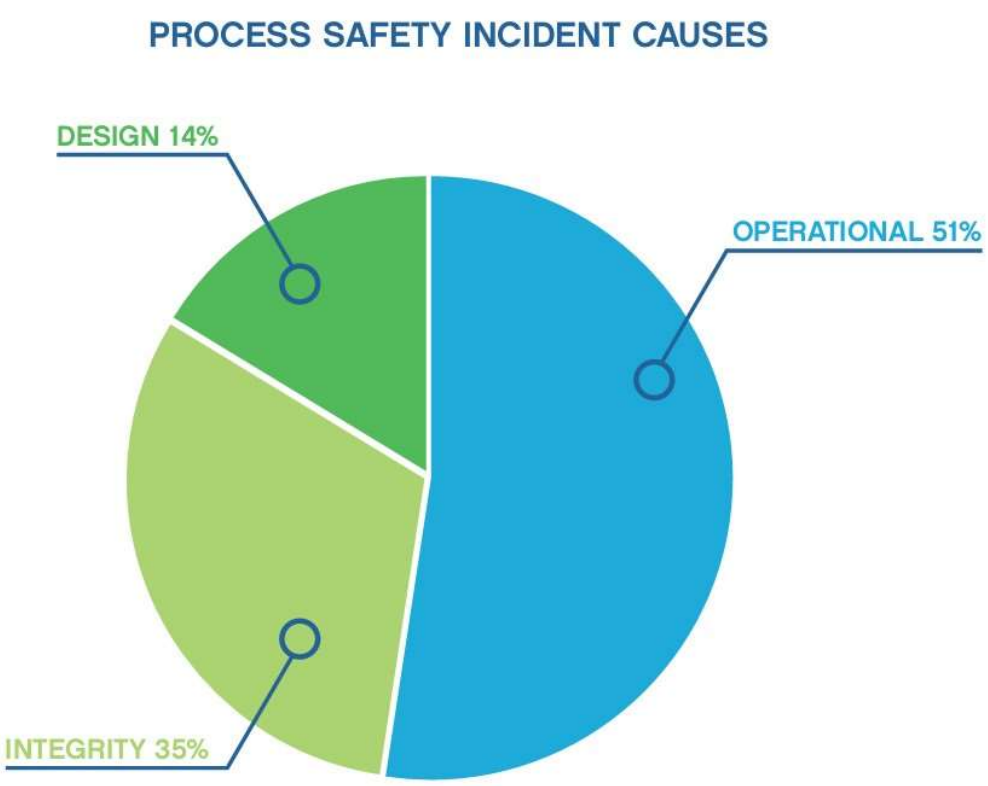
THE PROCESS SAFETY NETWORK

CONTEXT

Process Safety is about the avoidance of Loss of Containment of hazardous chemicals. For this three areas are considered relevant: Operational Excellence, Mechanical Integrity and Engineering Design. EPSC is doing a large study of the causes of incidents that classify as process safety incidents (according to ICCA or API-754 standard), among their industrial members. The result, shown in figure 1, shows that most cases originate in how the installation is operated. Losses are typically caused by operator handling or maintenance of the installation. This has led to the understanding that operational excellence on process safety is of great importance. One of the questions is, what type of incidents are we talking about and how could operation better prepare themselves to avoid these. Here the process safety fundamentals are defined that can play a role in strengthening process safety operational excellence on hazardous sites. To obtain this, Leadership and Competency on the critical operational and maintenance tasks is also essential.

FIGURE 1. EPSC BENCHMARK RESULTS OF 2019 INCIDENT ROOT CAUSES (ON CA 1000 CLASSIFIED PROCESS SAFETY CASES)



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The effectiveness of the integrity assurance processes are highly depending on demonstrated leadership by management at different levels of the organization, but also by collective commitment demonstrated by the entire workforce.

To avoid chemical releases so called "barriers" are identified. These barriers can be hardware, human or organizational as shown in Figure 2. The scope of this booklet is limited to preventive and mitigating human barriers, and more specifically the operating discipline principles that need to be respected rigorously to avoid process safety incidents and accidents. This rule based layer forms a solid foundation, on which the risk based methods can build, which are used to prevent the more complex process causes of incidents.

FIGURE 2. FOCUS ON HUMAN BARRIERS

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SCOPE OF EPSC PROCESS SAFETY FUNDAMENTALS

EPSC Process Safety Fundamentals are a set of basic principles intended to support frontline workers, supervisors and operational management. They draw attention to situations that could lead to a release of a hazardous chemical with potential for severe consequences and emphasize existing good practices to prevent such events. The EPSC Process Safety Fundamentals mention a number of typical critical aspects that are not easy to do well and that have resulted multiple serious incidents. Not all chemical safety hazards are addressed. They can be used very well at industrial sites dealing with hazardous chemicals, in addition to the existing process safety management systems. Therefore, the EPSC PSFs do not replace existing safety management systems (including policies, safe systems for work, safety training programs, change management, critical task analysis & procedures etc.) but provide a tool to increase understanding on the items that often go wrong in the field on the basis of a detailed discussion of the slides provided.

The current collection of EPSC Process Safety Fundamentals addresses 18 typical hazardous operational situations. Not all of these will be relevant for your site, and even you might find missing ones. It's suggested to select the most relevant ones for your site and start to work on those.

The EPSC PSF do not include new safe operation principles. Instead, they address well known basic principles but presented and visualized in a way that they can be used as a tool enabling front line workers to get a better understanding of process safety in their day to day activities.

EPSC PROCESS SAFETY FUNDAMENTALS & LIFE SAVING RULES

The EPSC Process Safety Fundamentals are intended as a complement to the Life Saving Rules adopted in many companies. However, the context of the use of the EPSC PSF is quite different from the intent of Life Saving Rules. Therefore, combining them in a single list is not recommended. A comparison of the use of Life Saving Rules and EPSC Process Safety Fundamentals is given in the table at the next page.

	LIFE SAVING RULES	PROCESS SAFETY FUNDAMENTALS
OBJECTIVE	Reduce number of injuries/fatalities	Avoid loss of containment of chemicals with potentially serious consequences for people, environment and assets
HSE DOMAIN	Behaviors in occupational safety	Behaviors in operations involving hazardous chemicals
TARGET POPULATION	All	Operation teams on hazardous sites (process operators, supervisors, operational management, contractors, maintenance technicians)
NATURE AND APPLICABILLITY	Simple rules that are easy to understand and apply in all circumstances	More complex principles that cannot always be fully applied (e.g. in case of design issues)
IMPLMENTATION	Non-negotiable set of requirements (Life Saving Rules / Golden Rules)	The aim is to identify situations that are not in line with the Process Safety Fundamentals and to start a discussion on how to proceed, while avoiding uncontrolled initiatives "to get the job done"

The deployment of the Process Safety Fundamentals is very different from the way that companies have implemented their Life Saving Rules. Life Saving Rules are introduced and managed as a set of non-negotiable simple requirements

while the Process Safety Fundamentals address more complex situations, where design and the practical situation need to be taken into account, to decide how the work can be executed safely. Therefore the PSF allow more flexibility, that is they have to rely more on advanced understanding and competency.
The intent of the PSFs is to emphasize some critical front-line tasks and behaviors that need to be fully understood and supported by all operational leaders to enable successful process safety performance. The deployment of the PSFs must allow a renewed focus on existing, good operating practices that we must get right every time. However, in practice, full application of the PSFs may not be easy or even not possible. It is also the aim of the PSFs to give visibility to these dilemmas that frontline operators may face and to engage them in a discussion with involved operational management on how to deal with these situations. In this context, Process Safety Fundamentals are not intended to be seen as "another set of rules", but rather as an opportunity for discussion between front-line operators and operational management when difficulties arise in the execution of some critical tasks.

In this context, the Process Safety Fundamentals provide an excellent tool for leaders to instill an open culture driving process safety excellence. Leaders should:

- Drive safety from a position of care.
  Be visible in the field.
  Have a regular dialogue on the PSFs. Help front line staff to comfortably
- surface dilemmas, operational issues, and weak signals.
  Have a high understanding of the compromising factors in practical
- situations. Once dilemmas are brought forward, work with the front line to resolve the issues.
  Show curiosity. Seek to understand and comply with the PSFs before allowing deviations.
  Recognize risk normalization in many of our daily activities and address it.

The list of 18 EPSC Process Safety Fundamentals is not a comprehensive or exclusive list of all possible challenges that operators may face in the field. Therefore, other Process Safety Fundamentals may be developed and adopted by companies depending on the local context and needs.

GUIDANCE CARDS

In this booklet, guidance cards can be found for each of the 18 EPSC Process

Safety Fundamentals. These guidance cards give supporting information for the implementation of the PSFs. They give a description of the operation principles to be followed, with a focus on hazards, possible challenges in the field and options to get it right.

DEPLOYMENT OF THE PROCESS SAFETY FUNDAMENTALS

The success of the deployment of the EPSC Process Safety Fundamentals is highly depending on the way in which they are rolled out.
A description of possible steps is given below:

Engagement Workshop

To introduce the Process Safety Fundamentals, a workshop may be organized with key people in the operational chain to ensure their commitment and involvement. These people include representatives from Operations, Maintenance, Process Safety, Asset Integrity. The participation and commitment of senior leadership is vital for successful implementation of the PSFs. In the workshop, a presentation can be given about the PSF program and a discussion can be organized with front line operators on how to effectively implement the PSFs in the field. A formal plan for implementation of the PSFs, endorsed by all people involved, may be one of the deliverables of the workshop.

Analysis and Promotion

To coordinate the implementation of the Process Safety Fundamentals, the company may choose to nominate one or more stewards or champions. The role of the stewards/coaches includes the organization of sessions to give further clarification to enable front line workers to understand the scope and objectives of the PSF program. These sessions can also be used for discussions on possible front-line dilemmas in the application of the selected PSFs. The content of the EPSC PSF guidance sheets can be used as a tool in the discussions. In the discussion it helps if the people that work in the field, can openly share all the cases, where one had deviated from best practices.

The type and number of PSFs to be included in the program may vary. One or more of the EPSC Process Safety Fundamentals may be selected. However, other PSFs may be included, based on specific local process safety challenges and supported by a thorough analysis of its internal incident and leading indicator data related to actual or potential high consequence process safety events.

One option could be to initially select a minimum set of PSFs to be promoted during a pilot phase over a one-year program, allowing a better estimate of the

required effort in terms of budget and resources allocation for a full-scale deployment over the following years.

Roll-Out

Please find in Table 2. some suggestions that can help you to role-out the process safety fundamentals within your company.

PRACTICE	PURPOSE
1. GAP ANALYSIS	
1.1 Individual, team or site gap analysis, with improvement action plan	Identify strengths and areas for improvement, using internet survey, card-sort or paper-based questionnaire.
1.2 360 degree feedback	For manager or supervisor behaviors in the area of Process Safety Fundamentals, linked to development.
2. INITIAL AND ONGOING EDUCATION &AWARENESS	
2.1 Awareness campaigns	Explain PSFs and why they are important. Ongoing sharing of the PSFs with the front-line workforce, making reference to real events that have occurred at site level, but also taking into account lessons learned and other available material from the industry.
2.2 Setting behavioral expectations	Emphasize behaviors expected in relation to the Process Safety Fundamentals.
2.3 Interactive exercises	For simple ways of explaining the Process Safety Fundamentals in an interactive and engaging way.
2.4 HSE days	Communication of Process Safety Fundamentals to workforce during themed HSE days / events.

PRACTICE	PURPOSE
2.5 Toolbox talks	Communication of Process Safety Fundamentals to workforce by supervisors.
2.6 Posters	Posters can be a powerful communication tool providing strong relevant images that can be displayed at strategic positions. A well-chosen image can often convey a meaning more powerfully than words alone.
2.7 Videos	Meaningful videos can result in greater attention to, and retention of information. They increase audience understanding, trigger emotions and encourage participant questions. A short video could be developed for each of the PSFs, to explain the its importance and the roles played by employees in preventing undesired process safety events.
2.8 Booklets	A pocket-sized booklet covering the PSFs can be a helpful resource to maintain awareness of PSFs and also be used to prompt process safety discussion, for example during toolbox talks, or during operational site visits by managers and supervisors.
3. BUILDING INTO HR PROCESSES & SYSTEMS	
3.1 Employee selection (all levels)	Use Process Safety Fundamentals as criteria for selection.
3.2 Management development	Develop manager engagement in application of Process Safety Fundamentals.
3.3 Supervisor development	Develop supervisor engagement in application of Process Safety Fundamentals.

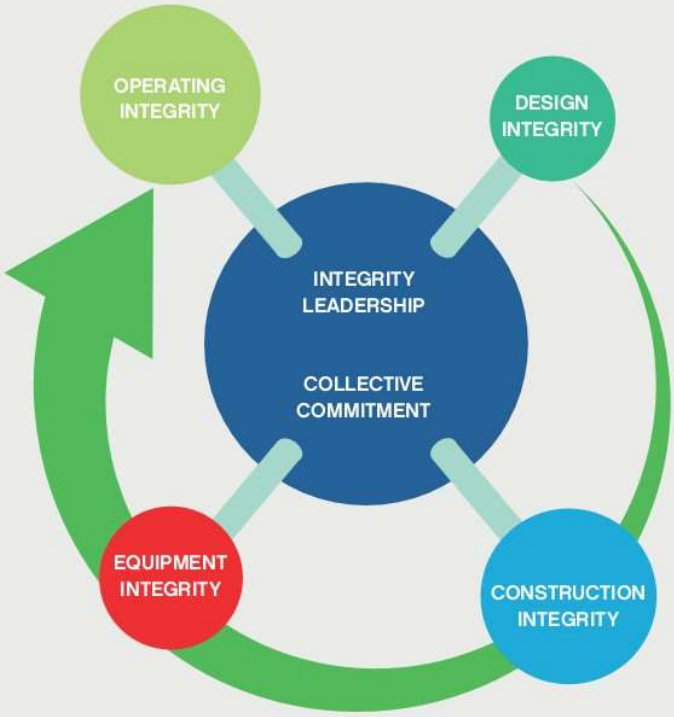
PRACTICE	PURPOSE
3.4 Coaching	Develop behaviors related to Process Safety Fundamentals.
3.5 Enhancement of personal HSE action plans	Add respect of Process Safety Fundamentals to personal HSE action plans.
4. BUILDING INTO HSE PROCESSES & SYSTEMS	
4.1 HSE improvement campaigns	Linking Process Safety Fundamentals to specific campaigns (e.g. certain types of injury or incidents).
4.2 During auditing	Inclusion of Process Safety Fundamentals during traditional HSE audits.
4.3 Reward and recognition	Linking to demonstration of excellent application of Process Safety Fundamentals.
4.4 Post-incident review	Following an incident, using the Process Safety Fundamentals to embed post-incident learning.
4.5 Near-miss analysis Executive Safety Tools	Identifying trends in application of Process Safety Fundamentals in a series of near-misses.
4.6 Executive Safety Tools	Simple practices which senior executives can use to promote Process Safety Fundamentals.
4.7 Contractor selection & management	Engage contractors in demonstrating and reinforcing the right behaviors related to Process Safety Fundamentals.

PRACTICE	PURPOSE
4.8 Integration in contractual agreements	The PSFs adopted inside the Company can be referenced in Tender documentation, not necessarily as a stand-alone document, but identifying the most suitable way to ensure Contractors working on Company's sites are fully aware that PSFs are part of Company policies/procedures.
5. DAY TO DAY PRACTICES	
5.1 Risk assessment	Encourage / maintain mindfulness.
5.2 Employee involvement	Get everyone involved in respecting Process Safety Fundamentals.
5.3 Safety moments	Encourage / maintain mindfulness.
5.4 Site visits and inspection program	Dedicated site visits can be conducted by supervisors and managers to support implementation of the PSFs; dilemmas raised by front line workers can then be addressed to facility continuous improvement in process safety performance.
5.5 Recognition and interventions	Inclusion of the PSFs in site hazard observation cards enabling dilemmas faced by frontline workers in trying to implement PSFs, to be raised. And an award or recognition program for the best card of the month. Another option is the inclusion of the PSFs in the pre-job Tool-Box-Talks materials, helping to increase understanding of the required controls to be applied before starting work.

MONITORING AND FOLLOW-UP

Management system activities include monitoring and follow-up. In the case of Process Safety Fundamentals (as part of process management), some time will be needed to measure the outcome of the implementation of PSFs (in terms of reduction of the number of Process Safety Events related to operating integrity). A more immediate step change will be more likely visible in terms of increased front-line awareness, competence and engagement in process safety.

FIGURE 1. INTEGRITY MANAGEMENT AREAS



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18 TOPICS FOR PROCESS SAFETY EXCELLENCE

1. APPLY DOUBLE ISOLATION
2. EMPTY AND DE-ENERGIZE BEFORE LINE-BREAKING
3. MONITOR AN OPEN DRAIN
4. MANAGE OVERRIDES OF SAFETY CRITICAL SYSTEMS LINE-BREAKING INCIDENTS
5. WALK THE LINE
6. VERIFY LEAK TIGHTNESS AFTER MAINTENANCE WORK
7. AVOID WORKING BEHIND A SINGLE VALVE
8. VERIFY THE CONDITION OF FLEXIBLE HOSES
9. OPERATE WITHIN SAFE LIMITS
10. CONTROL UTILITY SYSTEMS CONNECTED TO A PROCESS
11. REPORT DEFICIENCIES ON SAFETY CRITICAL EQUIPMENT
12. UNPLUGGING OF EQUIPMENT
13. STAY OUT OF THE LINE OF FIRE
14. CONTROL (UN)LOADING
15. CHECK ATMOSPHERE IN FIRE BOX BEFORE IGNITING THE BURNERS
16. AVOID SPLASH LOADING
17. AVOID RUN-AWAYREACTION
18. REPORT PROCESS SAFETY INCIDENTS

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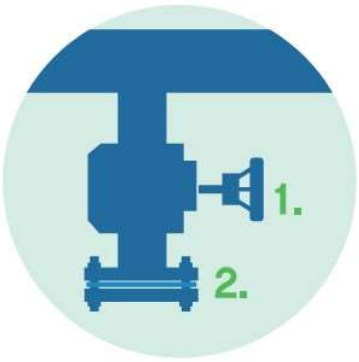
EPSC PROCESS SAFETY FUNDAMENTALS

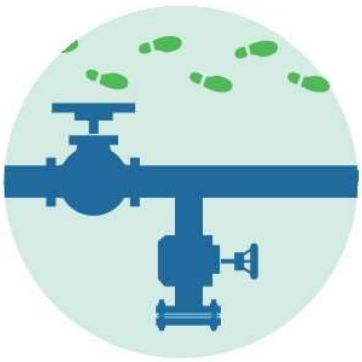


Apply Double Isolation

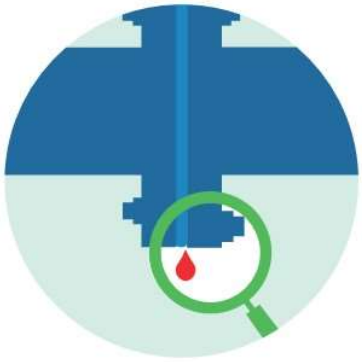
Empty and De-energize before Line-breaking

Monitor an open drain

Manage Overrides of Safety Critical Systems

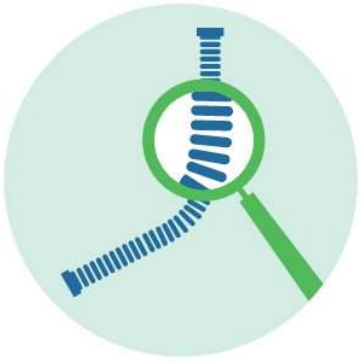


Walk the line



Verify leak tightness after maintenance work

Avoid working behind a single valve



Verify the condition of flexible hoses

Operate within safe limits

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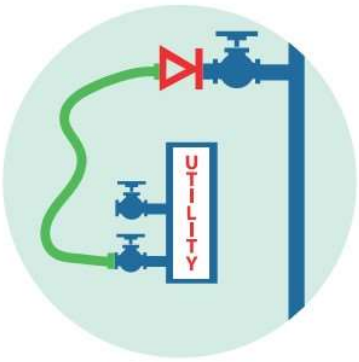
PICTOGRAMS

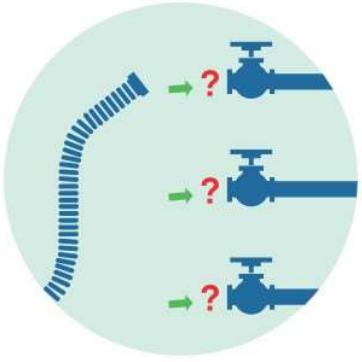


Control utility systems

Report deficiencies on Safety critical Equipment

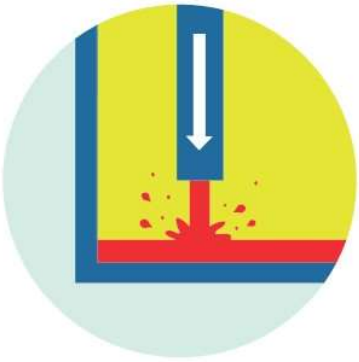
Control unplugging of equipment

Stay out of the Line of Fire



Control (Un)loading

Check atmosphere in fire box before igniting the burners



Avoid Splash Loading

Avoid run-away reaction

Report Process Safety Incidents

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GUIDANCE ON USING THE PROCESS SAFETY FUNDAMENTALS

These are safe operating principles related to hazardous chemicals to avoid spills, fire, explosion, exposure, or business interruption.

To establish Process Safety Excellence on chemical sites by enhancing awareness on typical hazardous operations and discussing the relevant details.

Understanding the challenges in the field and the good practices that help to get things right.

Select a limited number of PSF relevant for your operation to start; eventually expand in next steps with additional more specific PSF.

Use the PSF slide to start the discussion. It is the discussion that provides the understanding of where you really are and what can be improved!

Establish clear agreement & procedures on the discussed PSF

To get in the positive process safety mood, feel free to use this video made by Shell: https://www.youtube.com/watch?v=l9Fu4ydckGg

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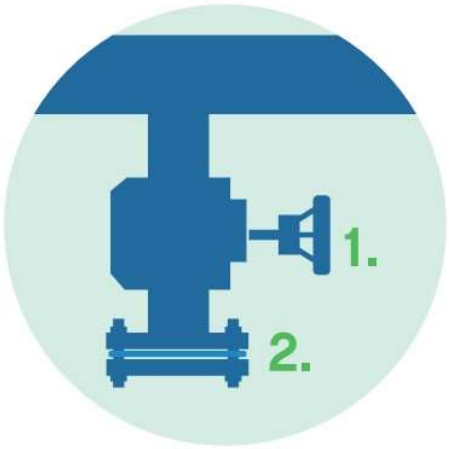

APPLY DOUBLE ISOLATION

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.

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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 re-energised: 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 Assessment 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.

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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.

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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.

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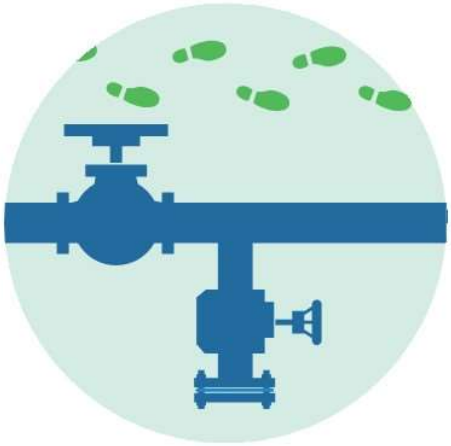

WALK THE LINE

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.

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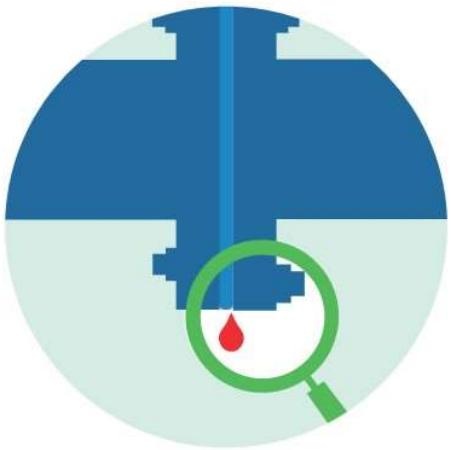

VERIFY LEAK TIGHTNESS AFTER MAINTENANCE WORK

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.

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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 de-energized.

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.

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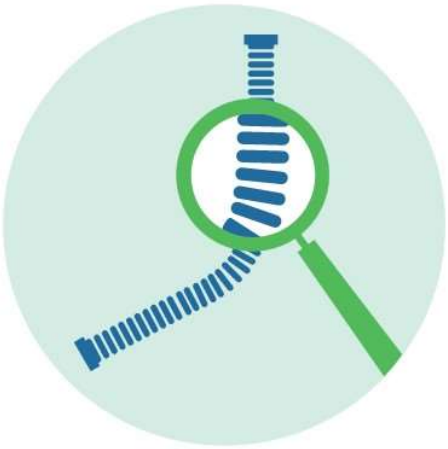

VERIFY THE CONDITION OF FLEXIBLE HOSES

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.

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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.

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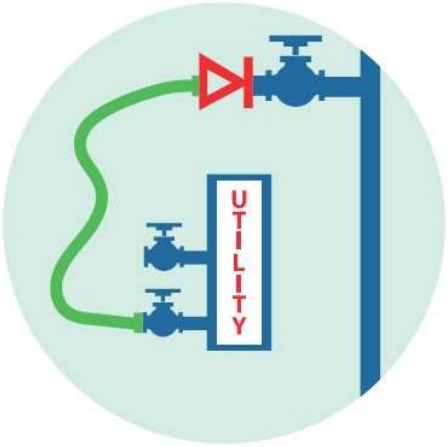

CONTROL UTILITY SYSTEMS CONNECTED TO A PROCESS

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.

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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.

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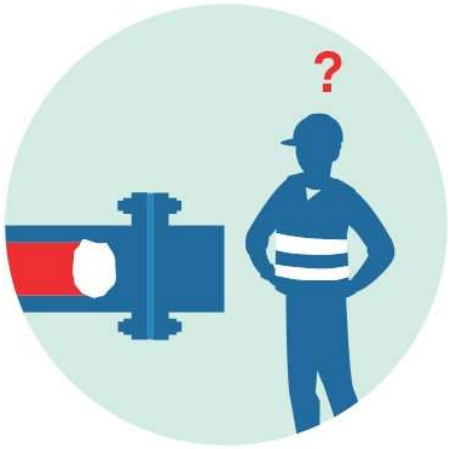

UNPLUGGING OF EQUIPMENT

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.

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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.

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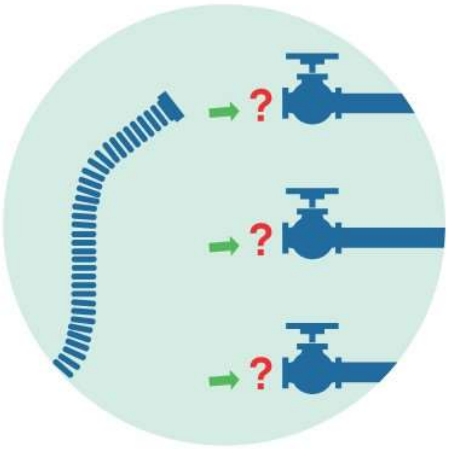

CONTROL (UN)LOADING

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.

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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.

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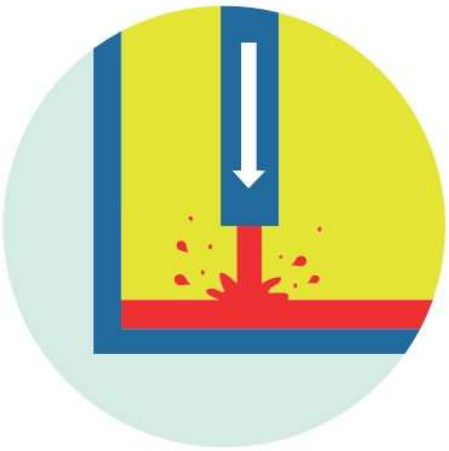

AVOID SPLASH LOADING

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.

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AVOID RUN-AWAY REACTION

Hazards

Bhopal & Seveso incidents occurred after an exothermic exponential runaway reaction started.

When important

- Exothermic batch reactions.
- Storage of reactive chemicals.
- Unexpected Polymerization or Decomposition.

Challenges in the Field

- Chemistry at increased temperature can be different or unknown to operators.
- Cooling can malfunction or might not be able to cope with the exponential increase of the reaction rate.

OPTIONS TO GET IT RIGHT

- Understand the chemistry and side reactions at abnormal conditions like elevated temperature.
- Understand the point where cooling can not cope with the exponential heat of the reaction (point of no return).
- Assure good design data is available on heat balance of all the reactions involved (like DSC curves).
- Understand the effect of malfunctioning cooling.
- Have a reactivity matrix available & make sure operators know the critical combinations of chemicals to avoid.
- Assure cooling is reliability and have back-up cooling available.
- Validate inhibitors are present as applicable.
- Have a last line of defence like Interlocks, Breaker plates, Bunkers.
- Have an emergency procedure: Run away in a runaway reaction!

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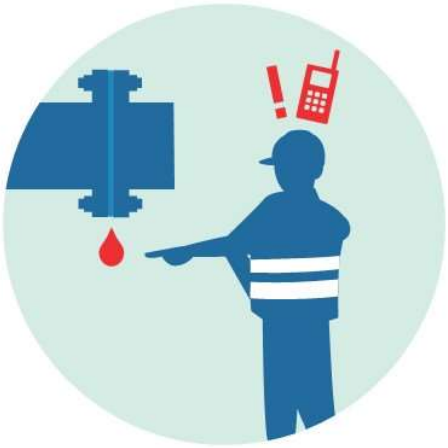

REPORT PROCESS SAFETY INCIDENTS

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.

THANKS TO:

This work has been made possible by the efforts of the following companies and EPSC work group participants:

COMPANY	NAME
BakerRisk	Robert Magraw
BASF	Thomas Müller
	Thomas Wolff
Bayer	Andreas Seidel
Covestro	Jörn Buhn
DOW	Osvaldo Fuente
DuPont	Pilar Eiroa
Eni	Antonio Mangini
	Stefano Pellino
EPSC	Tijs Koerts
Linde	Marianna Kuepfer
	Liana Marin
LyondellBasell	Martin de Zeeuw
MOL Group	Vojtech Merva
Nouryon	Johan Rood
OMV Petrom	Saadallah Harzalli
	Iulian Marin
Sabic	Marco van Pinxteren
Total	Dirk Roosendans
Vynova	Andreas Scholz

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THE PROCESS SAFETY NETWORK