



Process Safety Fundamentals



Acknowledgements

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About

Designed to support those working in front-line operations, maintenance, and on wells teams, the IOGP Process Safety Fundamentals are informed by data and designed to draw attention to situations that are most likely to lead to process safety event fatalities. They are therefore not intended to exhaustively address all process safety risks and hazards in the oil and gas industry, but to be deployed in addition to a company's underlying systems for process safety management.

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Process Safety Fundamentals

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Contents

Introduction	5	
1. The Process Safety Fundamentals	7	
2. Implementing the Process Safety Fundamentals	10	
3. Supporting information	14	
3.1 Guidance cards	14	
3.2 Data analysis	25	
3.3 Frequently Asked Questions (FAQs)	28	
3.4 Definitions	29	

Introduction

Data reported by IOGP Members over a period of ten years (2007-2017) shows that 128 people lost their lives in 56 process safety events. In response to this, the IOGP Process Safety Fundamentals (PSFs) have been developed to support companies as they seek to reduce, and ultimately eliminate, fatal and high severity process safety events.

Designed to support those working in front-line operations, maintenance, and on wells teams, the IOGP Process Safety Fundamentals are informed by data and designed to draw attention to situations that are most likely to lead to process safety event fatalities. They are therefore not intended to exhaustively address all process safety risks and hazards in the oil and gas industry, but to be deployed in addition to a company's underlying systems for process safety management.

Process safety is a disciplined framework for managing the integrity of operating systems and **processes** that handle hazardous substances. The goal of **process safety** and asset integrity is to prevent unplanned releases which could result in a major incident.

The content of the PSFs should be familiar to the industry, but presenting these concepts as this Report does offers a tool to enable the front line to get a clearer picture of what process safety means in their day-to-day activities.

IOGP PSFs are not intended to replace company management systems, policies, safe systems of work, safety training programs, operating procedures, or work instructions. In fact, they rely on these frameworks being in place.

PSFs are intended to be used in addition to the IOGP Life Saving Rules (LSRs): complementary but separate. It is not recommended that they are combined into a single list. Whereas the LSRs are primarily focused on personal safety events, albeit with some overlap into process safety, PSFs are specifically targeted at process safety hazards. Although there is some overlap between some LSRs and a PSF (e.g., Energy Isolation) the topic is retained within the PSFs to enable specific treatment of the process safety hazards.

A key success factor in using PSFs is the manner and tone in which they are presented. In this respect, there are some important differences compared to the way some companies deployed their Life-Saving Rules programs, as such programs have often been communicated and managed as mandatory requirements, with compliance strictly enforced.

The PSFs provide focus on supporting the front-line to enable successful process safety performance (see IOGP Report 456 – *Process safety - recommended practice on key performance indicators*). In some cases, trying to align with a PSF may prove difficult in practice, and employees should be encouraged to openly voice and report these dilemmas without fear of criticism. Bringing these issues into the open enables the company to decide on how to address the concern raised. It is important that front-line workers are given the flexibility to use the PSFs as a supportive tool to help improve process safety performance. The PSFs are not intended to be seen as 'another set of rules', and it is strongly advised that they are not associated with disciplinary measures for non-conformance. This approach to launching the PSFs may negate potential benefits that could be gained by the program.

This report presents a core set of ten PSFs. IOGP believes that these core items are relevant to all upstream operations. In some cases, companies may find it beneficial to add to the list based on local process safety challenges. A possible list of additional PSFs, based on existing member company deployments, is provided in Section 2.

Member company experience demonstrates that the PSFs and the Life Saving Rules can be used effectively in harmony with each other.

	Life-Saving Rules	Process Safety Fundamentals
Focus	Strong focus on personal safety with some overlap into process safety	Solely focused on process safety
Flexibility	Single common industry set recommended by IOGP	Core set recommended by IOGP, with flexibility to supplement or exchange a small number based on local process safety challenges

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While the IOGP PSFs have been developed based on upstream process safety events, IOGP believes that the PSFS are also applicable to downstream operations. Companies with downstream operations may want to consider including supplementary PSFs to address specific local issues. Fatal wells related process safety events are included in the analysis to develop the IOGP PSFs, so it is believed they are relevant to that area of operation. Companies who wish to apply to well operations may consider including supplementary PSFs to address well operational activities.

IOGP is seeking industry standardisation in recommending a core set of 10 PSFs. It is recognised, however, that some companies may wish to exchange a small number of the core set for others that are more tailored to their company specific operations and process safety challenges or to create standardisation on PSF across different businesses within an integrated company. In doing so, companies are encouraged to align with the core set as far as possible and exercise caution in removing core PSFs given they have been selected based on thorough data analysis.

As part of a continuous improvement cycle, IOGP intends to regularly seek feedback on the following;

- Effectiveness of the 10 core PSFs
- Other PSFs that have proved useful to IOGP Member companies
- Adaptations or supplementary PSFs that have been helpful to include downstream and wells activities

At appropriate intervals, IOGP may update the recommended PSFs based on real-world application feedback from IOGP Member companies.

It is intended that adoption of PSFs:

- Provides a focus for process safety at the front-line
- Enables process safety concerns to be raised and addressed
- Is a step towards industry-wide common language for process safety
- Helps companies to eliminate high severity process safety events

This document introduces the Process Safety Fundamentals, the supporting data analysis, and provides implementation guidance. Additional implementation resources will be available at www.iogp.org/psf.

1. The Process Safety Fundamentals



We respect hazards

- We improve our understanding of process safety hazards at our location and our roles in controlling them.
- We are vigilant about the potential impacts of uncontrolled process safety hazards.
- We discuss process safety hazards before starting a task.
- We bring forward process safety hazards to be included in activity risk assessments.

We apply procedures

- We use operating and maintenance procedures, even if we are familiar with the task.
- We discuss the key steps within a critical procedure before starting it.
- We pause before key steps and check readiness to progress.
- We stop, inform supervision and avoid workarounds if procedures are missing, unclear, unsafe, or cannot be followed.
- We take time to become familiar with, and practice, emergency procedures.

We sustain barriers

- We discuss the purpose of hardware and human barriers at our location.
- We evaluate how our tasks could impact process safety barriers.
- We speak up when barriers don't feel adequate.
- We perform our roles in maintaining barrier health and alert supervision to our concerns.
- We use an approval process for operations with degraded barriers.

We stay within operating limits

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- We discuss and use the approved operating limits for our location.
- We escalate where we cannot work within operating limits.
- We alert supervision if an alarm response action is unclear or the time to respond is inadequate.
- We obtain formal approval before changing operating limits.
- We confirm that potential for overpressure from temporary pressure sources has been addressed.



We maintain safe isolation

- We use isolation plans for the specific task, based on up-to-date information.
- We raise isolation concerns before the task starts and challenge when isolation plans cannot be executed.
- We check for residual pressure or process material before breaking containment.
- We monitor the integrity of isolations regularly and stop to reassess when change could affect an isolation integrity.
- We confirm leak-tightness before, during, and after reinstating equipment.

We walk the line

- We use up-to-date documentation (e.g., P&IDs¹) that accurately reflect installed systems and equipment.
- We physically confirm the system is ready for the intended activity (e.g., valve positions, line up of relief devices, etc.).
- We alert supervision to identified documentation and readiness issues before operation.

We control ignition sources

- We identify, eliminate, or control the full range of potential ignition sources during task risk assessments and during job preparation and execution.
- We minimise and challenge ignition sources even in "non-hazardous" areas.
- We eliminate ignition sources during breaking containment and start-up and shutdown operations.



We recognise change

- We look for and speak up about change.
- We discuss changes and involve others to identify the need for management of change (MOC).
- We review the MOC process for guidance on what triggers an MOC.
- We discuss and seek advice on change that occurs gradually over time.

¹ Piping and Instrumentation Diagrams



We stop if the unexpected occurs

- We discuss the work plan and what signals would tell us it is proceeding as expected.
- We pause and ask questions when signals and conditions are not as expected.
- We stop and alert supervision if the activity is not proceeding as expected.



We watch for weak signals

- We proactively look for indicators or signals that suggest future problems.
- We speak up about potential issues even if we are not sure they are important.
- We persistently explore the causes of changing indicators or unusual situations.

Guidance cards

A set of guidance cards to support implementation of the PSFs is available in Section 3.1. These have more detailed descriptions of the activities, definitions, and reference materials, and can support the understanding and implementation of the PSFs. Companies can use these to provide additional help and guidance to the front-line workforce, but they are more specifically intended for the supporting organisation, particularly supervisors and managers.

2. Implementing the Process Safety Fundamentals

A key success factor in using PSFs is the manner and tone in which they are rolled out. The following steps are suggested to be followed at site or plant level for the implementation of a PSF program:

Workshop with sponsors of the program

Sharing of PSF materials at site or plant level, with the involvement of interested groups and sponsors, can be a useful starting point. A half day workshop can be conducted with the participation of key representatives from HSE and Process Safety, Asset Integrity, Production, Operations, Maintenance, and Well Operations. In addition, the participation of senior management is fundamental to effective implementation of the program, sending a clear message that process safety involves everyone, and is not left to front-line workers alone.

The workshop can have the two main objectives. Firstly, the presentation of the PSF content and program. Secondly, through an interactive approach, to collecting feedback from the front line about how the PSFs can be effectively implemented in their field/plant.

Examples of the questions which could be used to encourage open discussion include:

- Why are PSFs important to you and the company?
- How can PSFs be effectively implemented in your location?
- What needs to be changed to enhance process safety improvement?
- How can leadership support the front line in using the PSFs?

One outcome from the engagement workshop can be to formally agree a proposed plan for PSF implementation based on the steps set out below.

Analysis and promotion

One or more PSF Promoters or Champions can be identified to coordinate rollout. Based on the local context, companies are strongly encouraged to honour the 10 core PSFs as much as possible, but have the flexibility to integrate additional PSFs (or exchange a small number of the core 10) based on specific local process safety challenges. Companies should be cautious about removing any of the core 10 PSFs as these have been selected using systematic data analysis of fatal events. And adoption of the core set will help drive industry standardisation and language around process safety. If, however, companies do choose to exchange one or more of the core PSFs, this should be supported with a thorough analysis of its internal incident and leading indicator data related to actual or potential high consequence process safety events.

Dedicated coaching sessions on the PSFs are encouraged, to be facilitated by the Promoters/Champions, with the purpose of further enabling front-line workers to understand the scope and objectives of the PSF program. The sessions can also provide clarification on the meaning of each PSF and promote discussion of potential front-line dilemmas. Data analysis on which the selection of the PSFs is based can be shared and opinions and suggestions from the front line can be collected.

The amount of time needed to complete the Analysis and Promotion phase can be variable depending on a variety of factors, such as the size of the organisation involved (one site vs. multiple sites, small or simple asset vs. large or complex asset, etc.), the type of agreements in place and number of involved parties (Production Sharing Agreements, Joint Ventures, etc.). 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.

Rollout

The rollout phase of the PSF program should be viewed as an ongoing engagement of the whole organisation. Each organisation can adopt the most suitable tools and approaches, including:

Awareness campaigns: ongoing sharing of the PSFs with the front-line workforce, referencing real events that have occurred at site level, but also taking into account lessons learned and other available material from the industry.

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 its importance and the roles played by employees in preventing undesired process safety events.

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.

Booklets/brochures: A pocket-sized booklet covering the PSFs can be a helpful resource to maintain awareness of PSFs and be used to prompt process safety discussion, for example during toolbox talks, or during operational site visits by managers and supervisors.

Recognition and interventions: Site hazard observation cards contain the PSFs, and use of the PSFs is encouraged by company programmes that recognise and award workers for utilising the PSFs. PSFs may also be included in the pre-job Toolbox Talks materials, helping to increase understanding of the required controls to be applied before starting work.

Site visits and inspection program: dedicated site visits should be conducted by supervisors and managers to support implementation of the PSFs; dilemmas raised by front-line workers can then be addressed to facilitate continual improvement in process safety performance.

Integration into contractual agreements: the PSFs adopted inside the Company can be referenced in tender documentation, not necessarily as a standalone document, but in a suitable way that ensures Contractors working on the Company's sites are fully aware that PSFs are part of Company policies/procedures.

Integration into existing systems and processes: implementation of PSFs can be made more efficient and sustainable by integration of the associated activities and communication into existing systems and processes (e.g., shift routines, maintenance planning, permit to work activities).

Monitoring and follow-up

Some time may be needed to measure the outcomes of implementing PSFs in a company.

As fatal process safety events (PSEs) are relatively rare in any one company, it may be more informative to observe process safety improvement in loss of primary containment and process safety near miss data. An analysis including the trends of leading process safety indicators may also offer more immediate indications of improvement.

When monitoring process safety trends within a company, consideration of different categories can be made, and events associated with design integrity, technical integrity or operating integrity can be excluded. PSFs are specifically focused on events associated with operating integrity.

While it may take several years to identify a statistical PSE reduction, a more immediate step change will be more likely visible in terms of increased front-line awareness, competence and engagement in process safety.

In the short term, consideration can be given to collecting near miss events and site improvement suggestions that are tracked to resolution, in order to support the workforce in their engagement with the PSFs and monitor the health of the program.

Additionally, it can be useful to collect data on situations where it was not possible for the front line to satisfy the intent of the PSF: for example, due to the existing design of the facility or absence of a comparable process. Collecting this data enables the company to identify variations in design and process and where needed make changes, such as engineering modifications, to further support PSF implementation but also to enable improvements to process safety. In turn, this can also serve to encourage front-line staff in their use of the PSF in daily operations such as during tool box talks, and permit to work meetings and to continue to report situations in which the PSFs are difficult to achieve with reasoning.

Potential additional PSFs

Additional PSFs have been established by IOGP Members within their production, refining, and well related operations, examples of which are listed below. Many of the topics covered by these other PSFs are covered (directly or indirectly) by the IOGP recommended PSFs; however, companies may choose to adopt or adapt versions of these to complement the core set of PSFs recommended by IOGP:

Operations

- We attend to open drains and critical transfers.
- We use at least two independent barriers for pressure containment and material process flow.
- We control utility systems connected to a process.
- We perform thorough shift handover.
- We check the absence of an explosive atmosphere in the furnace before igniting the burners.
- We stay out of the Line of Fire.
- We avoid splash loading.
- We remove non-essential workers from hazards.
- We practice emergency response procedures.
- We report incidents and near misses investigate, share and learn.

Wells

- We check well control equipment and confirm it is certified and tested.
- We ensure effective well isolation, with at least two barriers, when working downstream of a well.
- We "Walk the line" on temporary rig-ups and confirm setup against the layout drawing



3. Supporting information

3.1 Guidance cards

WE RESPECT HAZARDS

Incident investigations show that lack of hazard awareness is an underlying cause of many process safety events. It is important that we understand the process safety hazards that we face at our facilities and be aware of the harm they could generate if we lose control of them. Typical hazards include flammable liquids and vapours, combustibles, toxic chemicals, asphyxiants, corrosives, pyrophorics, and high pressure/temperature.

When we routinely work close to process safety hazards it is easy to become desensitised to them. Some companies call this risk normalisation. This can lead to us not treating the hazard with sufficient respect and us being less thorough about how we control them. Often, people underestimate the potential impact of process safety hazards, particularly if they have not been directly involved with a major accident. Pictures or videos of previous process safety incidents can help to reinforce the sheer size of the potential consequences of our hazards. It is good for teams to discuss the process safety hazards at their facility and whether they fully understand the potential impacts. It can be helpful to ask your company's process safety specialists to explain the facility's process safety studies.

Another common concern is that it can be easy to focus on personal safety issues at the expense of process safety. Sometimes personal safety issues are more obvious and readily spotted and that can lead to process safety hazards being missed. It is important to recognise that both personal and process safety are vitally important and that we need to give due attention to both. Teams are encouraged to be alert for risk assessments that do not cover all the process safety risks associated with an activity.

Depending on your company management systems and legislative framework you will find guidance on major hazard analysis in documents such as: Safety Cases, PHAs (Process Hazard Analysis), Safety Reports, Corporate Risk summaries, and other internal resources.



Tips for Managers:

Take time to discuss major accident hazards with frontline workers.

Check that risk assessments address both personal and process safety hazards.

Encourage front-line workers not to become desensitized to process safety hazards.

Additional guidance:

- Energy Institute:
 <u>Reflective Learning video</u>
 _ 'Removing the hazards'
- Step Change in Safety: <u>Major Accident Hazard</u> <u>Understanding videos and</u> <u>tool packs</u>
- Safer Together videos and other tools
- CCPS Beacon <u>August 2019</u>
- US Chemical Safety
 Board: <u>Preliminary</u>
 <u>Animation of Philadelphia</u>
 <u>Energy Solutions Refinery</u>
 <u>Fire and Explosions</u>
- US Chemical Safety
 Board: <u>Winterization</u>
 Safety Message

WE APPLY PROCEDURES

Many of the operations or activities we perform on our facilities are complex and/or have the potential to release hazardous materials if they are not performed correctly. Step by step procedures are developed to perform these tasks safely and prevent unwanted or hazardous situations. It is good practice to use procedures on site and use job aids (e.g., sign off) to confirm that key steps have been completed in the correct sequence as the activity proceeds. Each company or asset may want to consider which of its activities or tasks are "critical" and require the higher level of assurance that "sign off" for each step of a procedure gives to the process. Typically, activities such as startup/shutdown of a facility, or particularly hazardous activities like pigging, are considered "critical" procedures.

Before starting a procedure, it is good practice to discuss the task ahead and how it is expected to proceed. The team involved can discuss the key steps, particularly those which are irreversible, and what will be expected at those stages to confirm readiness to proceed further.

In most cases existing procedures will be accurate, however if you identify issues with the quality or completeness of the procedures such as a lack of clarity on a task or missing/incorrect data, then this should be raised so they can be addressed as part of your MOC process.

It is easy to become complacent about an activity that has been performed many times before without hazardous or unwanted outcomes. However, no matter how experienced we are, it is easy to make a mistake, and therefore it is important to apply the procedures thoroughly, every time.

If you cannot complete or follow the procedure as it is currently written or you think there is an issue with the procedure, halt the activity and raise the issue with your supervisor. If you think there is a better way of performing an activity/task discuss it with your supervisor and raise a formal change request.

Sometimes an activity or operation is not completed in one shift, and it therefore is important to ensure there is an effective shift handover process so that the new shift has accurate knowledge of the status of operations and any issues they should be aware of.

If a hazardous situation occurs, it is also important to understand and apply emergency response procedures. These need to be readily usable in more stressful situations and regular practice drills help to reinforce understanding and familiarity.



Tips for Managers:

Verify that procedures are up-to-date, effective, and easy to use.

Follow up if concerns about a procedure are raised.

Ensure that personnel have time to become familiar with the plant, its equipment, and its procedures.

Discuss Emergency Response procedures with front-line staff during site visits.

Additional guidance:

Refer to local company guidance on procedures and consider linking to Human Factors guidance

Center for Chemical Process Safety (CCPS). *Guidelines for Writing Effective Operating and Maintenance Procedures.* New York. 1996.

US Chemical Safety Board: Fire in Baton Rouge

WE SUSTAIN BARRIERS

Most companies find it helpful to think about the mental model of the barriers that we use to control process safety hazards. A barrier is a risk control that prevents unintended events from occurring or stops escalation to harmful consequences.

We can think about barriers as being either hardware or human barriers. Hardware barriers include primary containment, process equipment, and engineered systems designed and managed to prevent hazardous releases or mitigate their consequences. Although people are involved with maintaining and testing hardware barriers, they do not rely on someone taking action when a demand is placed on the barrier. Human barriers, however, do rely on the actions of people when a demand is placed on the barrier, for example response to a process alarm. Both types of barrier are important, but hardware barriers are typically considered to have greater reliability, if maintained correctly.

It is good for front-line teams to understand and discuss the barriers that are in place on their facility, and how reliable and effective they are. It is important that individuals feel able to speak-up if they believe that a barrier is weak or adequate. This can be also be done by practicing independent verification by coworkers.

Many find that a bowtie diagram is a helpful visual aid when having this conversation. Another helpful tool is to develop and provide a simplified scenario diagram showing the equipment and important barriers contained within the scenario.

Understanding the role that barriers play, and what could potentially happen if a barrier fails, is important as it allows teams and individuals to understand the influence they have in sustaining barrier health.

Process safety events can result from degraded or failed barriers. Degraded barriers include those that are inhibited, overridden, bypassed, unreliable or unavailable. These should be addressed without delay and normally require approval for continued operations. Often front-line workers will play a key role in sustaining and monitoring any additional mitigations that are put in place whilst a degraded barrier is being restored.



Tips for Managers:

Provide tools (e.g., bowties) to enable front-line workers to understand and visualise the process safety barriers at their location.

Discuss process safety barriers with front-line workers during site visits.

Ensure that systematic barrier management processes are in place and that necessary resources are allocated to test and maintain barriers.

Implement approved risk reduction measures for degraded or failed barriers and restore barrier functionality as soon as practical.

Additional guidance:

Energy Institute: Reflective Learning: <u>I own my barrier</u>

Reflective learning: <u>I keep my barrier strong</u>

US Chemical Safety Board: Animation of April 26, 2018, Explosion and Fire at the Husky Energy Refinery in Superior, Wisconsin

US Chemical Safety Board: <u>Blowout in Oklahoma</u>

Safer Together Process Safety: We all have a part to play

WE STAY WITHIN OPERATING LIMITS

Equipment operated with process conditions (e.g., temperature, pressure, level, flowrate) outside of safe operating limits (high or low) can result in unstable and unpredictable operation and the potential for process safety incidents. It is therefore important to understand the operating limits of the plant and stay within that operating envelope. It is useful for teams to discuss how these limits are documented at their site and whether the limits are clear and available.

Overfilling and overpressure are the most common operating limit excursions that lead to process safety incidents. One common type of fatal process safety related incident occurs when a temporary source of high pressure (e.g., pump, compressor, nitrogen bottle, etc.) is connected to the process with inadequate overpressure protection. This can lead to catastrophic failure impacting those working in the area even if the release does not ignite. Teams are encouraged to think about occasions when temporary pressure sources are used at their facilities and confirm that strong process safety barriers are present. Bear in mind that these are usually abnormal activities when regular barriers may not be in place.

IOGP Tier 1 process safety data also includes many examples of overfilling events. Confirming sufficient capacity for material transfers and monitoring the transfer whilst it progresses are important aspects of staying within the operating limits for level. Teams can discuss the potential for overfilling at their facility and whether the requirement for monitoring transfers are realistic given other workload and distractions.

Some potential operating limit excursions are less obvious for example:

- Change in fluid composition with the potential for corrosion and/ or erosion. This could be sudden (e.g., sand breakthrough from a well) or gradual (e.g., increasing water or hydrogen sulphide content of well fluids).
- Velocity changes due to lower operating pressure leading to excessive vibration or erosion.

Teams can discuss other potential operating limit excursions relevant to their facility. Where there are concerns, advice should be sought from supervision and support groups. While there is always a desire to return to normal operation as soon as possible it is imperative to investigate and understand the causes of an excursion to enable prevention of reoccurrence.



Tips for Managers:

Establish and document safe operating limits for key process variables and make them visible to front-line workers.

Regularly check that personnel have the necessary skills and knowledge to stay within operating limits.

Systematically investigate excursions outside operating limits.

Demonstrate through decisions that cost, production or schedule does not override safety

Additional guidance:

- IOGP Report 456 Process Safety – recommended practice on key performance indicators
- Center for Chemical Process Safety Beacon (November 2007): <u>Cold Embrittlement and</u> <u>Thermal Stress</u>
- US Chemical Safety
 Board: <u>Anatomy of a</u>
 <u>disaster</u>

WE MAINTAIN SAFE ISOLATION

It is important for every activity that requires breaking containment, that an appropriate isolation plan for the specific activity is used and followed. Some process safety incidents have occurred when an isolation plan for a similar (but not identical) task has been used but did not address all the relevant hazards. Isolation plans should therefore match the particular task and be based on up-to-date process safety information (e.g., P&IDs).

It is good practice to discuss isolation tasks and to raise concerns before the task begins. This enables concerns to be raised and resolved safely.

If for some reason the isolations cannot be executed as planned, you should stop work and seek advice from your supervisor on how to proceed safely.

Concerns raised might include isolations that do not achieve positive isolation, quantities of drained materials that are more or less than expected, or indications of the presence of significant residual pressure or material.

After breaking containment, it is important to remain vigilant to potential signs that might indicate that the effectiveness of the isolations, venting or draining arrangements have changed. This could include difficulties with proceeding with a task (e.g., due to trapped pressure or vacuum), more liquids arising, new smells, etc.

- Always make sure that you are either in sight of, or in control of the isolations you are using for your job. Before putting equipment back into service, it is important to verify that the system is mechanically complete using your local practices.
- Be vigilant about potential false pressure indications (e.g., line plugs, hydrates, etc.).
- Before introducing hydrocarbons, it is good practice to perform a gross leak test where possible.



Tips for Managers:

Monitor isolation practice at your location to verify that your local practice is safe and effective. Implement improvement where issues are identified.

Respond and follow up if isolation concerns are raised.

Regularly check that those performing isolations are effectively trained and supported.

More information on good practice related to this PSF can be found either in your local management system/procedures or in the following industry guidance:

Additional guidance:

UK Health and Safety Executive – <u>The safe isolation</u> of plant and equipment

WE WALK THE LINE

To avoid releases of hydrocarbons and other chemicals, we often need to check that our process systems are ready for the next stage of intended operation. Many fatal incidents in the IOGP process safety fatality data have occurred when the process system was used but its condition was not as intended. This could be a valve inadvertently left in the wrong position, a drain or vent left unplugged, or a piping joint not fully tightened. It is therefore important to check that systems are in good condition and correctly set-up each time we start them up or make a significant change in their use. This involves a physical, systematic inspection of the system in the field, sometimes in tandem with monitoring from the control room.

It is important that the process safety information (e.g., P&IDs) that we use to confirm readiness, is accurate and up to date.

Physically checking systems is not always easy due to difficulties in access or visibility. Teams are encouraged to discuss the challenges of performing thorough walk the line checks and alert supervision to readiness or documentation concerns.

Examples of when to walk the line include:

- Material Transfers
- Equipment changes
- Handover from another work group
- Manual change in operational state equipment idled on another shift
- Start-up after prolonged outage
- Changing direction of flow
- Return to operation after maintenance or turnaround.
- Changeover of equipment (e.g. relief valves, filters, pumps, compressors)
- Batch operations (e.g., pigging, bed regeneration)
- Temporary pipework in wells operations

What should we do: We physically verify the system is ready for intended operation, for example:

- P&IDs and other relevant information are consulted.
- Equipment and safeguards are installed correctly and functioning.
- Plugs, drain valves, blinds and spades are installed.
- Locked open/closed valves are in correct position.
- Relief routes are not blocked.
- Unintended routes to atmosphere are isolated.
- Pressure is verified.
- If necessary, clear communication between the control room and the field is maintained (e.g. confirming equipment tags before performing an operation).



Tips for Managers:

Regularly confirm that process safety information is accurate and up to date.

Discuss walk the line issues with front-line workers and follow up on concerns raised.

Additional guidance:

 Center for Chemical Process Safety Beacon (August 2015): Operational Readiness

WE CONTROL IGNITION SOURCES

If a hydrocarbon release does occur, we can often reduce or eliminate the worst of the potential consequences by avoiding ignition. About half of the fatal process safety incidents reviewed involved ignition, so minimizing the likelihood of ignition can make a big difference in avoiding fatalities. Some sources of ignition may be quite obvious, like hot work or nearby fired heaters, but others are less clear. The fatal incidents in the IOGP data show that ignition sources include hot work, static electricity, pyrophoric materials, ingestion into generators or other fired equipment, hot surfaces, lightning, defective electrical equipment and vehicles. Staff are therefore encouraged to understand the full range of potential ignition sources that are relevant to their facility and the measures in place to control them.

Use of hazardous area classification/zoning is widespread in the industry. But users should bear in mind that the flammable cloud from larger releases can extend far beyond the classified/zoned areas shown on the area classification drawings. It is important to recognise this, particularly if doing work in areas that are outside the formally classified areas. The likelihood of getting a flammable cloud in these areas may be low, but that does not mean that it cannot happen. Risk assessments and risk control measures will need to take this into account.

In preparing for and conducting work activities, consider and act on the following:

- Ignition sources can include vehicles, open flames, grinding tools, pyrophoric materials, electrical equipment, hot surfaces, lightning, static electricity, and other portable electrical equipment.
- Reporting of defects in electrical equipment and other potential ignition sources, such as cladding on hot surfaces, damaged EX equipment, open wires, damaged grounding aids, is important in controlling potential ignition.
- Vehicle entry into areas with the potential for flammable release should be avoided where practical. If that is not practical, vehicle entries should be minimized and controlled.
- Control of work risk assessments should evaluate the potential for flammable hazards even outside classified/zoned areas shown on the area classification drawing.



Tips for Managers:

Regularly check that personnel understand the full range of potential ignition sources and the requirements for ignition source control.

Additional guidance:

- IEC 60 079 series
- ANSI/API RP 505
- El Model Code of Safe Practice 15 -Area classification for installations handling flammable fluids
- Center for Chemical Process Safety Beacon (August 2016): <u>A little</u> static can cause a big fire!
- Center for Chemical Process Safety Beacon (August 2014): <u>Ignition Sources</u>

WE RECOGNISE CHANGE

Management of change (MOC) failure has been recognised for a long time in the oil and gas industry as being a cause of process safety incidents. It is normal for companies to have a management of change process in place, but despite this, the IOGP fatality data indicates that MOC continues to be linked to many fatal accidents. Most typically this is when a change was made without passing it through the MOC process, meaning that it did not get thoroughly reviewed and risk assessed. This can be because it was not realised that the change needed a MOC, so it is important that teams understand and are sensitive to what changes need to pass through the MOC process. This enables them to look out for change and speak up if they see a change occurring that they think should be managed by the MOC process.

Whilst it is expected that companies will have an MOC process in place already, this PSF focusses on recognising change that needs to be subject to MOC. Sometimes changes that might appear quite small can have a large impact on process safety, either by introducing new hazards or degrading existing barriers. It is good for teams to discuss changes at their location and to involve others to help identify whether management of change is needed.

Change, which can be permanent, temporary or emergency, is not limited to hardware modifications and can typically include:

- Operating or maintenance procedure revisions
- Changes to operating limits
- Changes to process operating conditions (e.g., temperature, pressure, flowrate, composition)
- Equipment changes (non like-for-like replacement)
- Change of chemicals or materials

Teams can review their local MOC process for guidance on what triggers their MOC process and discuss examples at their location. It is recognised that there may be pressure to "get work done" but experience has shown that change must be systematically managed in all situations to avoid unwanted incidents.

It is also important to remain alert to change that occurs slowly, perhaps over many years. This "creeping change" (e.g., gradual change in process fluid composition or gradual reduction in a team's experience level) also requires evaluation. Taking time out to discuss creeping change or perhaps the impact of multiple small changes on the same system, can be useful in avoiding incidents and teams can seek advice or alert supervision if they have concerns.



Tips for Managers:

Verify that systematic identification and management of change processes are in place and working effectively.

Ensure that workforce personnel and management are trained to recognize change.

Additional guidance:

Energy Institute, CCPS, OSHA, Process Safety Management Systems

Center for Chemical Process Safety Beacon (July 2017): <u>Management of Change</u>

Center for Chemical Process Safety Beacon (September 2016): <u>Can you recognize a</u> <u>change?</u>

Center for Chemical Process Safety Beacon (October 2012): <u>Manage Temporary</u> Changes!

US Chemical Safety Board: <u>Fire from ice</u>

US Chemical Safety Board: <u>Blocked in</u>

US Chemical Safety Board: <u>"CSB Safety Bulletin Says</u> <u>"Managing Change" Is</u> <u>Essential to Safe Chemical</u> <u>Process Operations"</u>. August 28, 2001.

WE STOP IF THE UNEXPECTED OCCURS

We normally plan our activities carefully, thinking about how we expect the activity to proceed and what could potentially go wrong. However, in real life there are times when things do not occur as planned or expected.

Often process safety incidents have occurred when an activity has deviated from the expected path, but those involved have continued anyway or informally adapted the plan on-the-run. While this may be well-intended, to get the job done, it has the potential to lead down a path that has not been fully evaluated and risk assessed.

This process safety fundamental highlights the importance of recognizing when things are not progressing as expected and being disciplined about stopping or pausing to understand what has changed and why things are not as planned. Often this may need a change to the plan or an update of the risk assessment, or it may prompt consultation with others to seek specialist input. We should be ready to speak up and challenge in unexpected situations and engage with supervision to discuss our concerns. Pausing or stopping a task may feel inconvenient at the time but keeping an activity on plan and under control will avoid incidents, keep people safe, and support good business performance.



Tips for Managers:

Positively recognize people who stop to reevaluate a task if it is not going as planned.

Communicate to front-line workers that they should pause and seek guidance if an activity is not proceeding as expected.

Additional guidance:

Center for Chemical
 Process Safety Beacon
 (July 2014): <u>Persistence –
 Good or Bad?</u>

WE WATCH FOR WEAK SIGNALS

One characteristic of most major process safety incidents is that before they occurred, there were noticeable indications that a problem was developing. Examples of weak signals include unusual vibration, ice unexpectedly forming on the outside of a pipe, weeps and seeps, passing valves, reoccurring alarms, or abnormal field readings. It is good practice for teams to discuss examples of weak signals that they have seen in their facility.

The key is to identify these "weak signals" and respond to them before something more serious occurs. Front-line workers are often those best placed to pick up on weak signals as they become very familiar with what is normal and what is not. Personnel are therefore encouraged to remain alert to these signals, even if they seem unimportant, so that they can be discussed and evaluated.

Operator rounds, visual inspections or just going about our routine work at site, are times when we can use our eyes and ears to remain alert to anything that seems out of place or different.

When weak signals are identified and reported it can be tempting to dismiss them too readily. Weak signals can be a vital opportunity to act early to avoid an accident, so it is important that they are persistently explored to understand the cause.

It is important to remain constantly aware of the potential for process safety incidents. Some companies describe this as maintaining a state of "chronic unease". Always being aware of our vulnerability to a process safety event helps us to avoid having one!



Tips for Managers:

Be alert to weak signals and respond pro-actively when these signals are raised.

Additional guidance:

Energy Institute Reflective Learning Tools: Chronic unease

International Association of Oil and Gas Producers: <u>Weak signals video</u>

3.2 Data analysis

Data reported by IOGP Members over a period of ten years (2007-2017) shows that 128 people lost their lives in 56 Process Safety Events (PSEs).

Analysis of the process safety related fatal incidents was conducted by a team formed from the IOGP Process Safety Subcommittee (PSSC) with the aim of determining what types of Process Safety Fundamentals (PSFs) were a factor in the incidents and how, if they had been implemented effectively, they might have prevented or mitigated the fatal consequences of these incidents.

The analysis considered a broad range of potential PSFs influenced by both the information on the fatal incidents provided by IOGP members and members experience. Each fatal PSE was reviewed against the list of potential PSFs and linked to one or more of the PSFs. By determining which of the PSFs could be linked to either the highest number of fatal incidents or number of fatalities allowed a shortlist of PSFs to be identified which eventually became the 10 IOGP PSFs.

Figure 2 shows the proportion of fatal PSEs that can be linked to the 10 IOGP PSFs. For the 47 incidents where the IOGP members had provided sufficient details on the incidents to allow an assessment to be completed, 43 of these incidents could be linked to at least one of the 10 IOGP PSFs. Three of the remaining four incidents could potentially be linked to other PSFs not included in the IOGP set of ten, and only one of the fatal PSEs had no links to any potential PSFs.



Not linked to one of the 10 PSFs:

Figure 1: Proportion of Fatal PSEs linked to one of the PSFs

Figure 2 shows how the 43 fatal PSEs were linked to each of the PSFs. In the initial analysis it was identified that some incidents could be linked to more than one of the PSFs. For the purposes of clarity, the chart shows the PSF that was considered the primary PSF involved in the incident.

Two of the ten PSFs - "Respect hazards" and "Report weak signals" - were not included in the original data analysis but were added later in the selection process as it became clear that they were considered an underlying cause of many of the incidents.



Figure 2: Number of Fatal PSEs linked to one of the PSFs

For the 47 incidents included in the analysis, there were a total of 79 fatalities associated with these incidents. The number of fatalities that could be linked to each of the PSFs are shown in Figure 3.



Figure 3: Number of Fatalities linked to one of the PSFs

Figures 2 and 3 show that the following three PSFs are linked to both the largest number of fatal incidents and the largest number of fatalities:

- Maintain safe isolation
- Control ignition sources
- Recognise change

In addition to looking at the fatal PSEs, a similar exercise was also performed on a different data set, the non-fatal Tier 1 PSEs from 2017. The data submitted by IOGP members on Tier 1 PSEs for 2017 was reviewed to identify those PSEs which were considered to have a higher potential for multiple fatalities if circumstances had been different at the time of the incident. After this initial review a total of 124 incidents with sufficient information to make an assessment were taken forward to be reviewed against the PSFs.

Figure 4 shows that the proportion of non-fatal Tier 1 PSEs that could be linked to one or more of the PSFs was 45% which is lower than that for the fatal PSEs. This is because the Tier 1 dataset includes a higher proportion of mechanical failure type events such as corrosion and erosion; these types of events are not the primary target of the PSFs. The chart shows that even though the PSFs are targeted at eliminating fatal PSEs, they will also have an influence on a good proportion of non-fatal PSEs.



Figure 4: Number of High Potential 2017 Tier 1 PSEs linked to one of the PSFs

Figure 5 shows the combined analysis for both fatal and non-fatal PSEs. This shows that when non-fatal PSEs are considered, the "Apply Procedures" PSF has the largest number of incidents linked to it.



Figure 5: Number of Fatal and Non-Fatal PSEs linked to a PSF

3.3 Frequently Asked Questions (FAQs)

- 1) What are the Process Safety Fundamentals? The Process Safety Fundamentals (PSFs) are a set of basic principles for front-line workers, supervisors, and managers that emphasise existing good practices to prevent fatalities from Process Safety Events. Preventing Process Safety Events is important because they can escalate into catastrophic events.
- 2) Why use the Process Safety Fundamentals? PSF are different than and complementary to programs such as IOGP's Life-Saving Rules, which focus on personal safety. The PSF program aims to enable front-line workers to raise concerns openly and transparently. It is expected that it may not always be possible to follow a particular PSF, but with the PSFs the front-line is empowered to raise issues and dilemmas, helping to ensure effective Process Safety Management, including potential engineering modifications to address the issues raised.
- 3) Is implementation of the PSFs mandatory for IOGP Members? No IOGP guidance is mandatory for Members. Annual data reported by IOGP Members shows an average 5 fatal Process Safety Events per year. IOGP developed a set of Process Safety Fundamentals tailored to eliminate such events and help the industry to achieve zero fatalities. IOGP encourages Members and the wider industry to implement the PSFs.

3.4 Definitions

Key Steps in Operation or Maintenance Procedure – A procedure step, series of steps, or action that, if performed improperly, will cause irreversible harm to plant, equipment, or people or will significantly impact plant operation. It is also known as "Critical Steps".

Safe Isolation – the separation of plant and equipment from every source of energy (pressure, electrical, and mechanical) in such a way that the separation is secure. Non-proved isolation methods (i.e., without provision to confirm effectiveness of the isolation) shall not be considered a safe isolation when dealing with hazardous conditions (e.g. hazardous substances, pressure, temperature, etc.).

Hazardous Material – Materials that can cause harm, for example by igniting or being toxic. API 754 and IOGP Report 456 refer to the United Nations Recommendations on the Transport of Dangerous Goods.

Like for Like equipment change – changes that are a "replacement in kind" which means to replace with the same design, same materials of construction and so on.

Safe Operating Limit (SOL) – Limits established for process parameters, such as temperature, pressure, level, flow, or concentration, based on a combination of equipment design limits and the dynamics of the process. For further reading refer to IOGP Report 456 – *Process safety – recommended practice on key performance indicators.*

Walk the line – Walk the Line is a practice sharing program that provides a variety of tools to help ensure that operators know where energy will flow between two points in a process. Typical activities for walk the line to be applied:

- Return to operation after maintenance or turnaround
- Changeover of equipment (e.g., relief valves, filters, pumps, compressors)
- Transfer of fluids (e.g., loading operations)
- Sequential or batch operations (e.g., pigging, bed regeneration)
- Temporary pipework

Hardware Barrier – Primary containment, process equipment and engineered systems designed and managed to prevent LOPC (Loss of Primary Containment) and other types of asset integrity or process safety events and mitigate any potential consequences of such events. These are checked and maintained by people (in critical activity/tasks). For further reading refer to IOGP Report 544 – *Standardization of barrier definitions*.

Human Barriers – Barriers that rely on the actions of people capable of carrying out activities designed to prevent LOPC and other types of asset integrity or process safety events and mitigate any potential consequences of such events. For further reading refer to IOGP Report - 544 Standardization of barrier definitions.

Weak signals – Weak signals are 'tell-tale" signs, which are not as per normal operating conditions of a given plant. There are various method to identify and report "weak signals" such as Behavioural Based Safety, near miss programs etc. A constant status of alertness to weak signals, such as asking the right questions and picking up on signals of potential failure when on site is a key behaviour for safety leaders at every level in the organization to help reduce the risk of incidents.

Risk Normalisation – The tendency to underestimate a risk that has become familiar, and is associated with tasks that we undertake regularly without incident. If someone deviates from safe practices on one occasion, it increases the likelihood they'll do it again, and again, until this unsafe behaviour becomes routine and accepted. This gradual justification and acceptance of unsafe behaviour can happen to any individual or organisation and vigilance is required to ensure that established safe practice is maintained.

Hazardous Area Classification (HAC) – Any place in which an ignitable concentration of flammable gases or vapours may occur in quantities such as to require special precautions to protect the safety of workers and plant. In this context, 'special precautions' is best taken as relating to the construction, installation, and use of apparatus. It should be noted there is limitation with HAC, whereby migration of flammable material (gas dispersion) can occur beyond limits of HAC.

Abnormal Situation – An abnormal situation is a disturbance or series of disturbances in a process that causes plant operations to deviate from their normal operating state (for further reading on normal operating limit refer to IOGP Report 456 – *Process safety* – *recommended practice on key performance indicators*). The disturbances may be minimal or catastrophic, and may cause production losses or, in serious cases, endanger human life.

Up-to-date P&IDs – Updated set of drawings (piping and instrumentation diagram, P&ID) reflecting the current and real plant status. Usually submitted by a contractor upon completion of a construction project and used in operations phase. It is also known as Red-Line Mark-Up or As-Built P&IDs.

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Designed to support those working in front-line operations, maintenance, and on wells teams, the IOGP Process Safety Fundamentals are informed by data and designed to draw attention to situations that are most likely to lead to process safety event fatalities. They are therefore not intended to exhaustively address all process safety risks and hazards in the oil and gas industry, but to be deployed in addition to a company's underlying systems for process safety management.