Process Safety and the ISC

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Purpose

The purpose of this document is to establish common terms for use within the IChemE safety centre. This will facilitate effective communication between members, who may have differing terms or language in their own organisation. It is not anticipated that these common terms will necessarily be adopted and implemented within the member companies, this would be an individual company decision. The language in this document is aimed at safety professionals and engineers.

Defining process safety

The most commonly accepted definition of a process safety is from the Centre for Chemical Process Safety (CCPS). The CCPS define process safety as 'a disciplined framework for managing the integrity of hazardous operating systems and processes by applying good design principles engineering and operating practices. It deals with the prevention and control of incidents that have the potential to release hazardous materials or energy. Such incidents can cause toxic effects, fire or explosion and could ultimately result in serious injuries, property damage, lost production and environmental impact.'[1]. Dissecting this definition, it is important to note that process safety is about a **disciplined framework**, with a focus on **prevention and control of incidents**. This can apply to both actual and potential consequence, or 'near misses'. Another important inclusion in the definition is the extension from **potential for release of hazardous materials** to also include **energy**. This brings in an aspect beyond just a loss of containment, recognising that a loss of control of energy can also produce catastrophic consequences.

This document also avoids using the terminology Process Safety Management or PSM, because this has a specific legal definition in some jurisdictions, and the management of process safety is not limited to that legal definition.

It is important to recognise that the management of process safety must extend beyond the management of high inventories only. While high inventories pose a potential risk, lower inventories in sensitive areas may also pose such a risk. Expanding the understanding and focus of the management of process safety to encompass other aspects will assist in recognising and eventually minimising societal risk.

Incidents and events

A process safety event can be defined as follows, 'an unplanned or uncontrolled LOPC of any material including non-toxic and non-flammable materials (e.g. steam, hot condensate, nitrogen, compressed CO2 or compressed air) from a process, or an undesired event or condition that, under slightly different circumstances, could have resulted in a LOPC of a material.'[2] While API RP 754 limits this to a focus on loss of primary containment, applying the broader definition of process safety, above, from the CCPS, it should also include release of energy. In simpler terms, this can be expressed as a requirement for a safety system to have a demand on it, regardless of control effectiveness.

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[1] Centre for Chemical Process Safety, *Guidelines for process safety metrics*, John Wiley & Sons, Hoboken, New Jersey, 2010

[2] API, *RP 754 Process Safety Performance Indicators for the Refining and Petrochemical Industries*, API Publishing Services, Washington, DC, 2010

An incident is an event where an actual consequence is realised. This may be an actual loss of control, such as a leak or fire. API RP 754 utilises a tiered ranking, to differentiate consequences.

At any facility, there are many more instances of potential consequences rather than actual consequences. Acknowledging and analysing these provides for an opportunity to learn from the near miss, rather than have the consequence realised at some future time.

The management of process safety - maintaining control

Based on the management of process safety being about having a disciplined framework focused on preventing and control of process safety events, control needs to be maintained at all phases of a facility lifecycle, and therefore management of process safety applies from initial concept or exploration phase right through to decommissioning or abandonment.

The ISC considers that process safety is fundamentally built on six functional areas or pillars. These are:

- knowledge and competence (KC)
- engineering and design (ED)
- systems and procedures (SP)
- assurance (AU)
- human factors (HF)
- culture (CU)

These areas break down aspects of an organisation's business, within each system for leadership, management and action. For complete management of process safety, it is vital to ensure there is high level leadership and commitment across all 6 functional areas.

Leadership in **knowledge and competence** in process safety is fundamental. This underpins inherently safer **engineering and design** and robust safety systems supporting the upholding and continued evolution of **systems and procedures** for maintaining safer process operations. These are sustained by the best practice in the **assurance** of process safety in a changing environment taking full account of the contribution of **human factors**, behaviours and external influences. These elements collectively shape the prevailing **culture** in the workplace and in society at large in order to build a common understanding of risk issues and to develop and utilise new ways for cost effective and sustainable risk reduction in the process industries.

The ISC framework

The ISC framework of six functional areas is shown in Figure 1. It defines each significant phase of a facility life cycle, from initial idea or exploration to eventual decommissioning, plotted against the six functional areas. It should be noted that 'operation', 'maintenance' and 'ongoing integrity' have been grouped together because they are a continuous loop in an operating facility.

The lifecycle commences with 'leadership', as this underpins every functional area, as well as all decisions and activities within an organisation. The overarching phases of design, construction, operation, maintenance and ongoing integrity and decommissioning or abandonment apply to all manner of facilities and activities, including, but not limited to plant, pipelines, wells and drilling.

Within these functional areas, typical examples have been included to explain their application in each phase. This list is not exhaustive; it just serves to give context in each phase. The framework documented from the functional areas is also used to provide a common platform for IChemE Safety Centre members to communicate, plan and make decisions.

This framework focuses on leadership within the organisation and how it interacts with day to day management. It does not explain the corporate governance of an organisation, though the framework has been mapped to *Corporate governance for process safety - guidance for senior leaders in high hazard industries*[3].

This simplification of management of process safety is done in an effort to make the concepts accessible to a wide audience. It serves as a road map to show basic concepts and their application. It is not intended to diminish the technical aspects of process safety or risk management.

Specific terms used in this framework, including the six functional areas have been defined in appendix 1, common terms.

There are several other frameworks or models for process safety, namely the CCPS, the Energy Institute (EI) and the Organisation for Economic Co-operation and Development (OECD). These frameworks focus on high level system management principles, and can be applied as a management system in an organisation. To aid organisations in understanding and applying the six areas, the three frameworks have been cross referenced with the six functional areas. This cross reference is found in appendix 2. The cross referencing is illustrative only and not exhaustive, other interpretations are possible. This work seeks not to create another framework to choose from, but to provide practical guidance in each of the six areas, to assist organisation to improve the management of process safety, assuming they already have a management system in place.

[3] OECD, *Corporate governance for process safety - guidance for senior leaders in high hazard industries*, OECD Environment Health and Safety Chemical Accidents Program, 2012

Figure 1 ISC process safety framework

Note: these examples are illustrative only, not exhaustive.

	knowledge and competence	engineering and design	systems and procedures	assurance	human factors	culture
leadership	demonstrated importance of knowledge and competence in an organisation, sufficiently resourced	robust engineering decisions supported, emphasis put on proving systems are safe, rather than unsafe	robust and practical management systems in place and followed by all, sufficient resources engaged to maintain systems	assurance processes valued in the organisation, practice of questioning good results and embracing poor results, ensuring processes delve sufficiently deep	recognising that all aspects of HF have an impact on the safety of an organisation, sufficient resources and planning implemented to minimise HF impacts	demonstrated fair and just culture, people accountable for their contribution, and empowered
design	design engineers, operations specialists inc drillers, scientists, other HSSE disciplines, other engineering disciplines	location and siting, inherently safer design, hazard and risk assessment, engineered safety systems, material specification, safety critical elements including ability to test, management of change, interfacing with other engineering disciplines, life cycle cost approach	design hazard management, management of change, preparation of operating and maintenance procedures, preparation of emergency procedures	design approvals, safety critical elements, heath, safety, environment and security reviews, authority to proceed through the various design stages, lessons learnt	motivation and empowerment of the design team, working with contractors and consultants, design taking HMI design into account	operability, working with stakeholders, working with regulators, working outside normal jurisdictions, operations and maintenance personnel engagement
construction	construction supervisors, trades, drillers, engineers, inspectors, commissioning teams, transfer of knowledge to eventual operating teams	ensuring as built construction does not compromise process design, material specification quality assurance, use and removal of temporary facilities for commissioning, hazard and risk assessment, management of change	fabrication and testing standards, safe work systems, quality assurance throughout, system checks, commissioning individual items of equipment (compressors etc.), training operations and maintenance personnel	application of quality assurance standards throughout, close out of outstanding action items from design and construction, pre-start up reviews, mechanical completion and handover, safety critical element testing	workforces with multiple nationalities, cultures and languages, event reporting and investigation, preventing industrial disputes, disengaging finishing trades, fatigue, organisational change and transition management	worker engagement, understanding hazards and risks, board and executive decision making driving culture
operation, maintenance and ongoing integrity	operations, drilling, maintenance and engineering personnel, supervisors/managers, specialist contractors, including inspection, engineering technical authorities and support, operational and process technical authorities and support (creating an awareness of process safety risk among senior managers, refresher training for all, inspection technical authorities and support	alarm management, including inspection and testing, management of change, ensuring quality of spares and equipment used for repairs meets original design specifications, life extension, management of deviation from design (excursions), ensuring inspection and test methods do not compromise plant integrity, hazard and risk assessment, risk based inspection and maintenance	standard operating procedures, safe work procedures, deviation and trouble shooting, emergency response drills, operating envelope, hazard and risk assessment, maintenance procedures and methods, inspection and testing procedures and methods, event investigation	lead and lag metrics, system audits, internal audit programme, external process safety audits, regulatory inspections/audits, maintenance and inspection audits, exchange of best practice on maintenance and inspection and testing methods, inspection of safety critical elements	written procedures, operability including alarm handling and control room design, maintainability, risk and hazard awareness, longer term motivation and empowerment of operating and maintenance personnel, professional development, working with contractors, consultants, community and regulators, safety critical communications, fatigue, organisational change and transition management	worker engagement, understanding hazards and risks, board and executive decisions and actions driving culture, senior management visibility, progression up the safety culture ladder
decommissioning or abandonment	trades, engineers inc drillers, supervisors/managers, specialist contractors, environmental disposal specialists, emergency response and clean up	isolation design, flushing and cleaning facilities, disposal of toxic materials, returning site to original state, hazard and risk assessment, management of change	standard operating procedures, safe work procedures, emergency response, hazard and risk assessment, demolition schedule, environmental permits, security procedures, event investigation	site inspections, quality assurance during demolition and removal, environmental close out of demolition and return of site to natural state	written procedures, constructability, risk and hazard awareness, possible multiple nationalities cultures and languages of demolition workers, continued motivation of workforce soon to become redundant, safety critical communications, fatigue, organisational change and transition management	worker engagement, understanding hazards and risks, board and executive decisions driving culture, senior management visibility

Appendix 1 - common terms

Framework

leadership

Leadership, and in particular safety leadership, is the art of creating a vision for a group of people and taking them on a journey to achieve the vision. Leadership is not dependant on authority, meaning safety leaders in an organisation may not be managers. Leadership is different to management, as Schein states, 'Leaders create and change cultures, while manager and administrators live within them.'[4]

knowledge and competence

Knowledge is the familiarity, general awareness or understanding of the impact of one's actions.

Competence means the ability to perform activities and to undertake work functions in accordance with agreed standards, rules and procedures, and to demonstrate defined behaviours on a regular and consistent basis over time. Competency is a combination of practical and thinking skills, experience and knowledge. Acceptable competency depends on the context and the environment in which the activity is performed, and also on the organisation's working culture. Generally, competency is the outcome of training both off-the-job and on-the-job.[5]

engineering and design

Engineering and design is about applying the hierarchy of controls in the design of equipment and safety systems. This includes the concept of inherently safer design as a starting point. This area also includes design across the entire life cycle of the asset, and the application of robustly engineered safety systems.

systems and procedures

This covers the concept of having high level management systems in place, be that safety, maintenance or other management systems, setting a standard to be adhered to.

The CCPS defines a management system as 'a formally established set of activities designed to produce specific results in a consistent manner on a sustainable basis.'[6] This definition encompasses the intent of the 'systems and procedures' functional area.

assurance

Assurance is a define program for the systematic monitoring and evaluation of all aspect of a business. This includes tools such as inspection, testing, monitoring, verification and audit. This also

[4] Schein, Edgar, *Organisation culture & leadership* - 1st ed., Jossey-Bass, San Francisco, CA, 1985
[5] APPEA Guide to competency management systems - behaviour and human factors
[6] Centre for Chemical Process Safety, *Risk based process safety*, John Wiley & Sons, Hoboken, New Jersey, 2007

applies to defining performance standards and metrics for an organisation and reporting performance against them, in addition to the feedback loop, resulting in actions based on data.

Assurance should be undertaken at both an internal level in an organisation, such as audit, inspection and testing, but it must also be undertaken at a governance level by the board. It is important that boards seek assurance of the processes and operations, rather than reassurance that everything is ok.

human factors

The Health and Safety Executive in the United Kingdom define human factors as the interaction between the three main factors affecting human performance at work - the job, the individual and the organisation.[7] This includes consideration of the following;

- competence
- humans and risk assessments
- written procedures
- emergency response
- maintenance
- safety culture
- safety critical communications
- alarm handling and control room design
- fatigue
- organisational change and transition management

Note that while culture is defined below and stated as a core functional area in this framework, it is also a subset of human factors. This emphasises the importance and impact of culture across an entire organisation.

culture

Culture is a complex concept to understand and positively influence. The work of two noted authors has been referred to below to explain what is meant by the term 'culture'.

In 1985, Edgar Schein first defined culture as:
"The pattern of basic assumptions that a group has invented, discovered or developed, to cope with its problems of external adaptation or internal integration, that have worked well and are taught to new members as the way to perceive, think, feel and behave."

Schein went on to explain how leadership drives culture in 2004 as:

'...what they systematically pay attention to. This can mean anything from what they notice and comment on to what they measure, control, reward, and in other ways deal with systematically.'[8]

Dr James Reason postulates that there are five elements to a good safety culture. These are; an informed culture, a reporting culture, a learning culture, a just culture and a flexible culture.[9]

[7] HSE, HSE human factors briefing note no. 1 - introducing human factors, HSE, UK, 2012
[8] Schein, Edgar, *Organisation culture & leadership* - 3rd ed., Jossey-Bass, San Francisco, CA, 2004

Informed	Relevant data is collected, analysed and safety information is actively disseminated
Reporting	Reports acted upon, and people confident that they can report without fear of retribution
Learning	The organisation learns from its mistakes and makes necessary changes
Just	Errors will not be punished if unintentional, but wilful, deliberate acts will have consequences
Flexible	People able to adapt effectively to changing demands

Other terms

safety system or barrier

A safety system is a control measure that has been implemented to guard against a hazard becoming a risk, or to mitigate the impact of the hazard. A barrier is a safety system, or component of a safety system that is in place to prevent a hazard progressing to an event, or to minimise the consequences of the event , should it occur. Safety systems or barriers can be engineered systems, such as automated emergency shutdown systems or pressure relief devices, or administrative, such as procedures or competency. Engineered barriers as safety systems are more robust that administrative ones. The hierarchy of controls lists the various types of controls from most effective to least effective.

hierarchy of controls

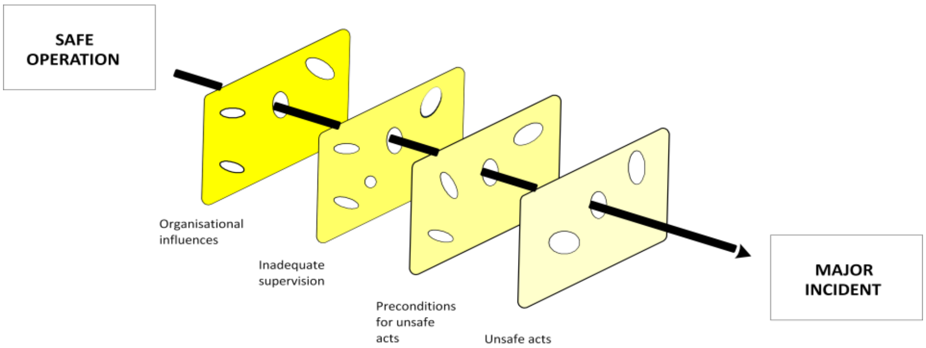
The hierarchy of controls lists the following types of controls from most effective to least effective, with some examples;

1. Elimination - remove the hazard from the workplace
2. Substitution - substitute the hazard with a less hazardous item
3. Isolation - use physical barriers to keep the hazard away from people or sensitive areas
4. Engineering controls - using alarms of warning systems
5. Administrative controls - procedures or training
6. PPE and equipment - flame retardant clothing

swiss cheese model

The swiss cheese model was first developed by Dr James Reason in 1990, and further explained in his 1997 book *Managing the risks of organisational accidents*. The model uses the image of slices of swiss cheese, with their characteristic holes, lined up. It suggests that the path to an event is blocked by the cheese, unless the holes line up. Each slice represents a different barrier or condition preventing the event. These barriers start with a series of latent conditions, such as organisation culture which shapes management decisions, deficiencies in how decisions are implemented and error or violation producing conditions. Active failures then enter the chain, with error or violating actions by people, and then lastly failures physical barriers, such as equipment. If all barriers fail to act as intended, the event can occur. This model evolved to include the concept that the holes in the swiss cheese are constantly moving, and thus moved from a static model to a dynamic one. Depending on multiple factors, each deficiency changes. Below is an adaption of Reason's swiss cheese model.

[9] Reason, James, *Managing the risks of organisational accidents*, Ashgate Publishing Limited, Hampshire, England, 1997

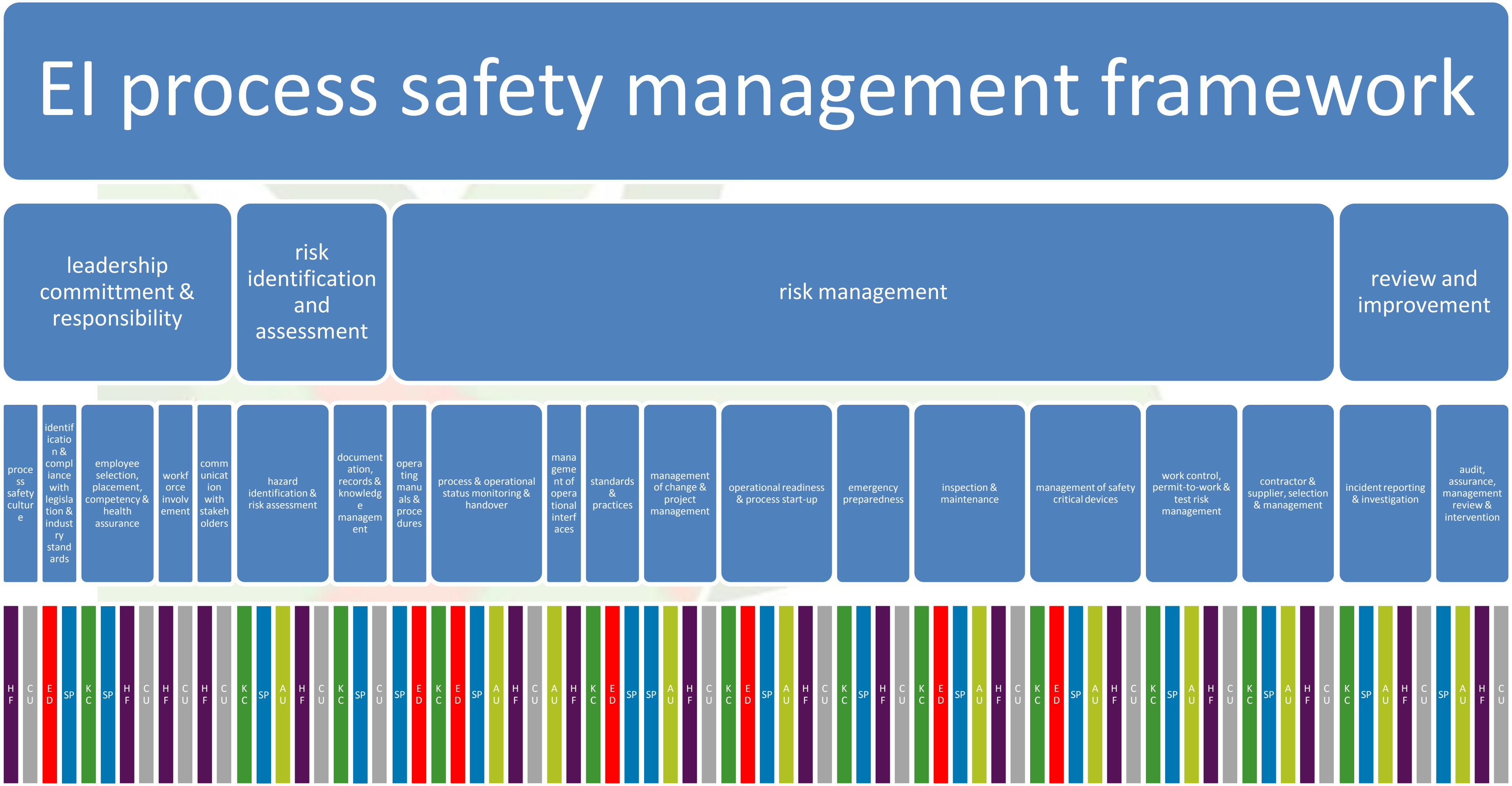

SAFE
OPERATION
Organisational
influences
Inadequate
supervision
Preconditions
for unsafe
acts
Unsafe acts
MAJOR
INCIDENT

Appendix 2 - Six functional areas cross referenced with CCPS, EI and OECD

CCPS[10]

[10] Centre for Chemical Process Safety, *Risk based process safety*, John Wiley & Sons, Hoboken, New Jersey, 2007

Energy Institute[11]



[11] Energy Institute, *High level framework for process safety management*, Energy Institute, UK, 2010

OECD[12]

[12] OECD, *Corporate governance for process safety - guidance for senior leaders in high hazard industries*, OECD Environment Health and Safety Chemical Accidents Program, 2012