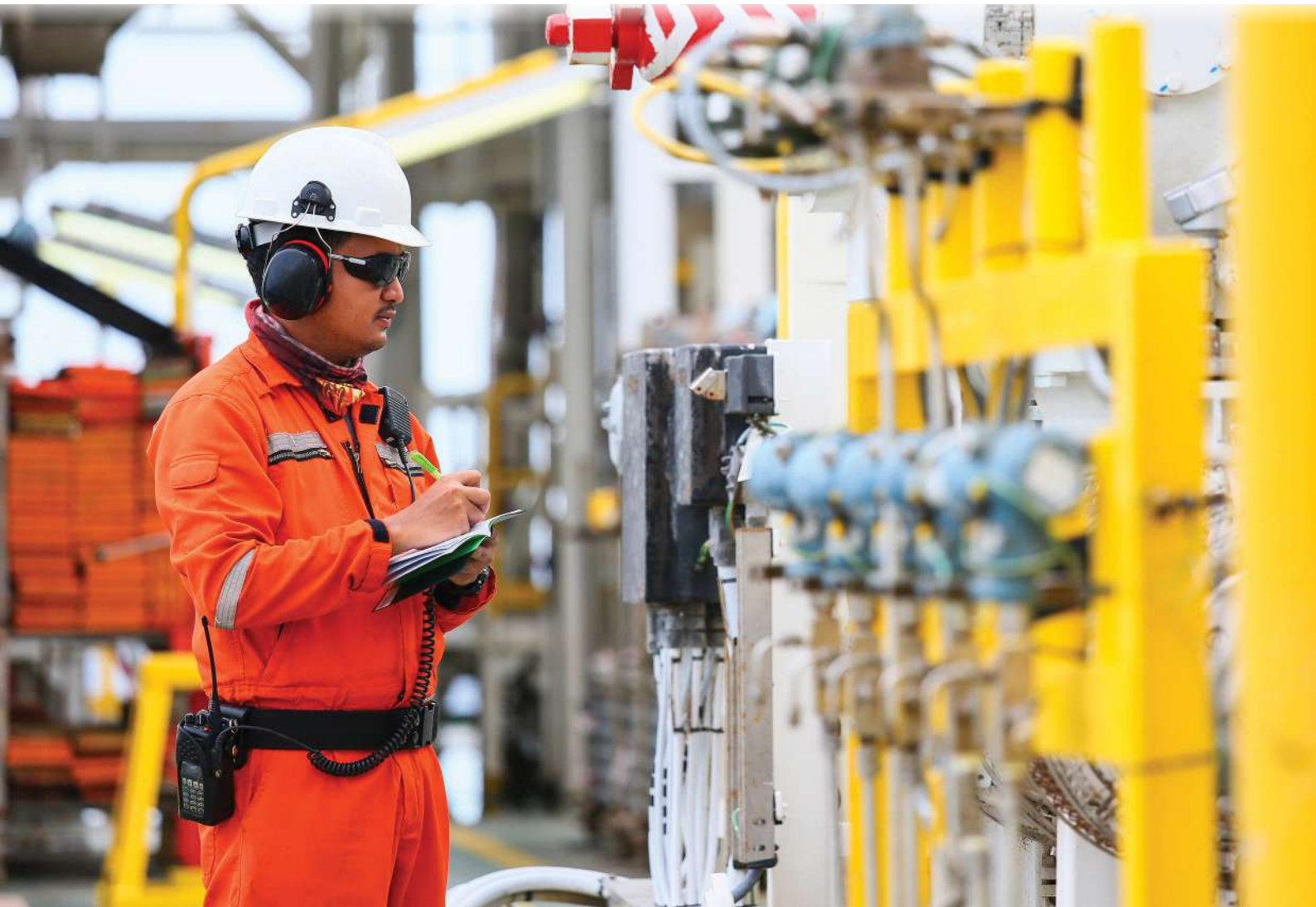
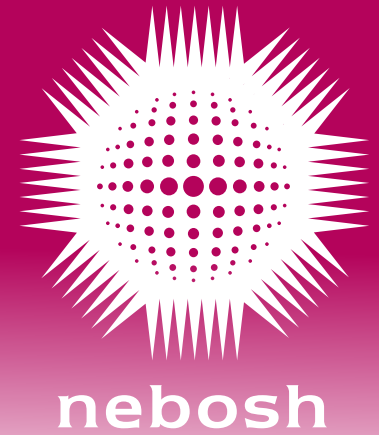
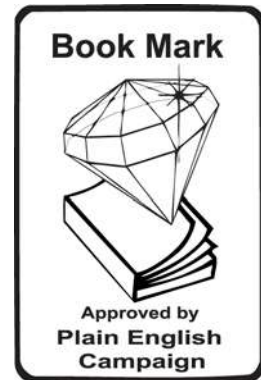


July 2017

Guide to the NEBOSH HSE Certificate in Process Safety Management





Qualification title: NEBOSH HSE Certificate in Process Safety Management
Version: 1
Specification date: July 2017
Guide publication date: September 2017

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Guide to the NEBOSH HSE Certificate in Process Safety Management (July 2017 specification)

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1. Introduction

NEBOSH has collaborated on the development of this specialist qualification with the United Kingdom's Health and Safety Executive (HSE). The collaboration combines the advanced technical 'high hazard' expertise of the HSE with NEBOSH's ability to deliver strong vocational qualifications.

This qualification aims to provide holders with the knowledge and understanding of process safety management to ensure that they can contribute to the effective management of process safety risks.

The NEBOSH HSE Certificate in Process Safety Management is suitable for supervisors, newly appointed managers, junior managers, safety representatives and newly qualified health and safety advisors within the process industries, both inside and outside the UK. The qualification is designed to provide a sound breadth of knowledge and understanding that enables qualification holders to contribute to the management of process safety risks. This qualification builds on the understanding already gained by studying the NEBOSH National or International General Certificate in Occupational Health and Safety.

Important note: this qualification is not designed for process safety/chemical engineers with extensive operational experience of working within the processing environment.

The September 2016 specification of the qualification was piloted in 2017 and launched as a NEBOSH mainstream qualification on 29 September 2017.

1.1 Benefits for employers

When things go wrong in the process industry the results can be catastrophic. This has been evidenced by incidents in the past which have led to loss of life and many billions of US dollars' worth of damages. The Deepwater Horizon incident which tragically led to 11 people losing their lives and the total cost to BP was in the region of \$62 billion.

The process safety industry is high hazard so having qualified people to manage activities within the industry will lead to safer workplaces. This will help to prevent loss of life but will also help to protect valuable assets and help organisations avoid prosecution and ultimately loss of reputation.

NEBOSH accredited course providers offer a variety of flexible course formats, so training can be arranged according to employer and / or student needs.

1.2 Qualification level and UK accreditation

This qualification *is intended* to be credit rated and levelled by the Scottish Qualifications Authority (SQA) Awarding (<http://www.sqa.org.uk/sqa/70972.html>) for inclusion on the Scottish Credit and Qualifications Framework (SCQF) (<http://scqf.org.uk/>) for delivery across the UK and internationally. We *anticipate* the qualification to be rated at Level 7 with 5 credits.

For users in England, Wales and Northern Ireland, this is broadly comparable to a Vocationally-Related Qualification (VRQ) at Level 4 in the Qualifications and Credit Framework (QCF), comparable to A-Level standard.

For further information on level comparisons please see the qualification regulator's "*Qualifications can cross boundaries*" document available from the SQA website (www.sqa.org.uk).

1.3 Key topics covered

- Process safety leadership
- Management of change
- Competence
- Management of process risk
- Process safety hazard control
- Fire and explosion protection

1.4 Course tuition and private study time requirements

Unit PSM1: 28 hours tuition and 20 hours private study

Total: 48 hours

A programme of study therefore needs to be based around a minimum of **28 taught hours** and approximately **20 hours of private study** for an overall total of **48 hours**.

A full-time block release course would be expected to last for a minimum of four working days and a part-time day release course would be spread over at least four weeks. For candidates studying by open or distance learning, the tuition hours should be added to the recommended private study hours to give the minimum number of hours that this mode of study will require.

Quoted hours *do not* include assessment time, ie, sitting the examination.

1.5 Entry requirements

NEBOSH does not set specific formal entry requirements for this qualification. However it should be noted that the achievement of either the NEBOSH National General Certificate in Occupational Health and Safety (NGC) or International General Certificate in Occupational Health and Safety (IGC) (or equivalent) prior to undertaking the NEBOSH HSE Certificate in Process Safety Management course is recommended. This qualification is not designed to replace knowledge and understanding of general health and safety, gained as part of the NGC or IGC.

It should also be noted that currently the assessment is offered, only in English.

1.6 Minimum standard of English required for candidates

The standard of English required by candidates studying for the NEBOSH HSE Certificate in Process Safety Management must be such that they can both understand and articulate the concepts contained in the syllabus. It is important to stress that the onus is on accredited course providers to determine their candidates' standards of proficiency in English.

NEBOSH recommends to accredited course providers that candidates undertaking this qualification should reach a minimum standard of English *equivalent* to an International English Language Testing System score of **6.0** or higher in IELTS tests in order to be accepted onto a NEBOSH HSE Certificate in Process Safety Management programme.

For further information please see the latest version of the IELTS Handbook or consult the IELTS website: http://www.ielts.org/institutions/test_format_and_results.aspx.

Candidates wishing to assess their own language expertise may consult the IELTS website for information on taking the test: <http://www.ielts.org/faqs.aspx>.

1.7 Languages

The unit examination must be taken in English.

1.8 Qualification type

NEBOSH qualifications are categorised as 'Other' qualifications by SQA Accreditation in Scotland. These are categorised as Vocationally-Related Qualifications (VRQs) in England, Wales and Northern Ireland.

VRQs provide the knowledge and practical skills required for particular job roles through a structured study-based training programme, that combine the testing of knowledge and understanding in written examinations with practical application of learning in the workplace.

VRQs are a popular type of qualification because they are nationally recognised, flexible and offer routes for progression to employment or further study.

1.9 Programmes offered by NEBOSH-accredited course providers

A list of course providers accredited to run the NEBOSH HSE Certificate in Process Safety Management can be found in the 'Qualifications' section of the NEBOSH website (www.nebosh.org.uk).

1.10 Examination dates

For this qualification, accredited course providers may request 'on-demand' examinations on a date of their choosing. On-demand request forms are available via the course provider section of the NEBOSH website. Once the 'on demand' examination date has been set by NEBOSH, providers may register candidates using the NEBOSH online registration system available via the NEBOSH website.

1.11 Specification date

The July 2017 specification replaces the 'Pilot' September 2016 specification for this qualification.

1.12 Syllabus development and review

The syllabus has been developed by NEBOSH and the HSE following extensive consultation with key stakeholders, notably accredited course providers, employers, and subject experts. NEBOSH would like to take this opportunity to thank all those who participated in the development, piloting and implementation of this qualification but in particular the following employers:

- AB Ports, UK
- Amec Foster Wheeler, UK
- Architectural Coatings UK & Ireland Ltd, UK
- Cabot Specialty Fluids, UK
- ConocoPhillips (U.K.) Limited, UK
- Dhuruma O&M Company Ltd, KSA
- Doosan Babcock, UAE
- Emirates National Oil Company (ENOC), Dubai, UAE
- Golden Swan G.E S.L, Equatorial Guinea
- Kuwait Gulf Oil Company, Kuwait
- LMP Technical Services, UK
- Marathon Oil Company, Equatorial Guinea
- Procter & Gamble, UK
- Robinson Brothers, UK
- Safety Engineering Associates Limited, UK
- Sanofi, Ireland

- Sonatrach, Algeria
- Staroil Operating Company, Sudan
- Wales & West Utilities, UK
- Western Power Distribution, UK.

1.13 Further information for candidates

Further information for candidates including a qualification overview leaflet can be found via the NEBOSH website (www.nebosh.org.uk). Sample assessment questions have been included within the syllabus.

1.14 Further information for accredited course providers

Further information for accredited course providers including policies and procedures can be found in the accredited course providers' section of the NEBOSH website.

2. Qualification structure

2.1 Unit assessment

The Certificate in Process Safety Management is a one unit qualification.

Unit PSM1: Process safety management

- Unit PSM1 is a taught unit, assessed by a 90 minute multiple-choice question paper.
- The question paper consists of 40 multiple-choice questions; 10 of the questions are extended scenario questions which will be randomly distributed throughout the paper
- Each question is worth one mark and has one correct and three incorrect responses available
- The question paper covers the whole syllabus with at least one question per element and all questions are compulsory

2.2 Achieving the qualification

There is no time restriction for passing the Certificate in Process Safety Management as this is a one unit qualification.

2.3 Assessment setting and marking

NEBOSH applies best practise in relation to assessment setting and marking. NEBOSH uses external assessment for written examinations and assignments: scripts are sent to NEBOSH and undergo rigorous marking, checking and results determination processes to ensure accuracy and consistency.

2.4 Unit pass standard

The pass standard for the unit/qualification is 60% (24 correct questions out of 40).

2.5 Unit result notifications

NEBOSH issues results notification letters for this qualification to accredited course providers via the online Course Provider Interface. Accredited course providers will then email or post the results to candidates.

2.6 Qualification grade

Once candidates have achieved a Pass in Unit PSM1, they are deemed to have completed the qualification. The only grade available for successfully completing this qualification is 'Pass'.

2.7 Qualification parchment

Once a candidate has achieved a Pass they are normally considered to have completed the qualification and a qualification parchment will be issued, usually within 20 working days of the confirmed date of the passed unit.

However, once the result has been issued the candidate has **20 working days** from the date of issue of that result to submit an Enquiry About Result (EAR) request (see Section 3.3).

2.8 Re-sitting unit/s

A candidate can re-sit if a 'Refer' result is received. Candidates must register and pay the current fee/s by the registration closing date for the relevant examination sitting.

Candidates who register for the Certificate in Process Safety Management whilst awaiting a result from a previous sitting of an examination for the same qualification may not seek a refund of the registration fee.

3. Policies

3.1 Requests for access arrangements/reasonable adjustments

Access arrangements and reasonable adjustments are modifications which are approved in advance of an examination to allow attainment to be demonstrated by candidates with either a permanent or long-term disability or learning difficulty, or temporary disability, illness or indisposition.

Requests for access arrangements or reasonable adjustments must be made to NEBOSH by accredited course providers at least one month before the assessment.

For further details see the NEBOSH *“Policy and procedures for access arrangements, reasonable adjustments and special consideration”* available from the NEBOSH website (www.nebosh.org.uk).

3.2 Requests for special consideration

Special consideration is a procedure that may result in an adjustment to the marks of candidates who have not been able to demonstrate attainment because of temporary illness, injury, indisposition or an unforeseen incident at the time of the assessment.

Candidates who feel disadvantaged due to illness, distraction or any other reason during the assessment must report this to the invigilator (or the accredited course provider in the case of a practical examination) before leaving the examination room and request that their written statement, together with the invigilator’s comments on the statement, be sent by the accredited course provider to NEBOSH.

Requests for special consideration must be made to NEBOSH by the accredited course provider as soon as possible and no more than seven working days after the assessment.

For further details see the NEBOSH *“Policy and procedures for access arrangements, reasonable adjustments and special consideration”* available from the NEBOSH website (www.nebosh.org.uk).

3.3 Enquiries about results and appeals

NEBOSH applies detailed and thorough procedures to moderate and check assessment results before they are issued. It thereby ensures that the declared results are a fair and equitable reflection of the standard of performance by candidates.

There are, however, procedures for candidates or accredited course providers to enquire about results that do not meet their reasonable expectations. An ‘enquiry about result’ (EAR) must be made in writing within 20 working days of the date of issue of the result to which it relates.

For details see the NEBOSH *“Enquiries About Result (EARs) and appeals policy and procedures”* document available from the NEBOSH website (www.nebosh.org.uk).

3.4 Malpractice

Malpractice is defined as any deliberate activity, neglect, default or other practice by candidates and/or accredited course providers that compromise the integrity of the assessment process, and/or the validity of certificates. Malpractice may include a range of issues from collusion or use of unauthorised material by candidates, to the failure to maintain appropriate records or systems by accredited course providers, to the deliberate falsification of records in order to claim certificates. Failure by an accredited course provider to deal with identified issues may in itself constitute malpractice.

For further details see the NEBOSH *“Malpractice policy and procedures”* document available from the NEBOSH website (www.nebosh.org.uk).

4. Notes for tutors

4.1 Tutor references

Tutor references are given to aid tutors with the teaching of the syllabus content; they are not an exhaustive list and tutors can use other references to those quoted in the syllabus.

4.2 Teaching of units

Although the syllabus sets out the Unit Elements in a specific order, tutors can teach the Unit Elements in any order they feel is appropriate. Course providers will need to reflect this in the timetables which are submitted for approval as part of the accreditation/re-accreditation process (if the course provider is using their own course materials).

4.3 Conflict of interest

Accredited Course Provider staff including Head of Accredited Course Providers, Tutors, Administrators, Examinations Officers and Invigilators must declare in writing to NEBOSH any employment and/or familial, spousal or other close personal relationship with any examination or assessment candidate. Further information can be found in the '*Instructions for Conducting Examinations*' document.

4.4 Minimum standard of English required for tutors

Tutors who are based overseas and wish to deliver the NEBOSH HSE Certificate in Process Safety Management must have a good standard of English. They must be able to articulate the concepts contained in the syllabus. The accredited course provider must provide evidence of the tutor's standard of English when submitting the tutor's CV for approval.

NEBOSH's requirement is for tutors delivering this qualification to have reached a minimum standard of English *equivalent* to an International English Language Testing System score of **7.0** or higher in IELTS tests.

5. Syllabus - NEBOSH HSE Certificate in Process Safety Management (July 2017 specification)

Structure

The qualification is a one unit qualification with Unit PSM1 being divided into four elements.

Unit PSM1: Process Safety Management

Element Number	Element Title	Recommended hours	Page
1	Process safety leadership	4	12
2	Management of process risk	9	15
3	Process safety hazard control	10	18
4	Fire protection and emergency response	5	22
	Minimum unit tuition time	28	
	Recommended private study time	20	

5.1 Unit PSM1: Process safety management

Element 1: Process safety leadership

Learning outcomes

- 1.1 Outline the meaning of process safety and how it differs from personal safety
- 1.2 Explain the role of leadership in process safety management
- 1.3 Explain the purpose of organisational learning, the sharing of lessons learnt and sources of information
- 1.4 Explain how 'change' should be managed to effectively reduce risks to people and plant
- 1.5 Outline the benefits, limitations and types of worker participation and engagement
- 1.6 Outline what is meant by competence and its importance to process safety.

Content

1.1 Process safety Management meaning

- The distinction between process safety vs personal safety
- 'Process safety' as:
 - 'a blend of engineering and management skills focused on preventing catastrophic accidents and near misses, particularly structural collapse, explosions, fires and toxic releases associated with loss of containment of energy or dangerous substances such as chemicals and petroleum products' (Energy Institute definition adapted from the Center for Chemical Process Safety of the American Institute of Chemical Engineers).

1.2 Process safety leadership

- The importance of leadership teams being fully aware of the hazard and risk potential of their processing activities and their possible impact on safety, reputation and business risk
- Board level visibility and the promotion of process safety leadership as being essential in developing a positive safety culture
- For PSM critical positions, the necessity to define and assign process safety responsibilities
- The reasons for holding to account all individuals with PSM responsibilities, regardless of their position within an organisation
- The provision of adequate resources (human, financial and physical) being made available and the consequences of failing to provide them
- Meaning of, and reasons, for establishing process safety objectives and targets that are routinely reviewed with performance on them, made publically available

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- Commitment to continuous improvement with regards to process safety performance.

1.3 Organisational learning

- The significance of learning lessons from incidences of actual or potential consequence
- The reasons for and benefits of accident and incident investigations
- Documented management processes in place to ensure the retention of corporate knowledge pertaining to process safety management ie, original design specification and plant modifications
- Arrangements with other relevant organisations in the sharing of lessons learnt and the adoption of such learning within process safety management systems
- Purpose of benchmarking and how this tool is used across similar organisations to identify best practices and drive process safety improvement ie, management of change, asset integrity and process safety culture
- Sources of process safety management information:
 - internal to the organisation (eg, inspection, audit and investigation reports, maintenance records)
 - external to the organisation (eg, manufacturers' data, legislation, EU (European Union) HSE (Health and Safety Executive), OSHA (Occupational Safety and Health Administration), trade associations and professional bodies eg IChemE (Institution of Chemical Engineers) and the Energy Institute; International, European and British Standards, ILO (International Labour Organisation) and other authoritative texts, IT sources.

1.4 Management of change

- Management of change control measures:
 - formal documented system developed to identify required modifications
 - the requirement for a full hazard and risk analysis exercise on implications of change ie, prevent the introduction of new hazards or unknowingly increasing the risk of existing hazards
 - process for all changes to be authorised by competent persons and where safety critical devices are to be removed, sanctioned and signed off by senior management
 - all changes to process plant and/or design correctly documented for process knowledge retention
 - consult and inform those affected by the changes (both operational and changes of key workers)
 - training programmes implemented where necessary.

1.5 Worker engagement

- The benefits and limitations of consultation with workers and contractors on all applicable process hazards and associated controls, policy development and process safety performance
- Types of consultees and their role / responsibilities:
 - safety committees
 - discussion groups
 - safety circles
 - departmental meetings

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- email and web-based forums
- Necessity of including workers / workplace representatives when (re)developing procedures, safe systems of work and undertaking risk assessments and accident investigations
- Why engagement with workers should be given a high priority by senior management and arrangements for engagement appropriately managed and compliance audited against.

1.6 Competence

- Understanding of what is meant by 'competence' (ie, 'the ability to undertake responsibilities and to perform activities to a relevant standard, as necessary, to ensure process safety and prevent major accidents. Competence is a combination of knowledge skills and experience and requires a willingness and reliability that work activities will be undertaken in accordance with agreed standards, rules and procedures'
Source: Operational Delivery Guide produced by COMAH Competent Authorities
- The role of competence in safe working and behaviours
- The development and implementation of systems (including the use of training and competency matrices / frameworks) to ensure that all levels of management possess the appropriate level of process safety knowledge and expertise
- Training and development programmes applicable to process safety risk:
 - standard
 - non standard
 - emergencies.

Recommended tuition time not less than 4 hours

Sample questions

- Q1 Process safety mainly deals with:**
- A high frequency, high severity risks.
 - B low frequency, high severity risks.
 - C low frequency, low severity risks.
 - D high frequency, low severity risks.
- Q2 Within a management of change procedure, final approval for removal of a safety critical device should be given by a:**
- A senior manager.
 - B lead operator.
 - C chemical engineer.
 - D process technician.
- Q3 Benchmarking is used to identify good practice across similar:**
- A committees.
 - B organisations.
 - C techniques.
 - D procedures.
- Q4 What is the most important benefit of involving workers when carrying out risk assessments?**
- A To reduce resistance and conflict when risk assessments are introduced.
 - B To make sure there is a balanced representation of workers and managers.
 - C To enable employer and employees to comply fully with legal requirements.
 - D To gather detailed practical knowledge about workplace hazards and risks.

Q 5 Which of the following is the most direct evidence of worker competence?

- A** Consistently performing a work-related task correctly to the required standard.
- B** Signing a document to confirm that a procedure was read and understood.
- C** Completing an attendance form following a process safety toolbox talk.
- D** Carrying out a work-related task without harming themselves or others.

Element 2: Management of process risk

Learning outcomes

- 2.1 Outline the purpose and importance of establishing a process safety management system and its key elements
- 2.2 Outline common risk management techniques used in process industries
- 2.3 Outline asset management and maintenance strategies for process plant
- 2.4 Explain the role, purpose and features of a permit-to-work
- 2.5 Explain the key principles of safe shift handover
- 2.6 Explain the principles of selecting, assessing and managing contractors.

Content

2.1 Establishing a process safety management system

- Reasons for developing an integrated and comprehensive process safety management system, including compliance obligations
- The key elements of a process safety management system
 - policy (Plan)
 - planning (Plan)
 - implementation and operation (Do)
 - checking and corrective action (Check)
 - management review (Act)
 - continual improvement (Act)
- 'License to operate' authorisation and dealing with regulators (safety cases)
- The purpose and typical content of Major Accident Prevention Plans (MAPP's)
- Differentiation between leading and lagging process safety performance indicators and their development and implementation as part of an assurance framework
- Auditing '*compliance*' with process safety management system objectives and the identification of opportunity for improved performance.

2.2 Risk management techniques used within the process industries

- The purpose and use of risk assessment
- The differences between qualitative, semi-quantitative and quantitative risk assessment processes and where they are indicatively used within a process environment
- The theory of risk control using barrier models (barrier between hazard and hazard realisation)
- The concept of hazard realisation – for example loss of containment leading to ignition, leading to explosion/fire, leading to damage/injury

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- How risk management tools are applied in process safety risk identification and assessment (Bowtie, HAZOP, HAZID, Event trees, What-if Analysis and FMEA), application in project phases from concept, design, start-up
- The concept of ALARP
- Hierarchy of risk controls:
 - inherent safety
 - elimination (including minimised inventories)
 - substitution
 - engineering controls (including the segregation and spacing of process plant)
 - administrative controls (procedural / behavioral).

2.3 Asset management and maintenance strategies

- Consideration of integrity standards at design stage inclusive of designing for maintainability and ease of inspection
- Consequences of failing to manage the integrity of assets
- Selection of plant and equipment suitable for the operating environment
- Asset integrity throughout the lifecycle, with inspection, testing and maintenance regimes based on manufactures recommendations and findings of risk assessments
- Plant maintenance documentation and recording requirements for inspection, maintenance, aging, life extension and obsolescence
- Different risk based maintenance and inspection strategies available:
 - planned preventative
 - condition monitoring
 - breakdown / failure based
- The importance of, and reason for, the risk based calibration of instrumentation.

2.4 Role and purpose and features of a permit-to-work system

- The purpose and effective use of a permit-to-work system, including the linkages to method statements and task analysis
- The key features of a permit-to-work:
 - scope of work
 - duration of work
 - known hazards and reference to risk assessments
 - isolation of energy sources and/or process equipment (lock out / tag out 'LOTO')
 - link to other open permits
 - specification of persons accepting permits and verification of their understanding of the risks and control measures
 - emergency controls
 - specific controls ie, gas testing
- Interfaces with adjacent plant/simultaneous operations
- Interfaces with contractors
- Types of permit and the circumstances when they would be typically used ie:
 - hot work

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- cold work
- electrical
- The benefits and limitations of both electronic and paper based permit-to-work systems
- Typical circumstances when a work permit would not be required.

2.5 Safe shift handover

- Two-way with both participants taking joint responsibility
- Competence of those involved in handovers – technically astute but also effective communicators
- Shift handover must be:
 - given the highest priority
 - conducted face to face
 - undertaken using accurate verbal and written communication
 - based on analysis of the information needs of incoming staff
 - given as much time as necessary to allow for questioning, explanation and clarification
- Typical practical examples of information shared during shift handover including physical demonstration of plant state.

2.6 Contractor management

- Scale and identification of contractor use within the processing industries
- Procedures for the selection of contractors
- Periodic review of contractor health and safety performance / compliance with tender documentation
- Contractor induction, indicative content and the obligation to provide information relating to site hazards/risks
- Siting of contractors accommodation
- Contractor ownership and site supervision/ representation
- Auditing of contractors health and safety compliance, before (method statements etc) during and after work is undertaken
- Contractor responsibilities including handover of buildings, plant and equipment.

Recommended tuition time not less than 9 hours

Sample questions

- Q 1** Process organisations have in place a wide range of mitigation measures designed to reduce the consequences of a major incident. Which risk management technique is especially suited to assess the effectiveness of these mitigation measures?
- A Failure Mode Effects Analysis (FMEA).
 - B Event Tree Analysis (ETA).
 - C Risk assessment (RA).
 - D Hazard Identification (HAZID).
- Q 2** Which of the following is an example of planned preventive maintenance?
- A daily visual inspections of process plant.
 - B greasing of pump bearings.
 - C regular sampling of product.
 - D testing of stack emissions.
- Q 3** Quantitative risk assessment differs from qualitative risk assessment because it is more:
- A adaptive.
 - B objective.
 - C subjective.
 - D detective.
- Q 4** A preferred method of conducting a shift handover is:
- A face to face using verbal and written communication.
 - B by telephone using verbal communication.
 - C via a log book using written communication.
 - D by radio using verbal communication.

Q 5 Which of the following is the most important consideration when selecting contractors?

- A** Proving that they have no previous or pending enforcement actions
- B** Providing method statements, risk assessments and safety policies
- C** Evidence of previous safe working and understanding their impact on others
- D** Membership of a professional body and adequate insurance cover for the work

Q6 Two separate work permits had been issued for the maintenance work on a pump. One was for repair of the pump and one was for removal and servicing of the pressure relief valve on the discharge side of the pump. The pump repair had been completed but the servicing of the pressure relief valve had not been completed by the end of the shift. In place of the pressure relief valve a 'blank' had been loosely installed. During shift handover, the maintenance work and return to service of the pump was discussed, but no mention was made of the servicing work being carried out on its pressure relief valve. The pump was then started, allowing flammable liquids to leak from the 'blank'. This vapour cloud ignited, causing a fire.

Which of the following actions during shift handover would have been most effective in preventing this accident?

- A** verbal communication in a quiet place between incoming and outgoing workers.
- B** confirmation of permits signed off as completed.
- C** discussion of the recorded process checks undertaken by the outgoing workers.
- D** a physical demonstration of the plant state between incoming and outgoing workers.

Element 3: Process safety hazard control

Learning outcomes

- 3.1 Explain the purpose and requirements of standard operating procedures
- 3.2 Outline the controls that should be adopted to control the safe start-up and shut-down of process plant
- 3.3 Outline the necessity for performance standards for safety critical systems and equipment and the concept of 'FARSI'
- 3.4 Outline the hazards and controls associated with the use of steam and water within the process industries
- 3.5 Outline the hazards and controls associated with electricity / static electricity within the process industries
- 3.6 Outline the physical forms of dangerous substances and how these can determine process risk
- 3.7 Outline the hazards presented by chemical reactions and the protective measures used to mitigate the consequences of a thermal runaway reaction
- 3.8 Outline the hazards and controls available for the bulk storage of dangerous substances.

3.1 Operating procedures

- What is meant by the term 'safe operating envelope' with reference to common parameters
- Purpose of operating procedures, types and who should be involved in their development
- What should be included within operating procedures
- Requirement for written procedures to be clearly understood by the end user
- Verification systems to ensure that operating procedures remain current and accurate
- Limitations of operating procedures / potential consequences of deviating from them
- Importance of responding to alarms.

3.2 Safe start-up and shut-down

- Types of start-up and shutdown: planned, unplanned, emergency, staged and delayed
- A pre-start-up safety review to confirm:
 - that any modifications meet appropriate management of change requirements
 - post pressure testing, plant has been suitably drained and/or dried of contaminants blanks removed and drain valves, sample points and relevant vents closed ready for service
 - visual inspection of plant to determine that all work has been completed
 - all alarms, trips and PRV's are in working order

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- when required, ie, new plant or changes, full training given to relevant workers/contractors
- Necessity for alarm systems to be in full working operation and designed to alert, inform and guide the operators, allowing for diagnosis of problems
- Software and control systems fully operational
- Plant shut-down:
 - undertaken in accordance with shut-down procedures
 - assessment and planning of the impact of plant shut-down on adjacent plant / shared services.

3.3 Safety critical performance standards

- Reasons for performance standards for both safety critical systems and items of equipment
- In relation to safety critical performance standards, the relevance of the elements of 'FARSI':
 - **F**unctionality
 - **A**vailability
 - **R**eliability
 - **S**urvivability
 - **I**nterdependency.

3.4 Utilities

- Uses of steam within the processing industries
- Properties of saturated and superheated steam
- Steam hazards and associated controls:
 - thermal expansion
 - prevention of the formation of vacuums
 - water in steam lines (water hammer)
- Water hazards and associated controls
 - vacuum formation during draining operations
 - hydrostatic testing / weight
 - cooling towers – legionella and water-vapor fog
- Characteristics of inert gases and its associated hazards
- Industrial uses of inert gases to include:
 - providing inert atmospheres / purging
 - blanketing of storage tanks
 - uses as a fire-fighting agent
 - pipeline freezing operations
 - nitrogen use as back up instrument air.

3.5 Electricity/static electricity

- Principles of electricity: basic circuitry for current to flow: relationship between voltage, current and resistance

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- Hazards of electricity:
 - voltage, frequency, duration, resistance, current path
- Electric arcs and sparks (ignition hazards) and how they can occur during normal operations
- Electrostatic charges, how they are generated
- Control of electrostatic charges
 - bonding and grounding
- Planning for power outages:
 - use of generators / uninterruptible power sources (UPS) to provide emergency power.

3.6 Dangerous substances

- Physical forms of dangerous substances and how these can determine risk potential
- Meaning of explosive, oxidising, flashpoint, flammable (and combustible) liquids and gas categories.

3.7 Reaction hazards

- The effects of temperature, pressure and catalysts on rates of chemical reactions
- Meaning of the terms ' exothermic reaction' and 'endothermic reaction'
- Meaning of the term 'thermal runaway reaction', the likely process causes and possible consequences of occurrence
- Protective measures commonly used to mitigate the consequences of a thermal runaway reaction:
 - containment within a reactor (tested and designed to withstand maximum generated pressure)
 - crash cooling
 - drowning and quenching of reactor contents
 - emergency venting / dumping of reactants ie, to scrubber systems, knock-out drums and flare stacks.

3.8 Bulk storage operations

- Hazards and risks including overfilling, effects of vacuum, overloading of foundations and failure modes for tank shells and associated pipe work (creep, stress, thermal shock and brittle fracture)
- Siting of tanks (distance from people, property and other tanks containing dangerous substances) and ventilation requirements
- Filling of tanks, overfilling/alarms/tanker connections
- Floating roof tanks (both external and internal roof types), landing the roof, sinking the roof and rim seal fires/failures
- Fixed roof storage tanks, pressure and vacuum hazards (ref 3.4)
- Bunding of storage tanks including volume and area sizing, construction and valving arrangements

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- Protection from extremes of weather
- Hazard potential of lightning strikes and suitable control measures
- Chemical warehousing to consider:
 - assessment and understanding of potential chemical hazards present
 - siting, location and security of warehousing
 - minimised inventories
 - separation and segregation of dangerous goods
 - control of ignition sources.

Recommended tuition time not less than 10 hours

Sample questions

- Q 1 The severity of injury received as a result of contact with electricity is minimised by:**
- A high current and low body resistance.
 - B low current and high voltage.
 - C low current and high body resistance.
 - D high current and high voltage.
- Q 2 What is saturated steam?**
- A where all the water has been converted to steam.
 - B where some liquid water is still retained in the steam.
 - C steam under very high pressure.
 - D steam with a temperature in excess of 200°C.
- Q 3 Legionellae bacteria grow at temperatures between:**
- A -10°C and -5°C.
 - B 20°C and 55°C.
 - C 60°C and 70°C.
 - D 70°C and 100°C.
- Q 4 One control adopted for safe start-up of plant is:**
- A Closing of all valves.
 - B closing of drain valves.
 - C opening of all valves.
 - D opening of drain valves.

- Q 5** In terms of safety critical performance standards, what does the abbreviation 'FARSI' stand for?
- A** functionality, availability, resource, survivability, interdependency.
 - B** functionality, asset integrity, reliability, survivability, interdependency.
 - C** functionality, asset integrity, reliability, systemic, interdependency.
 - D** functionality, availability, reliability, survivability, interdependency.

Element 4: Fire and explosion protection

Learning outcomes

- 4.1 Explain fire and explosion hazards relating to process industries
- 4.2 Outline appropriate control measures to minimise the effects of fire and explosion in the process industries
- 4.3 Outline how dusts have the potential to explode and commonly used control measures adopted to prevent and minimise explosion
- 4.4 Outline the purpose and features of an emergency plan and the requirements for the implementation.

Content

4.1 Fire hazards

- Fire triangle and modes of heat transfer – conduction, convection and radiation
- Typical ignition sources
- Upper flammable (explosive) limit, lower flammable (explosive) limit and the risk from working within these limits (ie, flammable/explosive range)
- Mechanisms for, and the possible consequences of:
 - jet fires, pool fires
 - BLEVE's, CVCE's and UVCE's.

4.2 Fire and explosion control

- Leak and fire detection systems, including gas / vapour detectors, spot, line, flame, and heat detection systems
- Passive fire protection, including passive fire protection of structures and equipment
- Active fire protection systems, including manual and automatic operation features
- Zoning / hazardous area classification and selection of suitable ignition protected electrical and mechanical equipment and critical control equipment
- Explosion protection systems including:
 - atmosphere control
 - pressure relief / explosion venting
 - automatic explosion suppression systems
 - automatic isolation
 - flame arrestors - active and passive isolation
- Benefits and limitations of chemical, foam and inert extinguishing systems
- Examples of fire protection systems for tank farms
- Mitigation of lightning strikes.

4.3 Dust explosions

- Why dust explosions occur
- Primary and secondary explosions
- Prevention of dust explosions to include:
 - an assessment of the risk / likelihood of explosion occurring
 - dusts replaced with granular or paste type products
 - prevention of explosive atmospheres by inerting
 - dust extraction systems and the necessity for good housekeeping practices
 - avoidance of ignition sources including the selection of appropriately rated electrical and non-electrical equipment
- Mitigation of dust explosions to consider:
 - explosion relief venting
 - explosion suppression and containment
 - plant siting and construction.

4.4 Emergency preparedness

- Purpose of an emergency plan
- Development of an emergency plan:
 - identification of possible scenarios and response required based on probability of occurrence and consequence
 - selection of on-site / off-site workers / agencies to be involved in plan development
 - resources required based on likelihood / consequences of events occurring
 - external emergency response and their availability
 - on site medical facilities / external medical facilities and their availability
 - requirement for both onsite and offsite emergency plans
- Content of an emergency plan:
 - systems for warning and alerting workers on site, neighbouring facilities and emergency services
 - delegation of responsibilities in the event of an emergency
 - expertise of teams involved in emergency response both internally and externally to the organisation
 - evacuation / shelter arrangements
 - emergency shut down of plant and services
 - consideration of vulnerable people
 - systems for accounting for site workers
- Information management during emergencies including liaison with the media
- Theoretical training – table-top exercises and simulations in testing incident response
- Competency of emergency responders / command team
- Practical emergency scenario testing – familiarity with emergency alarms, evacuation routes and safe havens / shelters and drills
- Provision of information to the public who may be effected by an onsite emergency.

Recommended tuition time not less than 5 hours

Sample questions

- Q 1 Which of the following best describes a Zone 1 hazardous area?**
- A a place in which an explosive mixture in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.
 - B a place in which an explosive atmosphere in the form of a cloud of flammable gas in air is likely to occur in normal operation occasionally.
 - C a place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation, but if it does occur, will persist for a short period only.
 - D a place in which an explosive atmosphere in the form of a flammable gas in air is not likely to occur in normal operation, but if it does occur, will persist for a short period only.
- Q 2 An external fire directly heats a vessel containing a flammable liquid. The liquid begins to boil, increasing the pressure which opens an integral pressure relief valve. The liquid level inside the vessel lowers and the fire now begins to heat the vessel above the liquid level. The vessel metal thins, weakens and ruptures. What type of explosion does this describe?**
- A a confined vapour cloud explosion.
 - B a secondary explosion.
 - C a boiling liquid expanding vapour explosion.
 - D an unconfined vapour cloud explosion.
- Q 3 Development of an emergency plan should consider areas that are:**
- A on-site only.
 - B either on-site or off-site.
 - C off-site only.
 - D on-site and off-site.

- Q 4 Which is the preferred fire extinguishing media in a typical process control room?**
- A chemical powder.
 - B foam deluge.
 - C carbon dioxide.
 - D water deluge.
- Q 5 In processes that involve combustible dusts, why is it especially important to maintain good housekeeping?**
- A dust can build up on a variety of flat and irregular surfaces which can spontaneously ignite.
 - B dust on surfaces can be disturbed by a primary explosion causing a larger secondary explosion.
 - C dust build up on surfaces can be clearly seen by visitors and gives a poor image of the company
 - D dust will adversely affect limit sensors and proximity switches causing them to malfunction.
- Q6 Flammable liquid leaked from a storage vessel into the bund which surrounded it. The liquid began to fill the bund. Liquid also began to leak through cracks in the bund and flow towards a faulty electrical pump usually used to empty the bund of rain water.**
- Within minutes the entire bund was on fire, taking several hours to extinguish. What is the best description of this type of fire?**
- A jet fire.
 - B pool fire.
 - C flash fire.
 - D secondary fire.

Unit PSM1: Tutor References

UK legislation

Legislation	Country	Element/s
Control of Major Accident Hazards Regulations 2015	Great Britain	2, 3
Dangerous Substances and Explosive Atmosphere Regulations 2002	Great Britain	3, 4
Health and Safety (Consultation with Employees) Regulations 1996	Great Britain	1
Management of Health and Safety at Work Regulations 1999	Great Britain	2
Safety Representatives and Safety Committees Regulations 1977	Great Britain	1
Control of Major Accident Hazards Regulations (Northern Ireland) 2015	Northern Ireland	2, 3
Dangerous Substances and Explosive Atmospheres Regulations (Northern Ireland) 2003	Northern Ireland	3. 4
Health and Safety (Consultation with Employees) Regulations (Northern Ireland) 1996	Northern Ireland	1
Management of Health and Safety at work Regulations (Northern Ireland) 2000	Northern Ireland	2
Safety Representatives and Safety Committees Regulations (Northern Ireland) 1979	Northern Ireland	1

International statutory instruments (Directives, Conventions, Recommendations and Protocols)

Reference title	Reference detail eg link to Convention	Element/s
Occupational Safety and Health Convention (C155) and Recommendation (R164)	Link to C155 Link to R164	1
Prevention of Major Industrial Accidents Convention, ILO, C174 and Recommendation R181	Link to C174 Link to R181	2

Other relevant UK references

Reference title	Reference detail eg ISBN number	Element/s
COMAH – accident reports, HSE	COMAH accident reports	1
COMAH Competent Authority, Inspection of Competence Management Systems at COMAH Establishments, Operational Delivery Guide.	Operational Delivery Guide	1
Consulting employees on health and safety, A brief guide to the law, INDG232	HSE Books, INDG232	1

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Reference title	Reference detail eg ISBN number	Element/s
Dangerous substances and explosive atmosphere, Approved Code of Practice and guidance, L138	HSE Books, ISBN: 978-0-7176-6616-4 L138	2, 3
Designing and operating safe chemical reaction processes, HSG143	HSE Books, ISBN: 978-0-7176-1051-8 HSG143	3
Developing process safety indicators, A step-by-step guide for chemical and major hazard industries, HSG254	HSE Books, ISBN: 978-0-7176-6180-0 HSG254	2
Energy Institute	PSM definition	1
Guidance on permit-to-work systems. A guide for the petroleum, chemical and allied industries, HSG250	HSE Books, ISBN: 978-0-7176-2943-5 HSG250	2
HSE information sheet, Guidance on risk assessment for offshore installations	Offshore information sheet no. 3/2006 Info sheet no. 3/2006	2
Human factors: Shift handover	HSE website Shift hand-over	2
Improving inherent safety, OTH 96 521	Prepared by AEA Technology plc and Loughborough Consultants for the Health and Safety Executive OTH 96 521	2
Investigating accidents and incidents – a workbook for employers, unions, safety representatives and safety professionals,	HSG245, HSE Books, HSG245	1
Key Programme 3, Asset Integrity Programme	A report by the Offshore Division of HSE's Hazardous Installations Directorate http://www.hse.gov.uk/offshore/kp3.pdf	2
Managing contractors, A guide for employers, HSG159	HSE Books, ISBN: 978-0-7176-6436-8 HSG159	2
Plant modification / change procedures	HSE website http://www.hse.gov.uk/comah/sragtech/techmeasplantmod.htm	1
Health and safety bulletins, HSE	H&S bulletins	1
Operating procedures	HSE website http://www.hse.gov.uk/comah/sragtech/techmeasoperatio.htm	3
Organisational change and major accident hazards, Chemical Information Sheet No CHIS7	HSE, CHIS7	1
Process safety leadership in the chemicals industry, best practice guide	Chemical Industries Association Best practice guide	1
Reducing error and influencing behaviour, HSG48	HSE Books, ISBN: 978-0-7176-2452-2 HSG48	2
Remotely operated shutoff valves for emergency isolation of hazardous substances, HSG244	HSE Books, ISBN: 978-0-7176-2803-2 HSG244	3
Risk assessment, A brief guide to controlling risks in the workplace, INDG163	HSE Books, Link to INDG163	2
Safety and environmental standards for fuel storage sites, Process Safety Leadership Group, Final report	HSE Books, ISBN: 978-0-7176-6386-6 Final Report	1
Safe handling of combustible dusts; Precautions against explosions, HSG103	HSE Books, ISBN: 978-0-7176-2726-4 HSG103	4
Storage of flammable liquids in tanks, HSG176	HSE Books, HSG176	3

*The Guide to the NEBOSH HSE Certificate in Process
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Reference title	Reference detail eg ISBN number	Element/s
The Control of Major Accident Hazards Regulations 2015, Guidance on Regulations	HSE Books, ISBN: 978-0-7176-6605-8 L111	2
The safe isolation of plant and equipment, HSG253	HSE Books, ISBN: 978-0-7176-6171-8 HSG253	2, 3
The Flixborough disaster	Report of the Court of Inquiry	1

Other relevant international references

Reference title	Reference detail eg ISBN number	Element/s
Chemical Safety Board	www.csb.gov	1
Corporate Governance for Process Safety, Guidance for Senior Leaders in High Hazard Industries, Series on Chemical Accidents No. 24	Organisation for Economic Co-operation and Development, Ref ENV/JM/MONO(2012)39, 19 December 2012 Link to Guidance for Senior Leaders	1
International Association of Drilling Contractors	Safety Alerts	1
International Council of Chemical Associations (ICCA) – Responsible Care commitment	Link to ICCA - Responsible Care	1
Making the Case for Process Safety Competence	European Process Safety Centre, Making the case competence	1
Occupational health and safety management systems – requirements (OHSAS 18000 series) ¹	OHSAS 18001 ISBN: 978-0-5805-9404-5 OHSAS 18002 ISBN: 978-0-5806-2686-9	2
Prevention of major industrial accidents, ILO, Code of Practice	ISBN: 92-2-107101-4 Link to Prevention of major industrial accidents CoP	2, 3

¹This reference will be updated once the revised ISO 45001 standard is published.

6. Glossary of process safety management terms

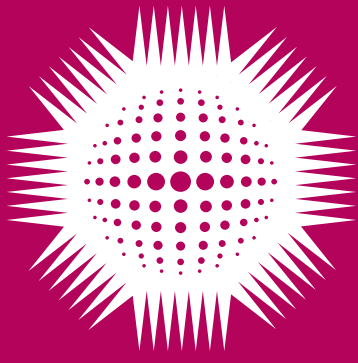
Term	Definition	Source
As low as is reasonably practicable (ALARP)	<i>ALARP means that the risk hasn't just been reduced, but is now at the lowest level that can be achieved without incurring disproportionate costs (costs can be financial, time, effort and inconvenience).</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Asset	<i>An item of equipment or an area of production plant.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Asset integrity	<i>The ability of an asset to perform its required function effectively and efficiently whilst protecting health, safety and the environment.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Barriers	<i>Controls that can be put in place between the initiator (the triggering event) to either prevent it from happening or to mitigate the outcome. Also see Bow-Tie model and Hazard realisation.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Bow-Tie model	<i>Used with 'hazard realisation'. As the hazard realisation is worked through then 'barriers' can be identified that can be placed between the initiator (the triggering event) to either prevent it from happening or to mitigate the outcome (also known as layers of protection or defence. When these are drawn together this is known as a bow-tie.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Classification of hazardous places (zones)	<i>Hazardous places are classified in terms of zones on the basis of the frequency and duration of the occurrence of an explosive atmosphere: Zones 0-2 relate to gas/vapours/mists and Zones 20-22 to dusts.</i>	Dangerous substances and explosive atmosphere, Approved Code of Practice and guidance, L138, HSE Books, ISBN: 978-0-7176-6616-4 L138
Competence	<i>"The ability to undertake responsibilities and to perform activities to a relevant standard, as necessary, to ensure process safety and prevent major accidents. Competence is a combination of knowledge skills and experience and requires a willingness and reliability that work activities will be undertaken in accordance with agreed standards, rules and procedures"</i>	COMAH Competent Authority, Inspection of Competence Management Systems at COMAH Establishments (Operational Delivery Guide) Operational Delivery Guide
Contractor	<i>"A contractor is anyone you get in to work for you who is not an employee".</i>	Managing contractors, A guide for employers, HSE Books, HSG159
Endothermic	<i>A reaction is called endothermic if energy (heat) is absorbed during the reaction.</i>	Designing and operating safe chemical reaction processes, HSG143, HSE Books, ISBN: 978-0-7176-1051-8 HSG143
Exothermic	<i>A reaction is called exothermic if energy (heat) is released during the reaction.</i>	Designing and operating safe chemical reaction processes, HSG143, HSE Books, ISBN: 978-0-7176-1051-8 HSG143
Explosion relief venting	<i>One or more deliberate points of weakness are included in process plant; if they are of suitable size and in the right place, they will safely vent an explosion with the plant.</i>	Safe handling of combustible dusts; Precautions against explosions, HSG103, HSE Books, ISBN: 978-0-7176-2726-4 HSG103
Explosive	<i>A substance has the risk of exploding in the right mixture with oxygen and if sufficient energy is available.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6

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Term	Definition	Source
Event tree analysis	<i>Used to evaluate the mitigation measures that will operate after an event. The process starts with an initiating event and works forward in time to see what protective measure will operate. Each control will either be a success or a failure and, in this way, branches are built up on tree.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Failure Mode and Effects Analysis (FMEA)	<i>A study often used to brainstorm how a component or a system might fail, the potential effects/consequences of those failures, existing safeguards against those failure modes and whether more should be in place.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Flammable	<i>The property of a substance (usually gas or liquid (or the vapour above the liquid)) to ignite when sufficient energy is applied in the form of heat.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Flashpoint	<i>The minimum temperature at which a liquid, under specific test conditions, gives off sufficient flammable vapour to ignite momentarily on the application of an ignition source.</i>	Dangerous substances and explosive atmosphere, Approved Code of Practice and guidance, L138, HSE Books, ISBN: 978-0-7176-6616-4 L138
Hazard and Operability (HAZOP) Study	<i>An advanced risk assessment. It is a very thorough analysis of a process to identify ways in which the process could deviate from its design intention in order that controls can be developed. It is usually chaired by an independent HAZOP leader and involves a multidisciplinary team of designers, engineers, safety professionals, operators and other specialists.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Hazard Identification (HAZID)	<i>A brainstorming activity to identify hazards before changes are made to existing processes and plant (sometimes called a walk-through).</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Hazard realisation	<i>In hazard realisation, the assessor looks at 'the worst-case scenario' to understand the potential consequences of the hazard so that controls can be implemented in the form of barriers.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Lagging indicators	<i>Reactive measures that look at failures such as the number of injuries, near misses and spills which are reported, or excursions where plant is operated outside of the intended operational envelope.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Leading indicators	<i>Proactive measurements of conditions that monitor process safety management before something goes wrong and to see if things are operating as intended.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Lower explosion limit (LEL)	<i>The minimum concentration of vapour in air below which propagation of a flame will not occur in the presence of an ignition source. Also referred to as the lower flammable limit or lower explosive limit.</i>	Dangerous substances and explosive atmospheres, Approved Code of Practice and guidance, L138, HSE Books, ISBN: 978-0-7176-6616-4 L138
Oxidising	<i>The property of a substance to readily accept electrons from another substance.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Permit-to-work system	<i>A formal recorded process used to control work which is identified as potentially hazardous. It is also a means of communication between site/installation management, plant supervisors and operators and those who carry out the hazardous work.</i>	Guidance on permit-to-work systems, A guide for the petroleum, chemical and allied industries, HSE Books, HSG250

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Term	Definition	Source
Process safety	<i>“A blend of engineering and management skills focused on preventing catastrophic accidents and near misses, particularly structural collapse, explosions, fires and toxic releases associated with loss of containment of energy or dangerous substances such as chemicals and petroleum products. These engineering and management skills exceed those required for managing workplace safety (Adapted from Centre for Chemical Process Safety of the American Institute of Chemical Engineers)”</i>	Energy Institute
Safe operating envelope	<i>The limits of the operating conditions under which a process can take place safely. Typically, process limits are established by setting upper and lower levels for a range of parameters.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Safe operating procedure (SOP)	<i>A document step-by-step instruction on how to conduct specific parts of the operating process. It sets out the way a certain task or activity is done so that mistakes which might lead to a situation where the safe operating envelope could be breached are avoided. The overall purpose of the SOP is to identify and maintain the operating parameters such as pressure limits, temperature range, flow rates etc at the required safe level.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Shift hand-over	<i>The terms used to describe the transfer of information between a shift who are leaving work and incoming new shift.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6
Thermal runaway reaction	<i>A reaction that is out of control because the rate of heat generation by an exothermic chemical reaction exceeds the rate of cooling available.</i>	Designing and operating safe chemical reaction processes, HSG143, HSE Books, ISBN: 978-0-7176-1051-8 HSG143
Upper explosion limit	<i>The maximum concentration of vapour in air above which the propagation of a flame will not occur. Also referred to as the upper flammable limit or the upper explosion limit.</i>	Dangerous substances and explosive atmospheres, Approved Code of Practice and guidance, L138, HSE Books, ISBN: 978-0-7176-6616-4 L138
What-if analysis	<i>In ‘what-if analysis of risk realisation, the assessor asks, “what-if” and then digs deeper to look at the true potential of an incident.</i>	NEBOSH Process Safety Management Book ISBN: 978-0-9571751-3-6



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