

Unit 148: Process Safety Management in Engineering

Unit code:	M/505/8267
QCF Level 3:	BTEC Nationals
Credit value:	10
Guided learning hours:	60

● Aim and purpose

The aim of this unit is to give learners knowledge and understanding of the critical importance of process safety in engineering and process safety management. The unit also gives learners the skills needed to deal with maintaining a safe and incident free working environment.

● Unit introduction

Process safety and process safety management is increasingly important in the UK. High-profile incidents at regional, national and global level highlight the need to address process safety management and to have a strategy for the implementation of process safety management training across the UK process industries.

The safety of people working in UK process industries is of primary importance. The manufacture, handling and use of dangerous substances can pose major hazards to people who work in the process industry, to members of the public and to the built and natural environment. Process safety management in engineering is about how the process industry assesses and controls these major hazards.

Unexpected releases of toxic, reactive, or flammable liquids and gases associated with chemical and petroleum products have, unfortunately, been reported for many years. However, it should be remembered that although these incidents have the potential to be high in consequence, the frequency of such events is low. Effective process safety management should aim to minimise the chances of these unexpected fires, explosions and toxic releases, due to loss of containment, occurring at process plants.

This unit will give learners knowledge and understanding of:

- how process safety differs from occupational safety
- the major process and physical hazards and risks associated with working in a process plant
- the risk analysis methods employed
- the safe work practices
- the associated legislation and regulations
- their role and that of others in complying with the related legal obligations.

Learners will need to understand why achieving a positive process safety culture is important in driving continuous improvement in the management of process safety. They will study the principles of managing the risks posed by everyday activities and be able to carry out incident investigations.

● Learning outcomes

On completion of this unit a learner should:

- 1 Understand the key features of process safety management and culture
- 2 Know how to monitor and test process and physical hazards associated with working in the process industry
- 3 Understand how to reduce the risks associated with hazards within the process industry
- 4 Be able to review the roles, responsibilities and competencies required for an incident free workplace

Unit content

1 Understand the key features of process safety management and culture

Key features of process safety legislation: major process-related events (fires, explosions and hazardous material releases) in process plants; current and relevant regulations and laws, e.g. Control Of Major Accident Hazards (COMAH), Health and Safety at Work Act (HASAWA) 1974, EU Machinery Directive 2006/42/EC, Chemical Agents Directive 98/24/EC, ATEX Workplace Directive, Dangerous Substance and Explosive Atmosphere Regulations (DSEAR), Pressure Systems Safety Regulations 2000 (PSSR), Control of Substances Hazardous to Health (COSHH), Classification, Labelling and Packaging (CLP), ISO 14001, The Management of Health and Safety at Work Regulations 1999, LOLER, Working at Height Regulations)

Process safety culture: reinforcement of positive behaviours and attitudes toward process safety; culture ladder (pathological, reactive, calculative, proactive, generative); the energy institute high level framework for process safety management (PSM framework); workforce involvement, e.g. hazard identification, conduct of operations; management processes, e.g. risk management, involving stakeholders, training and performance, incident investigation, contractor management, emergency management, process knowledge management, management of change, operational readiness, management review, continuous improvement; safe work practices, e.g. (Lock Out Tag Out – LOTO), isolation of hazardous energy, confined space entry, hot work, working at height, excavations, line breaking, stop work authority; asset integrity, e.g. measurement and metrics (leading and lagging indicators), auditing

2 Know how to monitor and test process and physical hazards associated with working in the process industry

Process and physical hazards: identify process and physical hazards, e.g. line of fire, release of hazardous chemicals, spills of hazardous chemicals; materials, e.g. characteristics of materials, materials storage and handling; equipment, e.g. start up and shut down, utilities; human activities, ergonomics, noise, slips, trips and falls, motor vehicle operation

Monitoring and test equipment: parameters, e.g. temperature, pressure, radiation, speed; use of instruments, e.g. meters, gas analysis, thermal imaging, reactive screening devices, temperature sensors, pressure gauges, infrared techniques; alarm systems

3 Understand how to reduce the risks associated with hazards within the process industry

Managing risk: assessment of risk, e.g. HSE five steps to risk assessment structured what-if technique, Hazard And Operability Study (HAZOP), Failure Mode And Effects Analysis (FMEA), risk matrix; risk avoidance, e.g. elimination, substitution, maintenance of equipment

Use of control measures: facility design and building siting; safety procedures, e.g. operating procedures, training and competency, active and passive controls, process safety information, use of Personal Protective Equipment (PPE), permit to work systems, isolation of hazardous energy and the steps required for successful isolation reliability and asset integrity, stop work authority and worker intervention

Layer of Protection Analysis (LOPA): countermeasures against consequences; step by step approach; independence of protection layers, e.g. safe design, physical protection, emergency response, back-up systems, fail-safe components; risk tolerance criteria

4 Be able to review the roles, responsibilities and competencies required for an incident free workplace

Roles, responsibilities and competencies of those conducting work: the four stages of competence, supervisor; permit management, e.g. permit issuer, permit approver, permit acceptor/holder; entry management, e.g. authorised entrant, entry supervisor, entry watch; qualified gas tester; operating safety considerations, e.g. bottle watch, fire watch, person conducting hot work, operator, maintainer, person conducting work at height, standby person

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 Explain the key features of relevant process safety regulations and laws as applied to given process-related events	M1 Analyse the key features of process safety management as applied to a process plant environment	D1 Justify the use of risk assessment methods used in the process industry in accordance with workplace policies and legal requirements
P2 Describe the key features and differences between a strong and a weak process safety culture	M2 Analyse how process control measures are used to prevent incidents	D2 Evaluate the impact of a given process safety failure on a business, the environment and the community
P3 Describe the methods used to identify hazards in a process plant	M3 Explain how layers of protection failure and human factors can lead to process safety failure	
P4 Describe the process and physical hazards associated with the process industry	M4 Assess the main function and requirements of permit to work systems in helping to prevent major process incidents	
P5 Describe the type and use of monitoring and testing equipment required for safe working in confined spaces		
P6 Explain the techniques used for managing risks commonly adopted by process industries		
P7 Explain the use of control measures commonly adopted by process industries		
P8 Explain the use of Layer of Protection Analysis (LOPA) within a process industry environment		

Assessment and grading criteria

To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P9 Carry out a review of the roles, responsibilities and competencies required for a typical process industry work activity		

Essential guidance for tutors

Delivery

Case studies could be used for the delivery of this unit to focus learners on the relationship between the process and unexpected releases of toxic, reactive or flammable liquids and gases.

Case studies might be based on a site where the learner is working but it is more likely to be based on any of the number of case studies that tutors can research from the Health and Safety Executive (HSE) or US Chemical Safety Board (CSB) that have been developed from incidents that have taken place either regionally, nationally or globally. If case studies are based on a site where the learner is working, learners may need to formulate and agree the scenario and the terms of reference for the case study with their tutor.

The learning outcomes form a natural order for delivery. Learning outcome 1 is about distinguishing between process safety and occupational health and safety and the importance of a strong process safety culture. Current and relevant legislation and regulations can be made available but learners could be asked to research at least one given area, they could then present their findings to the rest of the group, so that the whole group benefits from the exercise. The four focus areas and 20 elements of process safety management can be made available but learners would be expected to research a given area and participate in a group presentation. It is essential that learners appreciate the difference between process safety and occupational safety. A high-level process safety management framework can be easily found on the internet. The HSE have a number of guides that are useful for the study of the safe work practice elements.

Learning outcome 2 is about knowing how to identify process and physical hazards, the characteristics of each and the types of testing equipment used to monitor each. This learning outcome could be covered through practical visits to companies operating in the process industry.

Before learning outcome 3 is delivered it is appropriate to emphasise the differences between hazards and risks, a hierarchy of control measures used to manage risk should be introduced.

Learning outcome 3 is about understanding the ways that risks are managed. Learners should be given opportunities to build their confidence in using risk assessment tools, over a number of scenarios. This should allow them to produce appropriate written evidence when looking at risk assessment. Learners should be taught about the importance of updating process safety information. This can then lead to a comprehensive Layer of Protection Analysis (LOPA).

Learning outcome 4 is about carrying out a review of the roles and responsibilities of individuals in performing work activities in process industries and the competencies that are required.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment	Learning time hours
<p>Learning outcome 1</p> <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"> introduction to unit, scheme of work and methods of assessment examine some of the major process-related incidents and causes introduction to process safety management focus areas and elements. <p><i>Individual/small-group work:</i></p> <ul style="list-style-type: none"> work using case studies to explore what led to major process-related incidents explore focus areas and elements of the process safety management framework. <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"> describe key features of process safety culture discuss the differences between strong and weak process safety cultures and the barriers to process safety deployment. <p><i>Individual/small-group work:</i></p> <ul style="list-style-type: none"> investigate what is meant by safety culture and the elements that form the culture ladder. <p>Preparation for and carrying out Assignment 1: Process Safety Management and Culture (P1, P2 and M1)</p>	<p>3</p> <p>5</p>
<p>Learning outcome 2</p> <p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"> introduction to process and physical hazards and the methods used to identify, measure and record these hazards examine the hazards associated with given work activities (e.g. confined space entry, hot work, working at height). <p><i>Industrial visit(s):</i></p> <ul style="list-style-type: none"> view a process environment to consider potential for harm and monitoring and testing of processes. <p><i>Group work:</i></p> <ul style="list-style-type: none"> use of case studies to look at process environments and identify the potential for harm in a number of relevant scenarios use of measurement techniques to monitor process variables. <p><i>Individual learner research:</i></p> <ul style="list-style-type: none"> review MSDSs for given hazardous products identify classification, physical and chemical properties of hazardous materials and the precautionary measures/emergency response to take. 	<p>8</p> <p>4</p> <p>2</p>

Topic and suggested assignments/activities and/assessment	Learning time hours
<p><i>Group work:</i></p> <ul style="list-style-type: none"> review the basic steps of a Job Safety Analysis. Carry out a simple Job Safety Analysis for a given scenario use of case studies to identify and evaluate the process safety management failures that lead to catastrophic incidents. 	3
<p><i>Individual learner activity:</i></p> <ul style="list-style-type: none"> investigate the roles, responsibilities and competencies required for a given work activity at a process plant. <p>Preparation for and carrying out Assignment 4: Assuring Incident Free Workplaces (P9, M4 and D2)</p>	4
Feedback on assessment, unit evaluation and close	
Total learning time hours	60

Assessment

Evidence of criteria can be collected from case studies, assignments and projects, which should enable learners to explore the application of legislation and regulations and hazards and risks in the workplace.

The pass grade specifies the minimum acceptable level required by learners. Assessment will need to cover all the learning outcomes but not necessarily all the topics included in the unit content. Achievement of a merit or a distinction grade will require answers that demonstrate additional depth and/or breadth of treatment.

To achieve a pass, learners must demonstrate an understanding of process safety management and knowledge of the process and physical hazards as applied to process engineering industry. They will need to explain the key features of process safety management, leadership and culture and relevant legislation and regulations whilst describing a range of roles and responsibilities. They will gain knowledge of the connection between major hazard identification and the risk assessment methods used by process industry. Learners will need to explain the differences between process safety and occupational health and safety and between a strong and a weak process safety culture.

This unit could be assessed through four assignments. The first assignment could consist of a series of written tasks. The first task could ask learners to research and then explain the key features of relevant process safety regulations when considering health and safety as it is applied in the process engineering industry (P1). It would be expected that learners are able to clearly differentiate between process safety (dealing with loss of containment events) which can lead to catastrophic incidents, and more general incidents that affect individual employees.

Another task could then ask them to explore the key features of a strong process safety culture and how this differs from a weak process safety culture (P2). A further task could then ask learners to consider their responses to the tasks targeted at P1 and P2 in order to provide an analysis of process safety management (M1). It is expected that both tasks would require learners to explore the four focus areas and associated 20 elements of process safety management.

It would be expected that learners make reference to the characteristics of strong and weak process safety cultures, the need for 100% workforce involvement and the barriers to process safety deployment. All responses could be in a written format, although for the pass criteria a presentation to the class or an annotated poster could be used. In these cases, it must be remembered that presentation skills or poster design skills are not being assessed.

The second assignment could cover P3, P4 and P5. This could start with a written task requiring learners to describe the methods used to identify hazards in a process plant (P3) and another, which describes the process and physical hazards for a given case study (P4). A further written task requiring learners to describe the type and use of monitoring and testing equipment required for safe working in confined spaces could be adopted (P5).

A third assignment could focus on P6, P7 and P8 along with the higher criteria M2, M3 and D1. The whole assignment could be based on an activity to explain the control measures required for given work activities (e.g. confined space, hot work, working at height) in a typical process environment. Written tasks could be used to allow learners to explain the techniques used for managing risk in the given scenario (P6), explaining the control measures adopted (P7) and providing an LOPA for the process (P8). Learners could then be given the opportunity to provide a written analysis of the use of control measures (M2), how weaknesses in a LOPA, along with human factors, can lead to process safety failure (M3) and a justification of the use of risk assessment within the process industry (D1).

The final assignment could cover the remaining criteria P9, M4 and D2 with a written task given for each. The first task could ask learners to carry out a review of the roles, responsibilities and competencies required for a typical process industry work activity (for example confined space, hot work, working at height) for P9. The second task could ask learners to assess the main function and the requirements of permit to work systems in helping to prevent major process incidents (M4). The third task could ask learners to evaluate the impact of process safety failures, from a given incident case study, on a business, environment and community, for example, the Buncefield incident (D2).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2 and M1	Process Safety Management and Culture	A written activity requiring learners to explain the key features of process safety regulations, differences between a strong and weak process safety culture, and to analyse the key features of process safety management as applied to a process plant environment.	<p>A report which explains the key features of relevant process safety regulations and laws as applied to two given process related events.</p> <p>A report which describes the key features of a strong process safety culture.</p> <p>A report which assesses the key features of process safety management as applied to a process plant environment.</p>
P3, P4 and P5	Monitoring of Process and Physical Hazards	A written activity to describe the major process and physical hazards for a given work activity and the monitoring techniques required to record appropriate process data.	A report describing process and physical hazards and process monitoring/measurement techniques for a given case study.

Criteria covered	Assignment title	Scenario	Assessment method
P6, P7, P8, M2, M3 and D1	Controlling Process Risks	A written activity explaining risk-management techniques, control measures and the use of LOPA along with an analysis of how process control measures are used to prevent incidents, how LOPA failure and human factors can lead to process safety failure and a justification of risk assessment methods within a process industry environment.	<p>A report with written responses that describes risk management techniques and justifies their use.</p> <p>A report with written responses which describes control measures and LOPA in a process industry environment.</p> <p>A report which analyses how process control measures are used to prevent incidents and how LOPA, failure along with human factors, can lead to process safety failure.</p>
P9, M4 and D2	Assuring Incident-Free Workplaces	<p>A written activity requiring learners to carry out a review of the roles, responsibilities and competencies required for a typical process industry work activity.</p> <p>A written activity that assesses the main function and requirements of a permit to work.</p> <p>A written activity that evaluates the impact of process safety failures.</p>	<p>A report with written responses that reviews the roles, responsibilities and competencies required for a typical process industry work activity.</p> <p>A report that assesses the main function and requirements of permit to work systems in helping to prevent major process incidents.</p> <p>A report that evaluates the impact of process safety failures.</p>

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC engineering sector suite. This unit has particular links with the following unit title in the Engineering suite:

Level 1	Level 2	Level 3
		Unit 1: Health and Safety in the Engineering Workplace

Essential resources

Learners need access to a wide range of process-industry-related safety literature. Ideally, the centre will be able to provide access to health and safety legislation and learning materials in a virtual learning environment.

Employer engagement and vocational contexts

Access to workplace policies, documentation and reports would help in understanding how process safety management can be effectively organised and implemented. If these could be gathered and placed in context through industrial visits then their value and relevance would be enhanced. In particular, learning outcomes 2, 3 and 4 would benefit from company visits and extend the learner's experience of potential hazards in a process environment and the measures used to control these. If industry visits are not possible then a visiting speaker with responsibility and experience of process safety and process safety management in an industrial setting could be used to bring an element of application and reality to an otherwise theoretical subject.

There is a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- local, regional business links – www.gov.uk/browse/business

Indicative reading for learners

Books

Center for Chemical Process Safety (CCPS) – *Guidelines for Risk Based Process Safety* (Wiley-Blackwell, 2007) ISBN 9780470165690

Ed Ferrett – *Health and Safety at Work Revision Guide: for the NEBOSH National General Certificate* (Routledge, 2nd edition 2012) ISBN 9780415519793

ICChemE – *BP Process Safety Series* (The Institute of Chemical Engineers, 2007) ISBN 9780852955215

Kletz T – *What Went Wrong (5th Revised Edition): Case Histories of Process Plant Disasters and How They Could Have Been Avoided* (Butterworth-Heinemann, 2009) ISBN 9781856175319

Marshall V and Ruhemann S – *Fundamentals of Process Safety* (The Institute of Chemical Engineers, 2000) ISBN 9780852954317

Websites

Chemical Safety Board www.csb.gov

Energy Institute www.energyinst.org

Health and Safety Executive www.hse.gov.uk