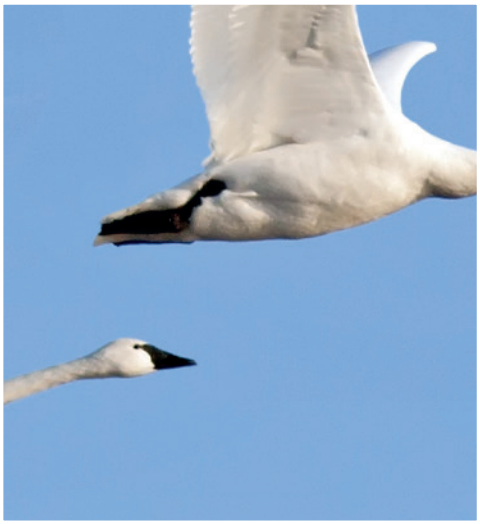
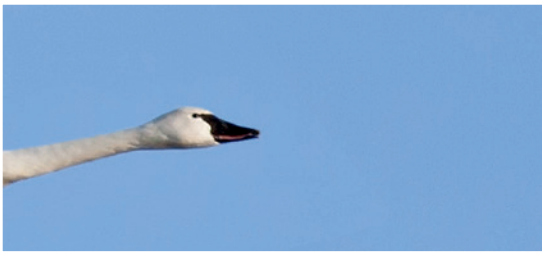
IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

IChemE Safety Centre Guidance

Sample University Laboratory Process Safety Management System





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IChemE Safety Centre

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Preface

This document has been developed to assist academic institutions in their application of process safety management in their laboratory activities. This is done to expose students to process safety in practice as defined in the IChemE Safety Centre Undergraduate Learning Outcomes Guidance Document. This document is not mandatory for academic institutions to use but offers advice and resources to improve process safety education.

There are two main process safety management systems defined. The first by the Center for Chemical Process Safety (CCPS) called Risk Based Process Safety Guidelines[1] and the second by the Energy Institute (EI) called High Level Framework for Process Safety Management[2]. These are key references for comprehensive process safety management system requirements. This guidance document is not a complete process safety management system, but a simplified version that is commensurate with the hazards involved at an academic institution, while still introducing process safety concepts in practice. This means that the guidance does not follow precisely the elements contained in the referenced process safety management systems. Rather the elements have been developed based on logical groups for application in laboratories.

During engineering education, students learn a range of different process safety concepts in different subjects. Risk assessment and management is also usually covered in the design project subject, where students perform a detailed risk assessment as part of their design. This guidance document introduces lower level risk assessment concepts that can be applied in the laboratory setting.

There are a number of other resources available to assist in the teaching of process safety. This document compliments, but does not replace them. For example DowDuPont offer a range of laboratory safety material on their website[3]. The American Institute of Chemical Engineers, via its Safety And Chemical Engineering Education (SAChE), offer a certificate program aimed at university students using complete online modules[4]. The ISC offer case study material[5] for use in universities to assist with learning from past incidents and will be producing additional resources to improve interactions between students and industry when on work placements. The ISC has also developed a laboratory specific case study, called Laboratory Experiment, which has been designed to support this safety management system. This is available as a free download from **icheme.org/knowledge/safety-centre/case-studies/** Additional information can be obtained from **safetycentre@icheme.org**

[1] ***CCPS, 2007. Guidelines for Risk Based Process Safety, Wiley, New York***
[2] ***https://publishing.energyinst.org/topics/process-safety***
[3] ***https://corporate.dow.com/en-us/science-and-sustainability/lab-safety***
[4] ***https://www.aiche.org/ccps/community/technological-communities/safety-and-chemical-engineering-education-sache/certificate-program/Level-One-Basic-Curriculum***
[5] ***https://www.icheme.org/knowledge/safety-centre/case-studies/***

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How to use this document

This document can be used in whole or in part, depending on the needs to the university. It is important to note that the resources contained here are examples only for the university to use for structure, not necessarily accurate details for direct application.

The following steps offer a guide to using this document:

- perform a gap analysis between the current management system in place and the suggested sections in this document. *Note: some aspects may be addressed in different ways, the outcome need not be achieved by following this model rigidly*
- determine if the gaps that emerge need to be closed
- develop an action plan to close the gaps. This may include:
  - determine which documents or systems need to be developed
  - prioritise the actions
  - develop necessary documents or systems based on the resources in this document, the resources here are templates only and not comprehensive examples
  - implement the systems or documents, including training of personnel as required
  - review the implementation periodically to ensure it is still functioning and providing the desired outcome

How this system is structured

Process safety in practice can be broken down into four fundamental areas:

- induction and competency
- risk identification and management
- operations
- review

Each of these four areas will be addressed, covering the basic requirements of the section and then introducing simplified resources where applicable to apply the requirements. It is vital that practical and relevant examples should be used to reinforce process safety concepts. This could be examples such as working at a fast food franchise or waiting tables. For many students this will be their only reference point for employment.

1 Induction and competency

An induction is vital to set the overall standards and expectations as well as educate people on the requirements. The induction should introduce the students to the following information:

- culture
- standards
- workforce involvement and working with others
- introduction to procedures
- training on equipment use
- emergency response and preparation requirements
- incident reporting requirements

Each of these seven areas will be discussed separately.

1.1 Culture

Establishing the organisation culture expected in a facility is an important element of the induction process, as it sets the expectations for behaviour. It is important to understand that there will be a culture established at all levels of the department in different groups. The key element for culture in laboratory safety is for every person, student and staff, to understand their responsibility to stop work and intervene where a hazard and its risk is not adequately controlled. Given a lack of experience in the environment, students may be unsure about stopping an activity. There needs to be a framework to allow them to err on the side of caution and intervene if they are not comfortable. This responsibility needs to form part of the base laboratory safety rules.

It is also important to understand that the application of the laboratory safety rules applies to all people, students and staff is vital. For example a tutor or lecturer not complying with a standard laboratory safety rule such as closed shoes or safety glasses because they are 'just passing through the room' sends a message to the students that the safety rule is not mandatory, creating a culture where they can make a judgement on when to follow the safety rules. The laboratory safety rules must be written so that they are clear and non-negotiable at all times.

Key elements

The key elements needed to help establish a consistent culture include:

- HSE policy
- stop work authority including who to seek advice from – if unsure err on side of caution and stop
- laboratory safety rules
- take 5/hazard observation

These all need to be followed by all people to ensure they are accepted as the minimum standard.

Resources

There are a number of resources available to reference or use to help build culture. The following examples are contained in **appendix 1:**

- example HSE policy
- example of laboratory safety rules

- example of a take 5 or hazard observation card
- example of an induction checklist

These all need to be followed by all people to ensure they are accepted as the minimum standard.

1.2 Standards

In any facility there are several standards and legislation that must be complied to. In most instances these documents may not be visible or in fact referenced regularly, but to demonstrate that they exist it can be helpful to have a register of applicable standards and legislation.

Some examples may include the annual inspection requirements on fume cupboards. There is a need for them to be tested and for the test date to be marked on the fume cupboard so any user can inspect to see it has been completed. Another example could be inspection of fire extinguishers. These should all have a tag to show they were inspected within the previous six months or required period.

Key elements

The key elements of standards and legislation include:

- defining the scope of the laboratory activities to understand what requirements are applicable
- listing the regulatory requirements and licenses
- listing the equipment standards
- maintaining a chemical inventory and managing safety data sheets
- appropriate disposal of samples to ensure incompatible materials are not mixed
- listing relevant safety standards

The application of required standards and legislation is vital to ensure that the best practices are applied. Standards can take many different forms, such as national, international or industry related. Refer to **section 2.3 – Risk identification and management – Implementation of controls and control validity** for a discussion on the application of standards in managing risk.

There are two main models of legislation applied to safety across the world. These two models are performance based and prescriptive. Performance based has a general duty to reduce risk as low as reasonably practicable. Where what is determined to be reasonably practicable can change over time as new technologies emerges or the cost of controls become cheaper. Prescriptive is where the rules are clearly defined and they must be adhered to. This could include the minimum spacing between equipment for example. For new technologies to be covered, the prescriptive rules need to be updated, where as for performance based the change needs to be considered with respect to the risk reduction without the need to update any rules.

Resources

There are a number of resources available to manage standards and legislation requirements. The following examples are contained in **appendix 1**:

- example of an applicable standards list
- example of an applicable legislation list
- example of a chemical inventory and safety data sheet register including infographic of incompatible materials
- example of an induction checklist

1.3 Workforce involvement and working with others

In the laboratory environment it can be assumed that all people present, students, and staff are part of the workforce. This assumption allows for the full engagement of the students in the safety of the work environment. Workforce involvement is about having all people no matter what their role engaged in the process safety management of the laboratory and activities performed in it. This includes interfaces with other stakeholders, such as other year level students, tutors, lecturers and perhaps even suppliers. This involvement is a fundamental part of communicating and of establishing competency for everyone. Each person needs to clearly understand their role and responsibilities to ensure safety for all. It is also important for people to understand the risks of being a lone worker, and how to ensure you are safe while performing activities out of normal hours.

Working with others is about ensuring that there is effective communication at all times to ensure hazards and controls are adequately communicated and therefore managed.

Key elements

The key elements of workforce involvement are:

- students considered as workforce
- roles and responsibilities are established, communicated and understood, so you are always aware who to ask for help
- the organisation is defined to show the roles and responsibilities
- working with others outside the chemical engineering department
- working with other students in team based activities
- have a defined safety champion – this could be more senior students leading junior ones
- using safety moments to communicate issues/learnings
- lone worker protocols defining who needs to be notified

Resources

There are a number of resources available to assist with workforce involvement requirements. The following examples are contained in **appendix 1**:

- example organisation chart showing responsibilities
- example position description for students
- example of an induction checklist
- example safety moments

1.4 Introduction to procedures

Use of procedures in the laboratory is important to ensure consistency in activities and experiments. Therefore, it is important for all people in the laboratory to be aware of what procedures exist and where to find them.

Key elements

The key elements to consider are what procedures are required and where they are located. It is also important to ensure that procedures undergo review to ensure they remain current as activities or circumstances change. It needs to be a requirement for personnel to follow procedures, unless it is unsafe to do so.

Resources

There are a number of resources available to assist with introduction to procedures requirements.

The following examples are contained in **appendix 1**:

- example of a procedures register
- example of an induction checklist

1.5 Training in equipment use

It is important to ensure that there is a system in place that ensures that all relevant people involved in the use, maintenance and disposal of equipment and materials associated with laboratories are suitably trained and checked for competency. This includes new, or revised, plans and procedures. This should include lone worker protocols where appropriate, for example some equipment must not be operated by a lone worker. Other equipment may have additional controls needed in this situation.

People training others should be competent in the task to ensure they are not training the wrong things.

Competence assessment requirements may be defined, commensurate with the complexity and associated risk of the task. A register of competent personnel should be maintained.

Key elements

They key elements of training in equipment use include the following:

- laboratory equipment
- safety equipment
- lone worker protocols

Resources

There are a number of resources available to assist with training in equipment use requirements. The following examples are contained in **appendix 1**:

- example of a training register including competency matrix for all people – the students should maintain the own record and ensure it is signed off as per the competency matrix
- example of an induction checklist

1.6 Emergency response and preparation requirements

Emergency response plans and resources are in place for all foreseeable laboratory related emergencies. Contingency and emergency plans incorporate the learning outcomes of incidents and there is a planned programme for emergency plan exercises in place. Plans should include a response for lone worker situations.

Key elements

The key elements required in emergency response and preparedness are how to:

- raise an alarm
- respond to an emergency
- safely evacuate

Resources

There are a number of resources available to assist with emergency response and preparedness requirements. The following examples are contained in **appendix 1**:

- example of an emergency response plan
- example of an emergency drawing
- example of an induction checklist

1.7 Incident reporting requirements

In the event of an incident or near miss in a laboratory it is important for the details to be reported so that root causes can be identified and rectified to prevent it occurring again. This reporting needs to be done after the situation has been made safe. The intention is to not blame people, but to learn, improve processes, and rectify problems to avoid this incident from re-occurring.

Key elements

There needs to be a simple procedure for raising and reporting an incident, and all people need to be familiar with how to do this. Past reports need to be kept for looking at trends of incidents.

Resources

There are a number of resources available to assist with incident reporting requirements. The following examples are contained in **appendix 1**:

- example of an incident report
- example of an incident database
- example of root cause analysis
- example of an induction checklist

Appendix 3–9–1 and **3–9–2** show an example of a laboratory incident.

2 Risk identification and management

Risk management provides the framework to understand the hazards and manage the risks during activities in the laboratory. The key aspects in risk management are:

- hazard identification
- risk assessment and identification of controls
- implementation of controls and control validity
- management of change

The first step in risk identification and management is to define the context. For the purposes of this guidance document the context is laboratory activities conducted by students in a university setting.

This process safety management system applies to laboratory activities not the design project.

The focus is upon the safety and risk element of the laboratory activities and, not other consequences such as environmental impact.

2.1 Hazard identification

There needs to be a process in place to identify and manage critical risk controls to prevent and recover from an incident associated with laboratory activities. These controls must be sufficient to ensure that the residual risk is acceptable. This process must be documented and updated regularly.

Key elements

The key elements of hazard identification include the following:

- understanding of what is a hazard, a control and risk
- hazard identification techniques
- hazards in the laboratory and workplace

Resources

There are a number of resources available to assist with hazard identification requirements. The following examples are contained in **appendix 2**:

- example of hazard identification methods
- example of infographics to show the hazards

2.2 Risk assessment and identification of controls

Risk assessment and identification of controls is covered within the design project subject, where the student is required to demonstrate that they have understood the process. Within the laboratory, there is a more practical task based risk assessment and identification of controls activity to be undertaken. In combination these two elements demonstrate how risk assessment can be project or task based. The method of implementation of risk assessment changes over the years as student progresses through university:

- in earlier years plans written for them and they review them
- in later years they write their own risk plans

The application of required standards and legislation is vital to ensure that the best practices are applied. Standards can take many different forms, such as national, international or industry related. Refer to **section 2.3 – Risk identification and management – Implementation of controls and control validity** for a discussion on the application of standards in managing risk.

Resources

There are a number of resources available to assist with risk management and identification of controls requirements. The following examples are contained in **appendix 2**:

- example of risk matrix (3x3)
- example of task based risk assessment forms
- flow chart on best risk assessment options to use

2.3 Implementation of controls and control validity

The risk assessment is an important element when managing risk, however the most important aspect is to actually implement the controls. Given that control implementation is the vital step, it is imperative that the controls are also valid in preventing or mitigating the risk.

Key elements

Some key elements to focus on are as follows:

- how many controls are enough?
- does the control degrade over time or have an expiry date?
- are they the right controls?
- how do you know the controls have had an impact?
- how are you checking controls are in place before and during work?

A key consideration in implementation of controls is whether the risk has been reduced as low as reasonably practicable (ALARP) or so far as reasonably practical (SFARP). This assessment guides whether any additional controls need to be considered. To determine ALARP, the following items need to be considered:

- likelihood of the hazard or risk occurring
- degree of harm that might result from the hazard or the risk
- what you know or ought to reasonably know about the hazard or risk and about ways to eliminate or minimise the risk
- availability and suitability of ways to eliminate or minimise the risk
- whether the cost to eliminate or minimise the risk is grossly disproportionate to the cost of the risk occurring.[6]

Where ALARP/SFARP is not used, another concept called recognised and generally accepted good engineering practice (RAGAGEP) is typically applied. This includes working to the following types of guidance or information:

[6] ***Adapted from How to determine what is reasonably practicable to meet a health and safety duty. SafeWork Australia. 2013***

- widely adopted codes
- consensus documents, such as those published by the America Society of Mechanical Engineers (ASME) or American National Standards Institute (ANSI)
- non-consensus documents, such as applicable manufacturers recommendations or association documents such as those produced by the Chlorine Institute
- internal standards, such as those developed within an organisation for internal use[7]

Due to the application of RAGAGEP, it is important to understand all the applicable standards and how to apply them in your environment.

Resources

There are a number of resources available to assist with implementation of controls and control validity requirements. The following examples are contained in **appendix 2**:

- example of risk matrix
- example of task-based risk assessment forms showing controls
- hierarchy of controls

Example box

Consider a fire extinguisher in the laboratory. There are a number of ways in which it might not be as effective as assumed:

- it could be out of testing date, and therefore has not been tested to ensure it is still charged correctly
- it may have been used by someone and put back in place without being recharged
- if pressurised, it may have lost pressure over time to a small leak
- if dry powder, it may have all settled out at the bottom of the extinguisher, making dispersion less effective

Any or all of these issues can impact the quality of the control measure.

2.4 Management of change

Management of change (MOC) is a 'golden thread' that runs through many aspects of the management system, rather than an element considered at a certain point in time. Changes come in many forms, and each needs to be managed. These changes can include; change to equipment, change to chemicals, procedures, organisational structure, etc. It should be noted that a temporary change can be just as hazardous (if not more so) than permanent change.

Example box

There can be many changes that occur in a laboratory. These include:

- changing a chemical in use, to a different compound or even a different supplier – this would need the chemical register to be updated with the new safety data sheet and supplier contact details
- replacing a pump in the system with a new version that is slightly different to the original one
- a change in heating elements in the laboratory, moving from gas to electric or vice versa would introduce different hazards to be managed

[7] ***Adapted from RAGAGEP in Process Safety Management Enforcement, US OSHA 1910.119. 2016***

Key elements

Key elements for focus on include:

- awareness of change and ability to detect change both transient and permanent change
- the need for a written management procedure to allow review of MOC when it arises, with examples (eg check list, clearance sheet, etc)
- importance of returning to original or design conditions in the event of temporary change (cross-reference with operations section, ie MOC is one of the needs for good handover logging)
- criteria for determining when changes may be more significant and the role of hazard analysis in helping determine whether the proposed change is safe
- importance of documenting change (eg amended P&ID, PFD, etc)
- special considerations during shut-down or process modification where changes are not 'replacement in kind'
- relationship between audit and MOC (closure of audit findings that lead to design / process changes can be missed as an MOC activity)

Resources

There are a number of resources available to assist with implementation of controls and control validity requirements. The following examples are contained in **appendix 2**:

- example of a management of change process
- example of a management of change form

3 Operations

Safe operations require a number of aspects to be embedded. These include:

- working with procedures
- safe work practices
  - permit to work
  - isolation
- pre start up safety review
- handover and logging

While these examples used in laboratories may seem trivial, there are several instances when trivia issues have led to significant consequences. This section aims to introduce simplified concepts and is not meant to devalue the application in the workplace.

3.1 Working with procedures

While a procedure provides a step by step guidance on how to perform a task, they also need to be critically reviewed to ensure they are still correct. This can typically be done by a procedure review process, where the steps are reviewed and discussed with people doing the task.

Key elements

Key elements in working with procedures include:

- selecting the correct procedure to the situation
- read and understand procedure prior to implementing
- pre-condition that person is competency in task prior to using the procedure
- following the steps as defined
- reviewing the outcome of the task and reflecting suggesting back on the procedure

Resources

There are a number of resources available to assist with working with procedures requirements. The following examples are contained in **appendix 3**:

- example of a procedure
- example of a procedure review checklist

Also see **appendix 1–10 Example procedures register**.

3.2 Safe work practices – permit to work

Permit to work procedures cover a wide range of activities in a workplace. These can include cold work (where there is no flame or spark potential) hot work (where there is flame or spark potential), confined space entry, excavation, high voltage electrical work, working at heights or break in (where holes are made into a cavity that may contain energy, such

as drilling into a wall where there may be electrical wires) to name a few. This guidance document will only look at cold work, as the others are beyond the scope of students working in a university laboratory.

Key elements

Key elements of a permit to work system include the following:

- definition of the work to be done
- risk review of the task
- implementation of control, including appropriate isolations
- approval or sign off to ensure reviews are adequate and to permit to work to take place

Resources

There are a number of resources available to assist with permit to work requirements. The following examples are contained in **appendix 3**:

- example of a permit to work procedure
- example of a permit to work form

3.3 Safe work practices – isolation

Isolation is a vital part of preparing a permit to work. Isolation ensures that people are kept away from any hazardous energy sources, such as pressure, fluid flow, electricity, etc. This is done in the form of isolation equipment and substances, and can include unplugging electrical equipment, or locking valves close. This is an introduction to the concept of lock out tag out or LOTO.

Key elements

Key elements include having a defined isolation standard which states the level of isolation required and when to apply that isolation. Once equipment is isolated there may also be a need to purge what ever substance is present to allow safe access.

Resources

There are a number of resources available to assist with isolation requirements. The following examples are contained in **appendix 3**:

- example of an isolation procedure
- example of an isolation sign off form, including P&ID
- example infographic showing different isolation equipment available for use

3.4 Pre start-up safety review

Prior to starting up a piece of equipment of an activity it is good practice to conduct a pre start-up safety review. This looks at the key safety elements to ensure they are in working order prior to starting up.

Key elements

A pre start-up safety review looks at a number of elements, including:

- visual inspection of equipment for damage or appropriate tags
- visual inspection of equipment to ensure it is assembled correctly and tight
- that all flow paths are as planned
- that all controls are in place as required and functioning

Resources

There are a number of resources available to assist with pre start-up safety review requirements. The following examples are contained in **appendix 3**:

- example of a pre start-up safety review form
- example safety moment showing that trivial issues can lead to significant consequences – CSB rainbow experiment

3.5 Handover and logging

When conducting activities in the laboratory it may be necessary to hand over the work to another work group. To ensure that all relevant information is handed over it is important to conduct a specific handover. It is also important to log various parameters during the experiment to monitor its performance. These are key skills that will be utilised in the workplace. Handover could be to a different group member or workgroup.

Key elements

Key elements include:

- what should be logged and communicated
- how it is logged and communicated
- systems need to be made safe prior to handover

Resources

There are a number of resources available to assist with handover and logging requirements. The following examples are contained in **appendix 3**:

- example of a process log
- example of a handover checklist

4 Review

In the academic setting there is less opportunity to consider review and metrics structures, however there is value in discussing how each step or activity could be improved. This not only leads to new suggestions on improving the activities, but also gets students used to challenging the work once it is completed to achieve continuous improvement.

A post activity review can help distil learnings as well as highlight areas for future improvement in the activities.

Key elements

Key elements of the review should include:

- detailed review of the steps undertaken and their success
- how participants interacted with the activity and each other
- what could be improved for future activities
- what the participant has learnt from the activity

Resources

There are a number of resources available to assist with review requirements. The following examples are contained in **appendix 4**:

- suggested questions for post activity review

Appendix 1

Resources

1–1 Example HSE policy

1–2 Example laboratory safety rules

1–3 Example take 5 or hazard observation card

1–4 Example induction checklist

1–5 Example applicable standards list

1–6 Example applicable legislation list

1–7 Example chemical inventory and safety data sheet register including infographic of incompatible materials

1–8 Example organisation chart showing responsibilities

1–9 Example position description for students

1–10 Example procedures register

1–11 Example training register

1–12 Example emergency response plan

1–13 Example emergency evacuation diagram

1–14 Example incident report

1–15 Example incident database

1–16 Example root cause analysis

Contents page

Appendix 1–1

Example health safety and environment policy

Health safety and environment objectives:

[University name/department] demonstrates our commitment to our employees, contractors, students and suppliers by:

- establishing clear health safety and environment objectives, ensuring our leaders at all levels, demonstrate their commitment to health safety and environment and maintain this focus throughout their work activities
- encouraging all employees, contractors, students and suppliers to exhibit high levels of health safety and environment awareness and to be accountable for creating and fostering a healthy safe and environmentally sustainable facility
- ensuring that all employees, contractors and students are adequately inducted in health safety and environment systems and processes before commencing work
- ensuring that effective systems and processes are in place to accurately report and record facility health safety and environment events and that appropriate investigations are conducted into these according to the scale and nature of the event
- ensure all laboratory activities are carried out in accordance with defined processes and workflow sequences
- regularly monitoring the application and suitability of these commitments to provide assurance that we are delivering continuous improvement and taking account of any potential organisational, best practice or legislative changes
- all personnel are enabled to refuse to carry out work that presents a serious risk to health safety or environment arising from an immediate or imminent exposure to a hazard

Signature

Head of Department Date

Appendix 1–2

Example laboratory safety rules

Laboratory name

Person in charge:

Phone:

Room:

After hours contact:

Phone:

Security/emergency:

Conditions of entry to laboratories

It is a condition of entry to all laboratories in this department to comply with all required safety rules.

When working in laboratories (either projects or activities) you must have completed the required training including induction prior to access being granted. Training must be recorded on your training register (refer **appendices 1–4 Induction checklist** and **1–11 Training register**). All laboratory rules shall align with the HSE policy.

Mandatory personal protective equipment (PPE) includes approved safety glasses, covered footwear and a laboratory coat. Other PPE may be required based on risk assessment. All chemicals shall be handled in accordance with their safety data sheets.

No eating or drinking in any laboratory.

A minimum of TWO AUTHORISED people to be present in the laboratory AT ALL TIMES.

Other conditions of entry to this laboratory include (please list if required):

Appendix 1–3

Example take 5 or hazard observation card

Take 5 or hazard observation cards are used to trigger a series of questions by the individual/team prior to starting work to help identify any safety issues before an incident. They are designed to have the user think through the task and plan how to avoid an incident. They usually have a series of prompts to help inform the review. Below is an example of the types of cards that can be used:

Name	
Job	
Date	
1. Stop and think Do I have the skills and knowledge? Does a procedure exist? Are the correct tools available and in good condition? Do I have the correct PPE? Do I have the authority to do the job? Am I focused on the job? Did I familiarise myself with MSDS for chemicals I am handling?	
2. Look for hazards What hazards are present? Am I or others in the line of fire? Other hazards include manual handling, work at heights, chemical exposure, confined space, hot work, etc	
3. Assess the risk Use a risk matrix to assess the risk of injury or incident from the job	
4. Make any changes Identify any controls to manage the risk Implement the controls before the job is done	
5. Do the job safely Follow the controls identified Complete the job following all procedures If conditions change review the job prior to continuing	

These questions can also be summaries into the following:

- what am I about to do?
- what can go wrong?
- what can I do to make it safer?

Appendix 1–4

Example laboratory induction checklist

This checklist outlines the specific induction and authorisation requirements for laboratories/workshops, including generic risk controls established by the laboratory/workshop. In addition, training will be provided for plant, equipment and safe work practices. This laboratory/workshop induction form must be completed and signed before authorised access to the laboratory/workshop is granted. Specific training must be documented in an attached training plan.

Faculty/school/unit		
Laboratory/workshop location: eg building number, name		
Laboratory/workshop identification: eg room number, name		
Inductee name		
Inductee user identification		
Laboratory manager name	Signature	
Supervisor name		
Date induction completed		
Refer to the safety manual throughout the training. Once complete, this form should be kept in the laboratory by the supervisor. It will be reviewed during any H&S audits	**Supervisors initials indicate competence demonstrated**	**Inductee's initials indicate training received**
Familiarity with the department safety manual Does the Inductee know: Where to find the safety manual Who to contact with H&S issues How to report an accident or near miss What to do in event of an incident or emergency		
Personal and protective equipment Does the Inductee have: Their own laboratory coat (and know when to wash it) Their own safety glasses (and know when they should be used) Gloves available (and know when and how to use) Goggles and face masks available (and know when and how to use) Enclosed footwear		

Personal and protective equipment Is the Inductee familiar with good laboratory practices as described in the safety manual? Is the Inductee aware that they should keep work areas clean and uncluttered and clean up when finished? Is the Inductee aware of the strictly no drinking and eating rule within the laboratory? Does the Inductee know the rules for out of hours/lone working? Is the Inductee aware of how to report building defects? Is the Inductee aware that their use of computer workstations within the laboratory needs to be assessed for ergonomics? Is the Inductee aware of how to check and safely use electrical equipment? Does the Inductee know how to access safe working procedures? Is the Inductee aware of how to safely handle large, awkward or potentially hazardous items?		
Risk assessment Does the Inductee know: Where to find the risk assessment forms and that they need to sign those that describe the procedures they perform? How to write new risk assessment forms and how these should be reviewed by the lab supervisors on completion? Actions in case of accident and spillage and disposal procedures?		
Emergency response Does the Inductee know the name and location of First Aiders and the first aid supplies including use of eye wash and safety showers? Does the Inductee know how to safely access and use fire extinguishers? Is the Inductee familiar with the emergency response plan?		
Chemical and biological safety For the chemicals they use is the Inductee familiar with: Material safety data sheets? Chemical hazard symbols? Biological hazard symbols? How to correctly label solutions? Which chemicals are highly flammable? Which chemicals are poisonous and/or carcinogens? The correct chemical spillage and disposal procedures? Correct storage requirements? Does the Inductee know how to use a fume cupboard? Are any specific licences required? If so, list them		

Radioisotope use (if relevant) Has the Inductee completed the required radiation safety course?		
Waste disposal Is the Inductee familiar with the waste disposal procedures? Is the Inductee familiar with the types of waste disposal bags and containers in use within the laboratory?		
A selection of comment hazards common to most laboratories (refer to the department safety manual for a comprehensive list)	**Supervisors initials indicate competence demonstrated**	**Inductee's initials indicate training received**
Compressed gasses and cryogenics including storage; transport, use of gas regulators, hazards		
Glassware usage and washing		
Microwave ovens including no screw top bottles, awareness of superheating of liquids		
Centrifuges including need to balance load symmetrically, place lids on buckets		
Fridges and freezers including items not to store, proper use of electrical equipment, correct storage of samples		
UV lamps including eye protection, correct disposal of mercury bulbs		
Water baths, heating elements and burners		
Vacuum systems		

I ……., have inducted and authorised ……. to access this location

(Laboratory Manager) (Inductee's name)

I ……. have undertaken this laboratory/workshop induction. I agree to abide by all the above

(Inductee signature) requirements as outlined by the laboratory/workshop manager.

Appendix 1–5

Example applicable standards list

The following is a guide only and not a comprehensive list of the type of applicable standards that may apply to the laboratory operations. A check should be made of other standards for relevance. Organisations specific standards should be added where applicable. Hyperlinks to the relevant documents should be used in these documents for ease of access.

International Standards
ISO 9001:2015 Quality management systems – requirements
ISO31000:2018 Risk management – guidelines
ISO14000:2015 Environmental management
ISO 45001:2018 Occupational health and safety
ISO 10648:1997 Containment enclosures – part 1: design principles
ISO 16496:2016 Laboratory glassware – vacuum-jacketed vessels for heat insulation
ISO 13994:2005 Clothing for protection against chemicals
National Standards (eg Australia and New Zealand)
AS/NZS 1336:2014 Eye and face protection – guidelines
AS/NZS 1715:2009 Selection, use and maintenance of respiratory protective equipment
AS 4332:2004 The storage and handling of gases in cylinders
AS/NZS 2161.1:2016 Occupational protective gloves – selection, use and maintenance
AS/NZS 2982:2010 Laboratory design and construction
AS 4775:2007 Emergency eyewash and shower equipment
AS/ZNS 2243.9:2009: Safety in laboratories – recirculating fume cabinets
National Standards (eg United Kingdom/EU)
BS EN IEC 61010-2:2018 Safety requirements for electrical equipment for measurement, control and laboratory use
BS EN 17242:2018 Recirculatory filtration fume cupboards
National Standards (eg USA)
ASTM E1269 - 11(2018). Standard test method for determining specific heat capacity by differential scanning calorimetry
NFPA 10 Standard for portable fire extinguishers
NFPA 13 Standard for the installation of sprinkler systems
NFPA 204 Standard for smoke and heat venting
National Standards (eg Malaysia)
MS 1042: Part 6:1992 Code of practice for safety in laboratories: part 6: mechanical aspects
MS 1042-7:2011 Safety in laboratories – code of practice part 7: fume cupboards

Appendix 1–6

Example applicable legislation list

The following is a guide only and not a comprehensive list of the type of applicable legislation and other legal documents that may apply to the laboratory operations. A check should be made of other legislation for relevance. Hyperlinks to the relevant documents should be used in these documents for ease of access.

National (eg Australia)
Industrial chemicals (notification and assessment) act 1989
Industrial chemicals (notification and assessment) regulations 1990
Therapeutic goods act 1989
National (eg USA)
29 CFR 1910.1450 Occupational exposure to hazardous chemicals in laboratories
National (eg UK)
Health and safety at work act 1974
National (eg Malaysia)
Occupational safety and health act 1994
Control of industrial major accident hazards regulations 1996
National (eg China)
Regulation on the safe management of hazardous chemicals 2011
State (eg New South Wales)
Work health and safety act 2011
Work health and safety regulation 2011
Environmentally hazardous chemicals act 1985
Environmentally hazardous chemicals regulation 2008
Explosives act 2003
Explosives regulation 2013
Poisons and therapeutic goods act 1966
Poisons and therapeutic goods regulation 2008
Codes of Practice
Labelling of workplace hazardous chemicals
Managing risks of hazardous chemicals in the workplace
Preparation of safety data sheets for hazardous chemicals
How to safely remove asbestos
Guidance on the classification of hazardous chemicals under the HS Regulations

Example chemical inventory and safety data sheet register

Example chemical inventory and safety data sheet register

This information has been adapted from WorkCover Queensland

A chemical inventory register is a list of all hazardous chemicals used, handled or stored at your workplace. You must keep the current safety data sheet (SDS) with this register and make sure it is accessible to workers. The SDS will tell you how to use and manage hazardous chemicals safely. The supplier of your chemicals should provide a SDS on request. *Note: chemicals not classified as hazardous chemicals do not require SDSs and do not need be included in this register. There are many on line systems available for registering and managing SDSs. This form offers a manual alternative to these systems if you do not have access to them.*

How can you tell if a chemical is classed as hazardous?

Review section 2 of the SDS

Does the label include the diamond shaped pictograms? (see right), have the signal words 'danger' or 'warning', have hazard or precautionary statements like 'toxic if swallowed' or 'wear eye protection', have risk or safety phrases such as 'harmful if swallowed' or 'keep out of reach of children'.

Contact the manufacturer or supplier for more details or for a copy of the SDS. Many companies also provide SDSs online.

Chemical name	**Manufacturer** including local contact details	**SDS issue date** (must be <5 years)	**Maximum quantity held on site***	**Storage location and type**	**Comments inc. shelf life and discard date where applicable**

Chemical compatibility chart

The segregation chart has been adapted from WorkCover Queensland and is provided to assist you to minimise the risk of storing incompatible goods. It recognises that transport guidelines are not suitable for workplace situations, where larger quantities of goods may be kept together in circumstances that enable better control measures.

Class of goods	2.1	2.2	2.2 SR 5.1	2.3	3	4.1	4.2	4.3	5.1	5.2	6.1	8	9	Combustible liquids
2.1	✓ A	✓ B	✘ S1	✘ S1	✘ S2	✘ S2	✘ S4	✘ S5	✘ S2	✘ S4	✘ S1	✘ S1	✓ C	✘ S2
2.2	✓ B	✓ A	✓ B	✘ S1	✘ S2	✘ S2	✘ S4	✘ S5	✓ B	✘ S4	✓ B	✘ S1	✓ C	✘ S2
2.2 SR 5.1	✘ S1	✓ B	✓ B	✘ S1	✘ S2	✘ S2	✘ S4	✘ S5	✘ S2	✘ S4	✓ C	✘ S1	✓ C	✘ S2
2.3	✘ S1	✘ S1	✘ S1	✓ I	✘ S2	✘ S2	✘ S4	✘ S5	✘ S2	✘ S4	✓ C	✘ S1	✓ C	✘ S2
3	✘ S2	✘ S2	✘ S2	✘ S2	✓ A	✘ S3	✘ S4	✘ S5	✘ S2	✘ S4	✘ S3	✘ S3	✓ B	✓ B
4.1	✘ S2	✘ S2	✘ S2	✘ S2	✘ S3	✓ A	✘ S4	✘ S5	✘ S2	✘ S4	✘ S3	✓ B	✓ B	✘ S2
4.2	✘ S4	✘ S4	✘ S4	✘ S4	✘ S4	✘ S4	✓ A	✘ S5	✘ S4	✘ S4	✘ S4	✓ B	✓ B	✘ S4
4.3	✘ S5	✘ S5	✘ S5	✘ S5	✘ S5	✘ S5	✘ S5	✓ A	✘ S5	✘ S5	✘ S5	✘ S5	✓ G	✘ S5
5.1	✘ S2	✓ B	✘ S2	✘ S2	✘ S2	✘ S2	✘ S4	✘ S5	✓ D	✘ S4	✓ C	✘ S3	✓ C	✘ S3
5.2	✘ S4	✘ S4	✘ S4	✘ S4	✘ S4	✘ S4	✘ S4	✘ S5	✘ S4	✓ E	✓ CE	✘ S4	✓ CE	✘ S4
6.1	✘ S1	✓ B	✓ C	✓ C	✘ S3	✘ S3	✘ S4	✘ S5	✓ C	✓ CE	✓ A	✓ H	✓ B	✘ S3
8	✘ S1	✘ S1	✘ S1	✘ S1	✘ S3	✓ B	✓ B	✘ S5	✘ S3	✘ S4	✓ H	✓ F	✓ C	✘ S3
9	✓ C	✓ C	✓ C	✓ C	✓ B	✓ B	✓ B	✓ G	✓ C	✓ CE	✓ B	✓ C	✓ A	✓ B
Combustible liquids	✘ S2	✘ S2	✘ S2	✘ S2	✓ B	✘ S2	✘ S4	✘ S5	✘ S3	✘ S4	✘ S3	✘ S3	✓ B	✓ A
✓	May be compatible in many cases with exceptions. Follow the **compatible goods guidance notes**.													
✘	Likely to be incompatible. Segregation strongly recommended, follow the **segregation of guidance notes for incompatible goods**.													

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Segregation guidance notes for incompatible goods

S1	Segregate these goods by 3m or more in a well ventilated area. For liquid dangerous goods the distance is measured from the edge of the spill catchment area. See supplementary notes 6 and 7.
S2	Segregate by 5 m or more. If one of the dangerous goods is a liquid, measure the distance from the edge of the spill catchment area. Liquid dangerous goods should be located within a separate spill catchment area. See supplementary notes 6 and 7.
S3	Segregate by 3 m or more for PG III goods and 5m or more for PG II, PG I goods or where the goods may react dangerously. If both are solids then a minimum of 1m separation may be used. Where one of the goods is a liquid the distance is measured from the edge of the spill catchment area. See supplementary notes 6 and 7.
S4	Segregation preferred by the use of fire-rated partitioned areas. Consider use of separate detached building for organic peroxides and for highly pyrophoric class 4.2 goods.
S5	Segregation of class 4.3 preferred by use of a separate, detached building without water based fire suppression system.

Compatible goods guidance notes

A	In most cases materials of the same class will be compatible. However, not all materials with different UN Numbers will always be compatible. The SDS should be checked.
B	In many cases the goods will be compatible. Must check for subsidiary risk compatibility and the SDS
C	If one of the goods present is also a fire risk substance (one of class 2.1, 3, 4, 5, a combustible liquid or has a subsidiary risk of one of these) or elevated temperature goods, segregation is required by at least 3 m or more. Sub-risk MUST be considered. Other exceptions apply. Check the SDS
D	Not all class 5.1 goods are compatible as follows: ■ ammonium nitrate is not compatible with tetranitromethane, dichloroisocyanuric acid, any bromate, chlorate, chlorite, hypochlorites, or chloroisocyanurate, or any inorganic nitrate ■ calcium hypochlorite (and its mixtures) are incompatible with dichloroisocyanuric acid, ammonium nitrate, or any chloroisocyanurate
E	Organic peroxides are highly reactive materials. Please check the SDS to ensure compatibility.
F	Where one of the goods to be stored together is a concentrated strong acid and the other a concentrated strong alkali, they should be deemed incompatible.
G	Class 4.3 goods must not be stored next to goods that are in a solution containing water, or where water or foam is the chosen fire-fighting/spill/leak dispersal or suppression media for the storage area.
H	Except where the class 6.1 is cyanide and the class 8 an acid. Check the SDS.
I	Toxic gases ammonia and chlorine must be segregated due to risk of explosion. It is important to refer to the SDS for incompatibilities within this class division. It is strongly recommended that each different toxic gas (class 2.3) be segregated unless information in the SDS says otherwise.

Other guidance notes

- class 2 dangerous goods (ie gases) are generally not recommended to be stored with any other class of dangerous goods particularly flammable dangerous goods due to the risk of flame impingement and overpressurisation of cylinders. Corrosive goods can cause corrosion damage to the gas cylinder walls and thus should be kept away from class 2. In a fire situation, gas cylinders need to have copious quantities of water applied to keep them cool. Toxic gases are stored away from other gases to minimise the release of toxic gases in a fire with other gases
- class 6.1 dangerous goods are not recommended to be stored with fire risk goods or gas cylinders. In the event of a fire, the toxic material will be liberated and may be spread more effectively due to the heat of the fire or explosion of gas cylinders
- two or more goods within the same class with incompatible subsidiary risk should be kept apart
- the packing group (PG) of dangerous goods denotes the magnitude of danger the material poses from its hazard. PG I is most dangerous. PG II these are more dangerous than PG III. If one of the incompatible materials is a PG I or II dangerous goods it is recommended that a greater segregation distance or other means of segregation is employed
- if class 4.3 dangerous goods are stored or handled care needs to be taken to segregate these away from all containers of aqueous (water containing) solutions even if the solutions are not dangerous goods. The areas these materials are stored in must not be serviced by a water based fire suppression system
- if one of the incompatible goods is a liquid OR a solid that is likely to melt from the heat of a fire, separate spill catchment systems or means of separating the incompatible goods must be considered. Solid dangerous goods should not be stored in direct contact with floor surface to avoid contact with liquids
- fire rated walls constructed of appropriate impervious, chemically resistant materials may be used if provided with an FRL of 240/240/240. Timber structures are not appropriate barriers
- in the case of incompatible gases in cylinders intended for use in welding (such as acetylene and oxygen), these gases may be stored together in a purpose built cradle and separated when not in use for extended periods of time
- for oxidizing agents: Although only dangerous goods and combustible liquids feature in the compatibility chart care must also be taken to segregate oxidizers from those dangerous goods and other materials that are combustible in nature (eg polymeric beads, cotton bales, excess packing materials). Chlorine and some other halogens are considered potent oxidizers even though their class and assigned with any oxidizing agent subsidiary risk under the dangerous goods classification system

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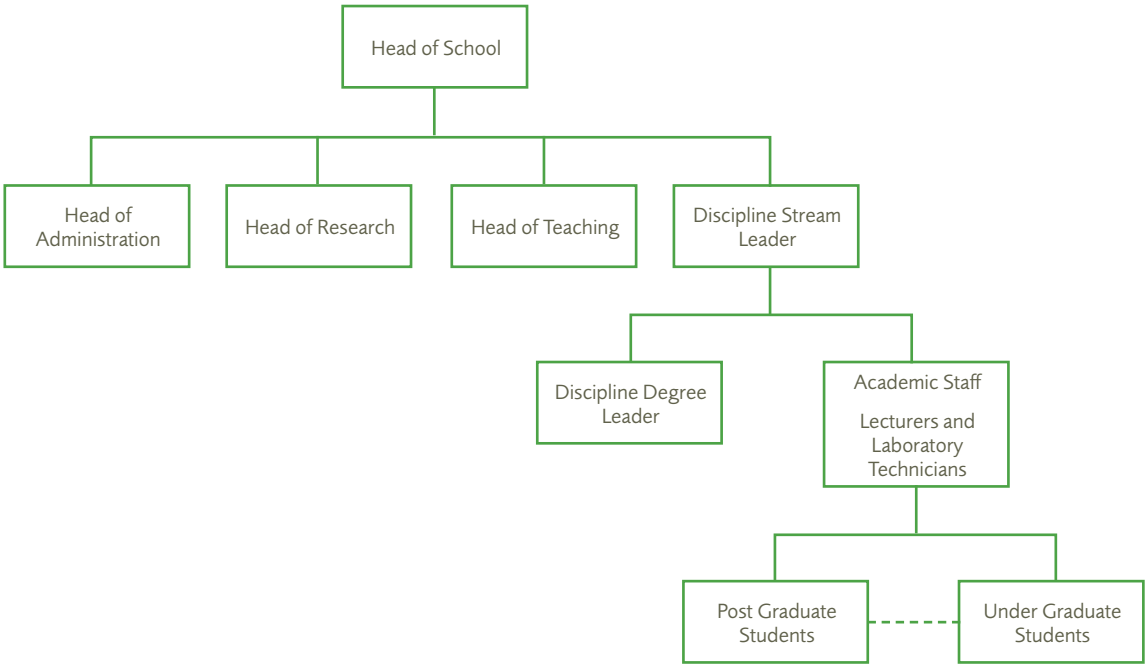
Appendix 1–8

Example organisation chart

This is an example only and shows the line where students would be, it does not show the entire organisation structure of a school.



Appendix 1–9

Example position description for students

Position summary

Becoming a successful student is very much like mastering a new job. In order to excel, it is necessary to know what is expected of you. There is a basic duty of care required to look after the health and safety of yourself and others. This includes a requirement to conduct yourself professionally. The details of this are described below.

Organisational environment

While there is not an employer/employee arrangement between the student and the university, a hierarchy of personnel exists. Within a faculty, this starts with the Dean of Engineering, then followed by the Head of Department (HoD), Professors, Associate Professors and tutors report through to the HoD. Students can be considered to report though to the Professors, Associate Professors and laboratory technicians.

Key duties and responsibilities

In a learning centred university laboratory environment, students are expected to:

- read and understand the laboratory safety management system
- read and abide by the laboratory schedule when registering each semester
- check with his or her major department for current information on requirements and curriculum
- talk to an advisor about the required training and courses needed for this laboratory unit
- schedule classes so that the most effective learning can occur

Students should have a personal commitment to learning to:

- allow adequate study time per week for each course
- show satisfactory academic progress
- assume responsibility for his or her education in the laboratory setting
- make use of the library and resources available
- develop a plan for increasing listening skills and improving study habits
- take notes during classes
- work collaboratively with other students and laboratory support staff
- evaluate his or her own progress

Laboratory environment

When in a laboratory environment there are hazards present and therefore the requirements for students and staff are similar with respect to safety. This includes:

- attend all sessions and be on time
- follow the handover process and sign the checklist
- be aware of what happened earlier in the laboratory/experiment
- complete all pre-work when absent from class
- read, understand, and follow the instructions in the task on hand
- complete reading and writing assignments in time
- turn in assignments on time
- ensure your work submitted in your own
- actively participate in discussions
- make appointments with professors during assigned office hours if help required
- exhibit respectful behaviour at all times

Appendix 1–10

Example procedure register

The following table outlines the important information when maintain a list of current procedures. It is designed to ensure you are always aware of the most up to date requirements.

Procedure number	Procedure name	Procedure approved by	Procedure owner	Revision number	Release date	Next revision due
This gives the procedure a unique identifier and may also describe what type of procedure it is. For example an operational procedure may have the code OP and a maintenance procedure may have the code MN	This is the descriptive title of the procedure	This is the person who is in charge of the procedure and may authorise changes to it	This is the person who develops the content of the procedure.	This shows how many times the procedure had been reviewed	This shows when the procedure was last reviewed and released	This shows when the procedure is next due for review. Periodic reviews are done to ensure that the procedures remain up to date and accurate
eg						
LAB-MN-001	Change out of filter pads	Prof Jones	Assoc Prof Smith	3	15 Jan 2017	15 Jan 2019

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Appendix 1–11

Example training register

Including competency matrix for all people – the students should maintain the own record and ensure it is signed off as per the competency matrix.

Mandatory training (cannot do job without it)		Trainer name			Student name
					14 June
Laboratory induction	Mandatory within 1 week of starting. Cannot enter laboratory without it		Online	Completion date	
			One-off	Next due	
			Online	Completion date	14 October
Work permit training	Mandatory for work involving a permit to work		One-off	Next due	
			Online	Next due	14 October
Isolation (tag-out/lock-out) training	Mandatory for work involving isolation		One-off	Next due	

Preferred/as required training		Trainer name			Student name
					17 October
Investigation training	Preferred during 3rd year		Online	Completion date	
			One-off	Next due	
			Online	Completion date	18 January
Management of change	Preferred during 3rd year		One-off	Next due	

Key			
In Date	Falling Due	Out of Date	

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Appendix 1–12

Example emergency response plan

This document provides a general format for an emergency response plan (ERP) that may be applied to a chemical engineering laboratory. Some ERPs are more abbreviated than others but there are a number of features that need to be present in all documentation. The key thing to remember is that to be effective, an ERP should be clearly documented and communicated in a way that is readily accessible to all stakeholders.

Tips, tricks and things to remember for developing your own ERP are shown throughout.

This ERP was developed based on the guidance presented in:

- NSW HIPAP 1 Emergency Response Planning
- NSW Work Health and Safety Regulation 2017
- AS/NZS 2243:2014 Safety in Laboratories

Emergency response plan

Introduction

This emergency response plan (ERP) is applicable for the [Laboratory Name], Chemical Engineering Building.

Aims and Objectives

The aim of an ERP should be expressed as a broad statement of intent.

The purpose of this ERP is to provide a system and resources to deal with emergency situations to protect people, property and the environment.

Scope

The scope of application and any limitations of the ERP should be clearly outlined.

The emergency response plan is applicable to emergency situations covering emergency preparedness and response.

An emergency situation is defined as: 'a hazardous situation (or threat of a hazardous situation) which requires action to control, correct and return to a safe condition and also requires timely action to protect people, property and the environment from harm'.

Examples of emergency situations that may be encountered in the laboratory are:

- fires (including the generation of toxic combustion products)
- spills (of hazardous solids and liquids, dangerous goods, flammables)
- gas leaks (flammable, toxic, asphyxiant, pressurised or refrigerated liquid)
- structural failures

These types of emergencies should be considered for both those arising within and those from outside the facility.

The ERP is applicable to all personnel in the laboratory inclusive of visitors and/or contractors.

Remember to check the hazard register and ensure the ERP covers all of the required incidents.

Hazards and levels of emergency

It is important to clearly identify and define the types of hazardous materials and other hazards that may be present, as these will inform the planning for the type of response required.

Hazardous materials

Hazardous materials stored and used in this laboratory are shown in the following table. Refer to the Chemical Inventory and Safety Data Sheet Register (refer appendix A–7).

Other hazards

Other hazards that may be present and how they will be managed are shown in the following table. Hazards should always be assessed and managed, as this list is an example only.

Hazards	Symbol	How hazard will be managed
Mechanical hazards		Barricades, signage, no loose articles of clothing
Electrical hazards		Signage, earthing
Working at height		Hand rails, safety helmets

Emergency functions and organisational structure

The functions nominated for an emergency response should be listed in the ERP, together with the associated roles, responsibilities and duties of personnel assigned to these functions, and arrangements for appropriate backup.

In an emergency situation, roles will be taken by different people as part of a coordinated response as described in the following table.

Roles	Responsibilities
First responder	■ raise the alarm to local emergency response coordinator ■ isolate the source of release
Local emergency response coordinator	■ coordinate evacuation of laboratory ■ contact emergency response team leader (if required)
Emergency response team leader	■ coordinate evacuation of neighbouring buildings (if required) ■ contact emergency services (if required) ■ terminate emergency response
Emergency services	■ coordinate emergency response (eg fire-fighting, ambulance)

The organisational structure in place in an emergency is shown in appendix A.

It is important to also consider who will respond to an emergency should it occur after hours.

Emergency procedures

Emergency procedures should describe the steps to be undertaken, the precautions, the protective clothing and equipment to be used, any special conditions, and the responsibilities and duties of people undertaking these procedures.

In the event of an emergency situation, the emergency procedure should be followed as shown in appendix B.

Emergency resources

The following resources (equipment and amenities) are provided to assist in the emergency response:

- fire-fighting equipment (ie hose reels, extinguishers, fire blankets)
- fire-fighting media (ie foams, additional water supplies)
- laboratory safety equipment (eye wash, safety showers)
- protective clothing (eg overalls, chemical splash suits, gloves etc)
- spill containment equipment
- first-aid equipment

Emergency alarm and notification system

An emergency alarm is provided within the laboratory which provides both a visual and audible alert (ie flashing light with siren). If evacuation is required there will be an audible announcement. Upon alarm activation, an alert will be provided to the site security who will coordinate evacuations in neighbouring buildings (if required). The alarm system is tested on a weekly basis on [insert regular test time and day].

Induction and training

All personnel (including visitors and contractors) should be provided with an induction and ongoing training so that they have a general awareness of the ERP and the capability to undertake their roles and responsibilities in the event of an emergency situation. Areas covered include:

- emergency functions of the organisational structure (including roles and responsibilities under the ERP) (see section 3)
- emergency procedures (see appendix B)
- emergency resources (see section 4.1).

All inductions and training should be competency-based, enabling personnel to develop skills in the use of emergency equipment and a working knowledge of emergency procedures.

Emergency response activation, reporting and termination

All stages of an emergency should be considered in the ERP from activation through to termination.

Activation

Once an initial alert is raised, the emergency response coordinator will investigate and determine if the level of emergency is of a high enough nature to constitute the activation of the ERP. Depending on the severity level, the emergency response coordinator will contact the emergency response team leader who will alert relevant stakeholders and coordinate the appropriate response.

Reporting

The emergency response team leader should attempt to gather all necessary information before consultation with the police, fire service, and other emergency services. The initial report would usually be made by dialling the emergency number [insert local emergency services number] and ask for the fire service.

The information provided in this report should include the following details, where available:

- name and location of the facility (suburb, street, nearest cross street to relevant site entry)
- number of injured persons or casualties and the nature of injuries
- the type and scale of emergency including a brief description
- hazards involved (including details of substances and quantities involved)
- telephone contact number and name of person making the call (for any return messages)

Termination

The plan should outline the procedures and responsibilities for terminating an emergency. These should be considered in terms of:

- the return of control to the facility emergency controller by the emergency services
- the declaration by the facility emergency controller that the emergency has been terminated 'all clear'
- clean-up operations and incident reporting

Supporting information

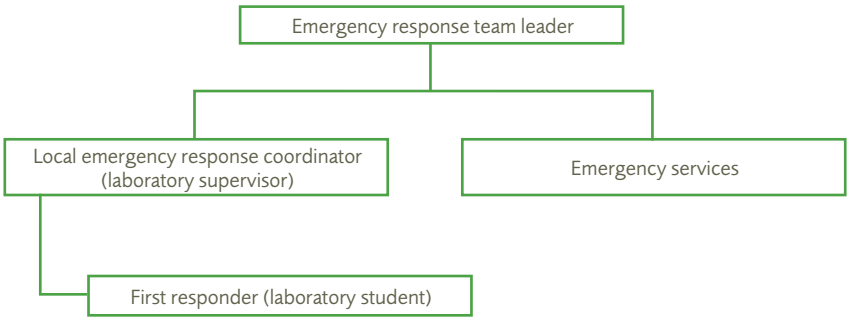
Information supporting the ERP needs to be included as an attachment and should also be available as a separate information package to be given to the emergency responders when responding to an emergency.

Information which supports the ERP includes:

- safety, health and environment information (including copies of SDS, hazard registers)
- emergency drawings (showing evacuation routes and emergency equipment)
- a list of emergency contact phone numbers
- relevant information relating to emergency resources and equipment

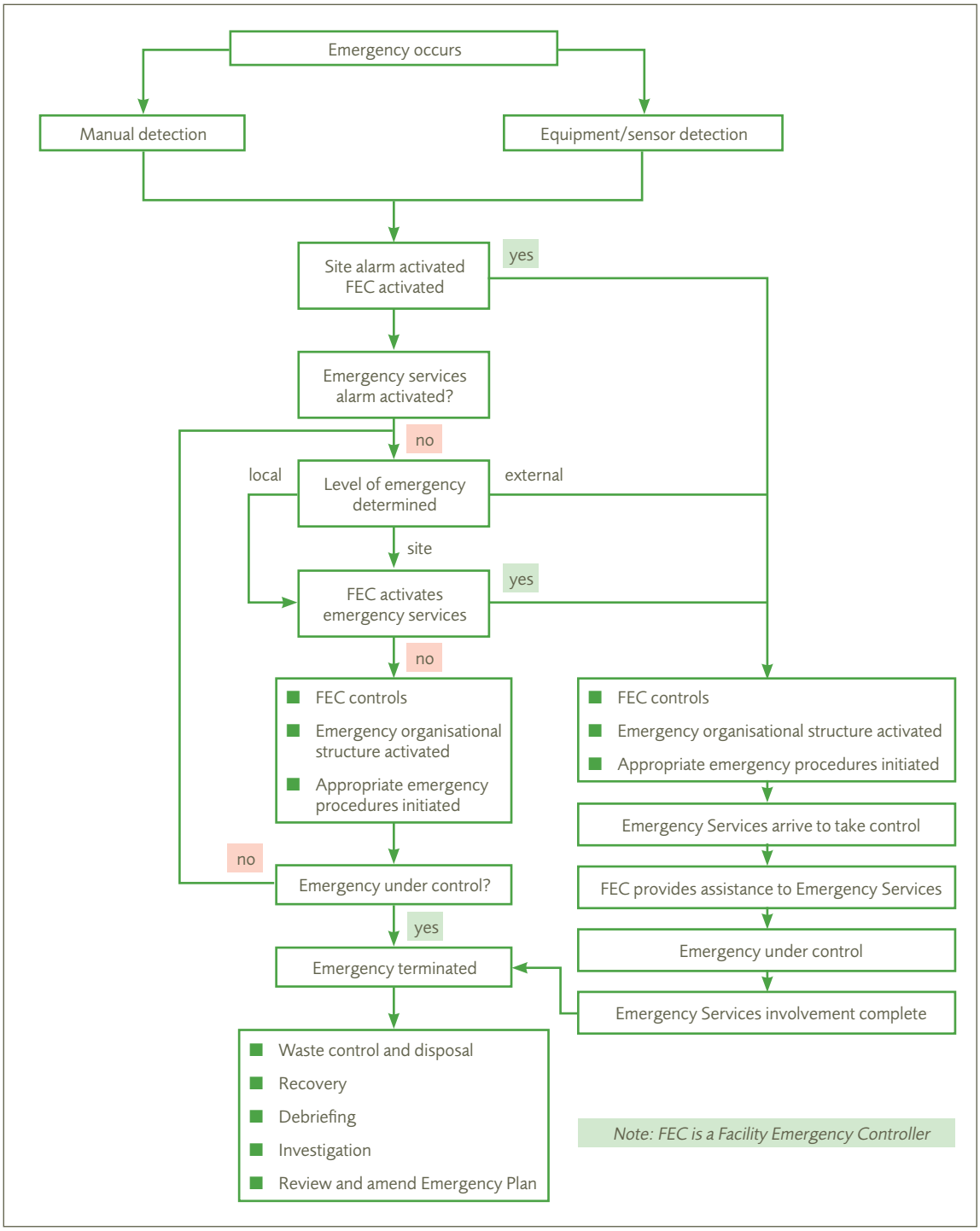
All supporting information has been prepared in consultation with the relevant emergency services to ensure that it meets their needs.

Emergency response organisation chart



Emergency response procedure flowchart

In an emergency situation, the following steps will be undertaken.



From *Hazardous Industry Planning Advisory Paper No 1 – Emergency Planning, January 2011*, New South Wales Government, Department of Planning.

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Appendix 1–13

Example emergency evacuation diagram

Explanatory notes

1. Position, orientation and minimum elements of evacuation diagram

According to AS 3745 – 2010 'Australian standard for planning for emergencies in facilities', site layout for emergency response and evacuation shall be provided according to following principles.

Clause	Title	Requirement
3.5.2	Number and location	Evacuation diagrams shall be displayed in locations where occupants and visitors are able to view the diagrams. The location within the facility and number of evacuation diagrams shall be determined by the Emergency Planning Committee.
3.5.3	Position	The evacuation diagram should be positioned within a zone at a height not less than 1200 mm and not more than 1600 mm above the plane of the finished floor.
3.5.4	Orientation	Individual evacuation diagrams shall have the correct orientation with regard to the direction of egress and its location to the 'YOU ARE HERE' point. Where an assembly area diagram is included, the assembly diagram area shall have the same orientation to the rest of the diagram.
3.5.5	Size	A pictorial representation of the floor or area, which shall be at least 200 mm × 150 mm.
3.5.5	Title	The title 'EVACUATION DIAGRAM'.
3.5.5	Relative location	The 'YOU ARE HERE' location.
3.5.5	Exit	The designated exits in the facility, which shall be green.
3.5.5	Communication equipment	Warden intercommunication points (WIPs), which shall be red; Manual call points (MCPs), which shall be red; Emergency call points (ECPs), which shall be coloured white, or have a black border.
3.5.5	Warning equipment	Main controls/panels for the occupant warning equipment.
3.5.5	Fire equipment	Main controls/panels for the occupant warning equipment.
3.5.5	Refuges	Show refuges, if present.
3.5.5	Validity date	Show validity date (also issue date and version according to appendix E example EVACUATION DIAGRAMS.
3.5.5	Assembly area	Location of assembly area(s), either stated in words or pictorially represented.
3.5.5	Legend	Show a legend, which shall reflect the symbols used
Other references:		
Building Code of Australia AS 2243 – 2004 'Safety in laboratories – storage of chemicals'		

2. Optional elements (see clause 3.5.6)

The following additional information **may be** considered by the EPC for inclusion on the evacuation diagram:

Clause	Title	Requirement
3.5.6	Doors	Direction of opening of doors on designated exits.
3.5.6	Orientation	Show north arrow.
3.5.6	First aid	Show first aid stations and kits (denoted by a white cross on a green background).
3.5.6	Chemicals	Show hazardous chemical store.
3.5.6	Spill response	Show spill response kits.
3.5.6	Emergency Information	For example, emergency telephone numbers, emergency response procedures, fire orders etc.
3.5.6	Contacts	Show warden details.
3.5.6	Evacuation paths	Show paths of travel, coloured green.
Other references:		
Building Code of Australia AS 2243 – 2004 'Safety in laboratories – storage of chemicals'		

3. Other considerations that may apply to a chemical engineering laboratory or pilot plant

According to Standard AS NZS 2243 'Safety in laboratories' laboratory hazards fall generally into one of five categories:

- biological – eg pathogenic micro-organisms, animals, biological tissues, blood and other body fluids (human and animal)
- chemical – eg corrosive, flammable, toxic
- physical – eg noise, radiation, manual handling
- electrical/mechanical – eg high voltage apparatus, machinery with moving parts
- psychological – eg emotional stress, workplace bullying

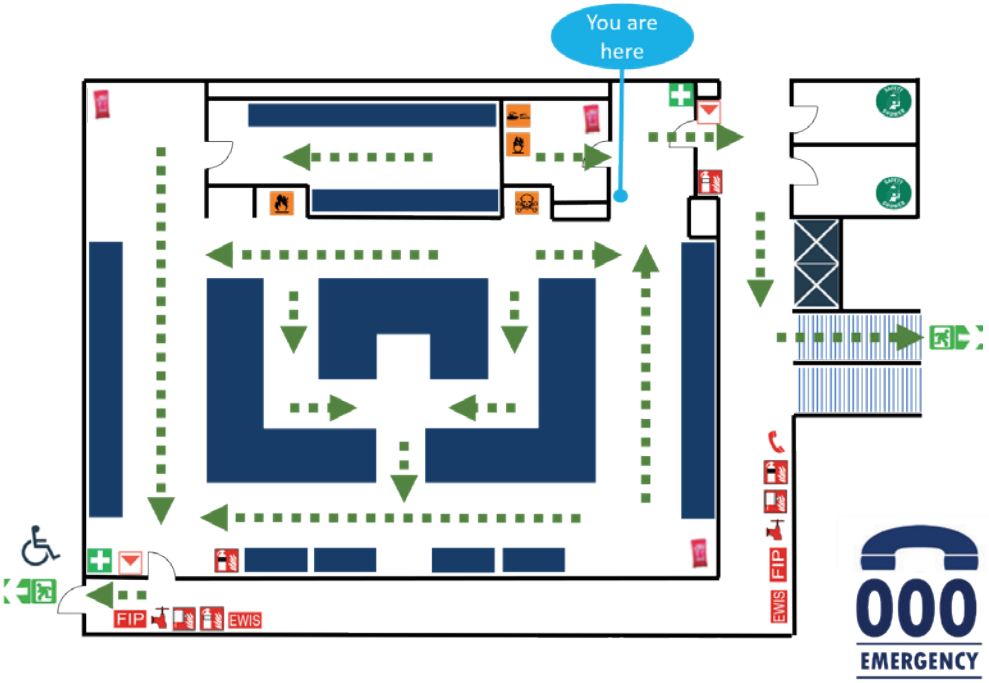
Other element to locate on the diagram may include:

- eyewash and safety shower facilities for the cases of chemical spill on skin or eye
- dangerous goods storage for corrosive, flammable, toxic, oxidizing materials
- location of large furniture/equipment as that could affect evacuation routes

Evacuation Diagram

Example Only

Chemical Engineering Laboratory
Building name, Address



Legend

CO2 extinguisher		Emergency Phone	
Dry chemical powder extinguisher		Elevator	
Fire hose reel		First aid Kit	
Fire indicator panel	FIP	Corrosive storage	
Manual call point		Flammable storage	
Emergency call point		Oxidizing storage	
Fire blanket		Poisonous Storage	
Fire hydrant		Emergency exit	
Emergency Warning and Intercommunication System	EWIS	YOU ARE HERE	
Safety Shower & Eyewash		Laboratory Equipment	

Assembly Area: Little Rock Park

Appendix 1–14

Example incident report

This details the specific information that should be recorded in an incident report. It is not an investigation report. For this, see **appendix 1–16** for an example of a root cause analysis.

Location

Faculty/school/unit
Laboratory/workshop location: eg building number, name
Laboratory/workshop identification: eg room number, name

Details

Type of report:

Injury	Equipment damage	Spill	Near miss	Observation

Persons involved

Person completing the report		Date and time	
Person(s) involved		Equipment identification	

Event details

Date of event	
Time of event	

Description of event including details of any injury sustained

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Definitions

Injury

An injury is an event where a person suffers some form of harm. This could be as minor as a small scratch or burn on a hand, or as significant as a fatal injury. Injuries should be reported regardless of their magnitude.

Equipment damage

Equipment damage is any instance where hardware is damaged at all, regardless of how the damage occurred. For example damage could be caused by wear and tear, misuse, or deliberate act.

Spill

This is where there has been an unexpected loss of containment. It may have been from decanting liquids or from a failure of containment systems such as a leak.

Near miss

This is where an incident (such as an injury) or adverse event (such as equipment damage) was narrowly avoided. For example if a piece of equipment fell from the bench, but was not damaged, and no one was struck by the falling object.

Observation

This is where an act is observed that is worth noting for learning, but where no adverse impact occurred. This could be an unsafe act such as failing to follow safety procedures, or a safe act such as seeing someone positively intervene to prevent an incident.

Appendix 1–15

Example incident database

An incident database will usually be an online system, where the incident is reported, recommendation can be stored and information on any remedial actions taken. The table below lays out typical information found in a database.

Incident number	Incident date and time	Type of incident	Description	Investigation report	Action taken	Open or closed
Unique identifier	Date and time of the event, not the report	Eg injury, equipment damage, spill, near miss or observation	Brief description	Details from investigation report attached	Actions taken linked to incident report	Status of the investigation

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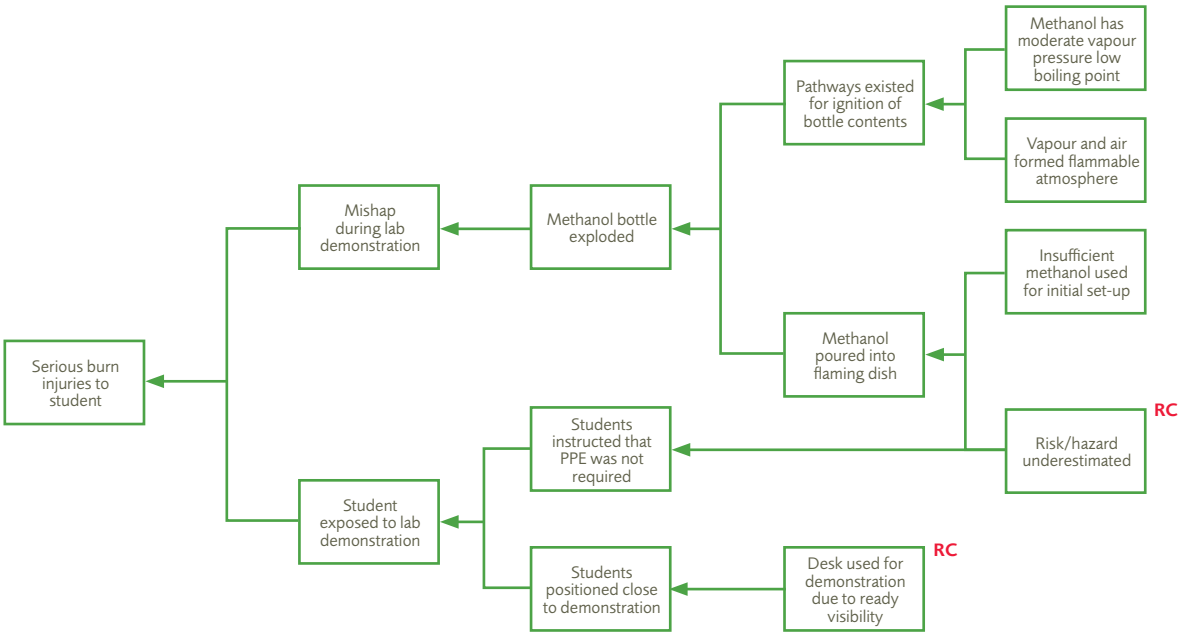
Appendix 1–16

Example root cause diagram



See CBS video '*Experimenting with Danger*'.

Note: above analysis is for illustration and not intended as a strict representation of the incident.

Appendix 2

Resources

2–1 Example hazard identification methods

2–2 Example infographics to show the hazards

2–3 Example risk matrix

2–4 Example task based risk assessment

2–5 Example management of change process

2–6 Example management of change form

Contents page

Commonly used techniques: What If Analysis

Description	Applicability				
■ What If Analysis is a brainstorming approach in which a group of experienced people familiar with the process ask a series of questions that begin "What if...?". Each question represents a potential failure in the facility. The response of the process and/or operators is evaluated to determine if a potential hazard can occur. The answers to these questions form the basis for making judgements regarding the acceptability of those risks and determining a recommended course of action for those risks judged to be unacceptable ■ outputs: completed "what if" scenarios, consequences, likelihoods and recommendations	Objective:	Identification	Analysis	Evaluation	Control
		✓✓✓	✓✓	–	–
	Phase:	Design	Commissioning	Operation	Modification
		✓✓✓	✓	✓	✓
	Comments: applicable to simple facilities as those containing basic fluid/gas transfer, storage or separation systems.				
	Qualitative	●			Quantitative

Advantages	Disadvantages	Applicability
■ simple to use, individuals with little training can participate fully ■ results of the analysis are immediately available and usually can be applied quickly	■ relies heavily on the experience and intuition of the review team (more subjective than other methods) ■ lack of structure (if not used together with a checklist) ■ may lead to people overlooking hazards	**Required resources:** Typical core team disciplines: process design, operations, safety and maintenance. Part-time co-opted specialists: instrumentation, rotating equipment, mechanical, electrical and control systems specialists **Required information:** PFDs, P&IDs, cause and effect matrices, project design basis, equipment and instrument data sheets, PSV calculation sheets, plot plans **Key success factors:** Team and facilitator with good knowledge of the process

Commonly used techniques: Checklist Analysis

<table>
<tr><th colspan="2">Description</th><th colspan="5">Applicability</th></tr>
<tr><td colspan="2" rowspan="6">■ Checklist Analysis is structured around a written list of items or procedural steps to identify common hazards, eg compliance with established practices and standards. Checklists provide a detailed examination of the process plant by applying experience of everyday operations and previous incidents in similar plants
■ outputs: completed hazard checklist template</td><td rowspan="2">Objective:</td><td>Identification</td><td>Analysis</td><td>Evaluation</td><td>Control</td></tr>
<tr><td>✓✓✓</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td rowspan="2">Phase:</td><td>Design</td><td>Commissioning</td><td>Operation</td><td>Modification</td></tr>
<tr><td>✓</td><td>✓✓✓</td><td>✓✓✓</td><td>✓✓✓</td></tr>
<tr><td colspan="5">Comments: applicable for well-known and simpler activities or processes.</td></tr>
<tr><td>Qualitative</td><td colspan="3"></td><td>Quantitative</td></tr>
<tr><th>Advantages</th><th>Disadvantages</th><th colspan="5">Applicability</th></tr>
<tr><td>■ simple to use; level of detail is adjustable to the steps being analysed
■ effective way to account for previous incident histories
■ provides consistency in analysis
■ good to identify hazards associated with routine operation</td><td>■ may lead to hazards being overlooked that are not on checklists (ie limited to the author's expertise)
■ requires periodic review to make sure that the list remains valid
■ not helpful in identifying new or unrecognised hazards</td><td colspan="5">Required resources:
Checklist authors with sufficient knowledge of the process being analysed

Required information:
Process description, engineering design procedures and operating practices manuals

Key success factors:
Checklists need to be audited and updated regularly as operating procedures are modified</td></tr>
</table>

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Commonly used techniques: Checklist Analysis

Description		Applicability			
■ a HAZOP is a facilitated group technique for identifying hazards and operability problems (both routine and non-routine) arising out of process deviations from design intent. It consists of three main steps: 1. understand project intent 2. analyse deviations from design intent through the application of guidewords, and discuss causes, consequences and existing safeguards 3. develop recommendations for improvement ■ outputs: HAZOP report and worksheets containing, for each deviation, causes, consequences, safeguards and recommendations		Objective:	Identification	Analysis	Evaluation	Control
			✓✓✓	✓✓	–	✓✓
		Phase:	Design	Commissioning	Operation	Modification
			✓✓✓	✓	✓	✓✓
		Comments: best used for new facilities, complex processes (eg containing hazardous chemicals or multiphase fluids) and manual operations with high employee counts.				
		Qualitative				Quantitative

Advantages	Disadvantages	Applicability
■ systematic and logical ■ comprehensive ■ flexible ■ enables a comprehensive identification of hazards and mitigations, especially for complex systems ■ provides good insight into operability	■ labour intensive ■ time consuming ■ potentially repetitive ■ poor where combinative events can be high-risk (given the consideration of single events in isolation)	**Required resources:** Typical core team: HAZOP leader and scribe plus representative of process design, operations, safety and maintenance. Part-time co-opted specialists: instrumentation, rotating equipment, mechanical, electrical and control systems specialists **Required information:** PFDs, P&IDs, cause and effect matrices, project design basis, equipment and instrument data sheets, PSV calculation sheets, plot plans **Key success factors:** Team with sufficient knowledge of the process and experienced HAZOP facilitator

Commonly used techniques: Failures Modes and Effects Analysis (FMEA)

Description	Applicability			
■ Failure Mode and Effects Analysis is a component by component assessment of the failure of each item of equipment in a system and the effects on system operation that result ■ it starts with a block diagram of a system and then it is considered what happens if each block fails with the results being recorded in a table. The design of the system is then corrected, and the table adjusted until the system is not known to have unacceptable problems ■ outputs: FMEA table containing severity, likelihood and chance of detection	Objective:	Identification	Analysis	Evaluation	Control
		✓✓✓	✓✓	–	✓✓
	Phase:	Design	Commissioning	Operation	Modification
		✓✓✓	✓	✓	✓✓
	Comments: FMEA is orientated towards equipment rather than process parameters.				
	Qualitative				Quantitative

Advantages	Disadvantages	Applicability
■ analyses all possible types of failure potential for a process ■ structured, detailed approach ■ detailed understanding of the causes and consequences of a system failure	■ can be subjective (lacks guideword structure of HAZOP) ■ focus on failure, not on the chain of events (cause/effect) ■ assumes causes are all single events (however combinations can be captured in a new single event)	**Required resources:** FMEA team, consisting of a facilitator, process owner, technical experts **Required information:** Block diagrams, components datasheet (by vendor) **Key success factors:** Good technical understanding of the system being analysed

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Appendix 2–2

Example infographics to show hazards

Explanatory notes

According to **AS 1319 – 1994** 'Australian standard for safety signs in the occupational environment' shall be used according to the following:

Regulatory signs

Signs containing instructions with which failure to comply constitutes either an offence at law, or a breach of standing orders, safety procedures or other directions, depending on which kind of control has been imposed at the work site or workplace.

Prohibition signs	Signs that indicate that an action or activity is not permitted
Mandatory Signs	Signs that indicate that an instruction must be carried out
Limitation or restriction signs	Signs that place a numerical or other defined limit on an activity or use of a facility (See AS 1742.1)

Hazard Signs

Signs advising of hazards. They are subdivided as follows:

Danger signs	Signs warning of a particular hazard or hazardous condition that is likely to be life-threatening
Warning signs	Signs warning of a hazard or hazardous condition that is not likely to be life-threatening *Note: the term caution used in earlier editions of this Standard has now been replaced by the term warning. The two terms are regarded as being interchangeable*
Emergency information signs	Signs indicating the location of, or directions to, emergency related facilities such as exits, safety equipment or first aid facilities. (See AS 2293.1 for additional information for use inside buildings
Fire signs	Signs advising the location of fire alarms and fire-fighting facilities

Sign colour code, shape and text

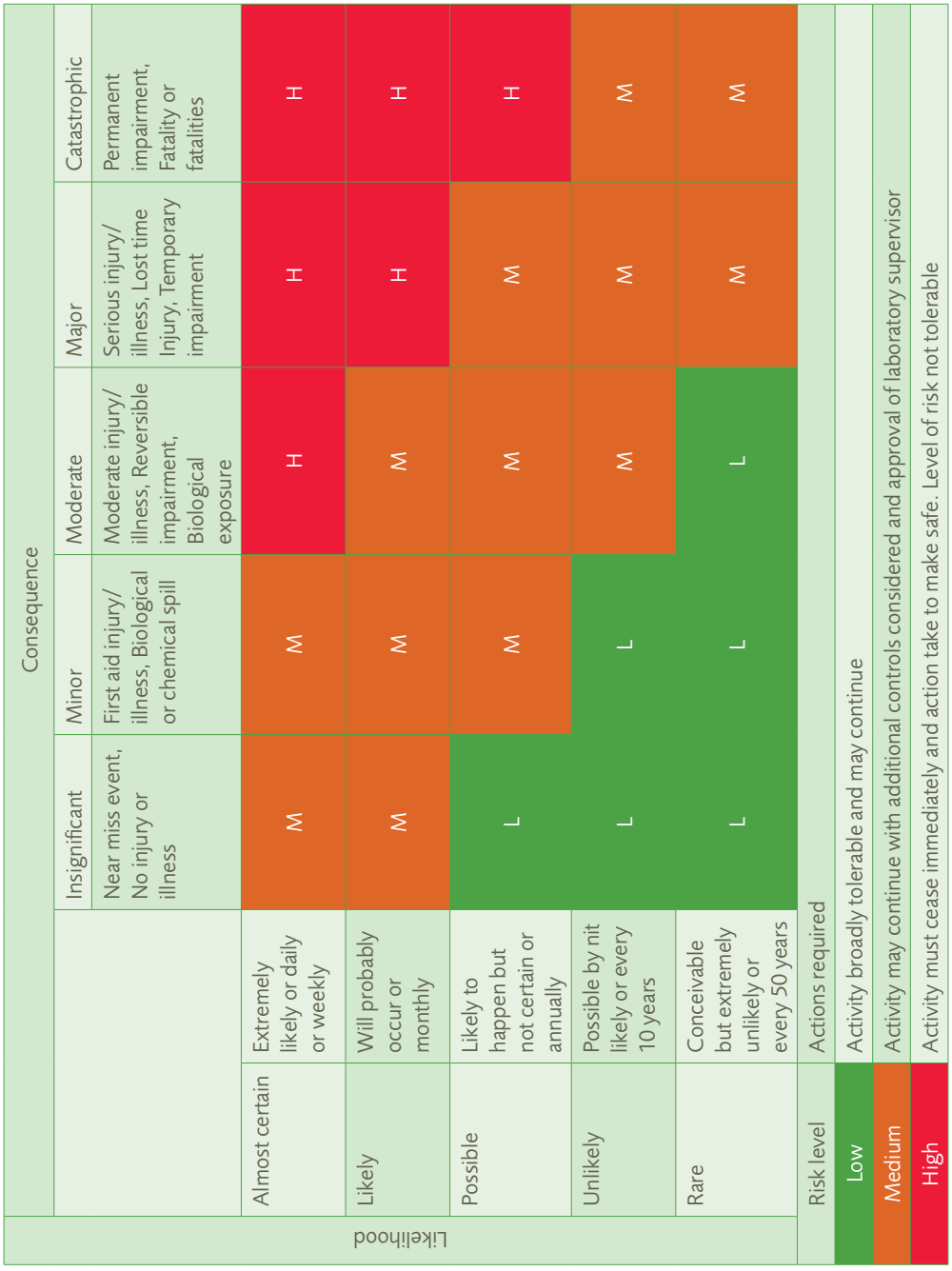
Danger signs	Danger signs communicate a hazard, condition or situation that is likely to be life threatening. The sign is shown as the word Danger on a red oval over a black rectangle. Text is black on a white background	
Warning signs	Warning signs warn of hazards or conditions that are not likely life threatening. These signs consist of a black triangle and icon on a yellow background with supporting black text if required	
Mandatory signs	Mandatory signs provide specific instructions that MUST be carried out. The pictograms or icons are in white reversed out of a blue circle. Text is white on a blue background	
Prohibition signs	Prohibition signs indicate an action or behaviour that is not permitted. The sign is shown as a red circle with a red slash over a black pictogram of the action. Text is white on a red background	
Emergency Information signs	Emergency signs are used to show the locations or directions to facilities such as first aid, emergency exits and other safety equipment. These signs use a green background with white symbols and texts	
Fire signs	Fire signs inform of fire prevention directions and location of fire equipment. These signs are shown as white symbols and text on a red background	

Note: the use of signs does not replace the need for adequate risk reduction measures.

Appendix 2–3

Example risk matrix

Note: this is an example only and needs to be adapted for your individual university requirements. To reduce consequence of a risk you need to implement mitigative controls, and to reduce likelihood of an incident you need to implement preventive controls.



Contents page

Appendix 2–4

Example task based risk assessment

This is an example of a task based risk assessment form:

Faculty/school/unit
Laboratory/workshop location: eg building number, name
Laboratory/workshop identification: eg room number, name
Task being undertaken
Procedure reference
Permit to work number if applicable

Name of people doing task ..... Signatures .....

....

Refer to risk matrix **appendix 2–3** for the example risk matrix.

Step 1. Identify each step of the task to be undertaken

Step 2. Identify all hazards in each step

Step 3. Assess initial risk on risk matrix based on hazards identified

Step 4. Identify any controls needed to address the hazards

Step 5. Assess the final risk after implementation of the controls

Step 6. Complete the task as per the assessment – if conditions change review and revise the assessment as necessary

Task steps	Hazards in each step	Initial risk	Controls implemented	Final risk

Contents page

Example task based risk assessment

This is an example of a competed task based risk assessment form:

Faculty/school/unit	Kletz School of Chemical Engineering
Laboratory/workshop location: eg building number, name	Building 101
Laboratory/workshop identification: eg room number, name	Room 10
Task being undertaken	decanting solvent
Procedure reference	OPS-ABC-123
Permit to work number if applicable	N/A

Name of people doing task: Joe Student, Jane Undergraduate

Signatures: J Student, J Undergraduate

Task steps	Hazards in each step	Initial risk	Controls implemented	Final risk
Locate solvent to be decanted	Incorrect solvent selected	M	Check safety data sheet and chemical register	M
	Out of date solvent selected	M	Check label on solvent for date and name	L
Ensure the solvent is in an accessible location	Manual handling injury when moving solvent	M	Use lifting aid to move drum	L
			Inspect tap for any signs of leaking, do not use if faulty	M
Prepare container to decant into	Insufficient volume in container	M	Ensure size of container is sufficient	L
	Incorrect container selected/ incompatible	M	Check material of container and ensure it is compatible with solvent	L
Decant solvent into container	Overflow/leak of solvent	M	Constantly monitor the decanting, controlling flow	L
	Personal exposure to solvent	M	Ensure appropriate PPE is worn in case of exposure	L
			Have spill kit available	
Reseal solvent container and new container	Overflow/leak of solvent	M	Ensure appropriate PPE is worn in case of exposure	L
	Personal exposure to solvent	M	Have spill kit available	L
Return all chemicals appropriate storage	Manual handling injury when moving solvent	M	Use lifting aid to move drum	L

Appendix 2–5

Example management of change process

University logo	Procedure	Doc no.	
		Version no.	01
	Management of change	Version date	
		Page no.	1 of 3

Purpose/scope

The purpose of this procedure is to define how to complete a management of change (MOC) activity.

References

Appendix 2–1 example of hazard identification methods

Appendix 2–3 example of risk matrix

Appendix 2–6 example management of change form

Records/attachments

Nil.

Definitions

Approver

Person with authority to approve the change.

Change

A change can consist of modification of either technical aspects, administrative processes or organisational structures. A technical change covers any physical change to an existing facility, equipment operational process change or deviation from the design intent, including software changes. An administrative change covers deviations from operating procedures. An organisation structure change covers a change of the structure or key personnel in the structure.

Authority	Prepared by	Reviewed by	Approved by
Signature and date			
Name			
Role			

Temporary change

A temporary change is one that has a defined expiry period. This should be no longer than one month.

Originator

Person who is requesting the change to be made.

Review team

A group of people who have been chosen to review the change, based on their relevant expertise associated with the change. These could include laboratory technicians, engineers or maintenance personnel.

Responsibility

Laboratory manager

Shall ensure that all changes are identified and undergo appropriate review. Typically, the laboratory manager will be the approver, unless they are the originator. Then the approver shall be their line manager.

Originator

Identify necessary changes and initiate the MOC process by completing section 1 of the form.

Persons completing work shall

Take all necessary precautions when handling or exposing self to process fluid and related equipment.

Once all work is complete, this procedure along with any associated documentation shall be given to the laboratory manager to approve and file.

Review team

The review team are responsible for identifying any hazards and assessing the risk of the change. They need to be knowledgeable in their area of practice. The assessment of an MOC is only as good as the reviewers. The original should not be part of review team.

Procedure

Change proposal

The reason for the change and a description of the change need to be clearly articulated so there is no confusion. The type of change also needs to be determined, such as technical, administrative or organisation. If the change is temporary it needs to have an expiry date. This date should be no longer than three months.

Preliminary hazard review and authorisation

The review team need to examine the proposed change and determine what types of risk assessment activities should be undertaken. This may range for a simple What if analysis to a full HAZOP, depending on the magnitude and impact of the proposed change. As the review team are responsible for this review, they need to have appropriate competence and capability to make the determination. Once they are satisfied with their assessment, they recommend the MOC to continue or to undergo further review.

Design approval

When the hazard assessments are complete, and all recommendations addressed, the design can be finalised and then approved by the Approval Authority.

Installation approval

When the design has been finalised then installation or implementation can be approved, and the work can be undertaken to make the proposed change. This approval is granted by the approval authority. If the change is not approved then the reason for declining the change must be documented and filed with the MOC form for future reference. This is done at the end of the form.

Close out

This is the final stage of an MOC. Once all the work has been undertaken to make the change, all documentation related to the change must be reviewed and updated accordingly. Until this is completed the change is not considered to be completed. Documentation may include items such as procedures and drawings.

Appendix 2–6

Example management of change form

Department name		**Plant change request**	
Title		Change no.	
Originator		Date raised	
Project		Work order	
Plant		Equipment no.	

Section 1: Change Proposal – to be completed by initiator

Reason for change:

Proposed change:

Notes:

Type of change

Technical ❑	Temporary ❑	Expiry _____	
Administrative ❑			
Organisational ❑			

Justification

Safety	❑	Plant reliability	❑	Financial return	❑	Other	❑
Quality	❑	Statutory	❑	Environmental	❑		

Details _____

Section 2: Preliminary Hazard Review and Authorisation				
Preliminary Hazard review has been completed – **attached**				
Review team		Signature	Date	
Change requires further review ❑ Change does not require further hazard review ❑				
Type of Review: HAZID ❑ HAZOP ❑ LOPA ❑ Alarm ❑ Other ❑				
Approved by		Signature	Date	
Comments:				
Section 3: Design Approval				
To be completed by approval Authority Design has been completed, Hazard reviewed, and all actions are closed out ❑				
Approved by		Signature	Date	
Section 4: Installation/Implementation Approval				
To be completed by approval authority Installation has been completed to the design and Hazard ❑				
Approved by		Signature	Date	

Section 5: Preliminary Hazard Review and Authorisation				
Change has been completed to relevant standards ❑ Relevant documentation including drawings have been updated ❑				
Approved				
Approved by		Signature	Date	
Change not approved and not progressed ❑ Comments:				
Declined				
Declined by		Signature	Date	

Appendix 3

Resources

3–1 example procedure

3–2 example procedure review checklist

3–3 example permit to work procedure

3–4 example permit to work form

3–5 example isolation procedure

3–6 example isolation sign off form

3–7 example infographic showing different isolation equipment available for use

3–8 example pre-start up safety (PSSR) checklist

3–9 example safety moment – the rainbow experiment

3–9–1 safety moment notes – the rainbow experiment

3–9–2 safety moment presentation materials – the rainbow experiment

3–10 example process log

3–11 example handover checklist

Appendix 3–1

Example procedure

University logo	Engineering and Maintenance, Testing Procedure	Doc no.	
		Version no.	01
	Pressure safety valve	Version date	
		Page no.	1 of 6

This is a sample procedure, showing relevant sections required. It is based on maintenance work being carried out on a pressure safety valve. In this instance the work would be performed by laboratory technicians, however this is just to illustrate the layout and sections of a procedure.

PPE Requirements

Purpose/scope

Define the scope of the procedure, for example:

To verify if PSV-123 installed on A-123 is clean, intact in service and that there is no impediment to flow in the inlet or discharge pipelines.

References

List any relevant references or standards applicable to the procedure.

Authority	Prepared by	Reviewed by	Approved by
Signature and date			
Name			
Role			

The controlled copy of this document is in electronic format and is stored in: file location.
All hard copies are uncontrolled unless specifically marked and endorsed as 'controlled copy'.
This copy was printed on 30 April 2019 at 1:16:32 pm.

Records/attachments

List any related documents or records applicable to this procedure.

Definitions

Competent

Person shall have relevant mechanical experience and training in performing inspections and pressure safety valve maintenance. Person shall hold working at height qualification.

Independent

A person who is separate and distinct from the responsibilities involved with that equipment. They could be from a separate organisation or department.

PSV

Pressure safety valve.

Responsibility

Laboratory manager shall:

Ensure that verification is completed by independent and competent personal.

Ensure equipment is shut down, drained and depressurised. Ensure feed pumps and process air blower are shut down and isolated.

Ensure access is made available to the device in situ through scaffolding.

Review, maintain and file all documentation into the maintenance recording system against the asset.

Operations shall:

Ensure that all persons carrying out this procedure follow university safety requirements including the use of the appropriate PPE and permit to work.

Persons completing work shall:

Take all necessary precautions when handling or exposing self to process fluid and related equipment.

Once all work is complete, this procedure along with any associated documentation shall be given to the maintenance manager to approve and file.

HSE/training advisor shall:

Notify laboratory manager if any devices fail the inspection and needs to be replaced.

Procedure

Pre-checks

	Initial	
Description/step	**Manager**	**Technician**
Competency checked by maintenance manager		
MOC complete if required MOC number _____		
This procedure must be discussed and organised with the maintenance manager to ensure the Formalin Plant is isolated and depressurised, and pumps and blowers are shut down and isolated		

Description/step	Technician
Acquire process and instrumentation diagram for this element	
Print off a blank inspection report from the dossier	
Don appropriate PPE	
Ensure PSV and system are at ambient temperature before performing verification	

Tools needed

Description/step	Initial
Personal gas detector	
Pneumatic air gun, sockets and spanners	
Canister mask on standby (to be used if required)	
Chain blocks to lift PSV (if required)	
Gantry crane on standby (to be used if required to lift PSV or piping)	
Harness and lanyard	

Preparation and removal of PSV.

Unbolt flanges to remove PSV and housing from flanges for inspection.

Do not stand directly over the pressure safety valve outlet when removing the valve in case there is still residual pressure in the line or the valve discharges.

Clean all surfaces which can be easily accessed on the valve and inlet and outlet pipes.

Carry out visual inspections on device.

Visual inspections (pressure safety valve).

	Device	PSV–123	Comments
General	External condition (valve, flange face surfaces, threaded connections)	good bad N/A	
	Tagged with label	yes no	
Valve inspection	Check if nameplate is intact and visible	yes no	
	Inspect the valve for evidence of malfunctioning:		
	■ check for corrosion or other surface damage	good bad	
	■ check for signs of excessive wear	good bad	
	■ check the stem to ensure it is straight	good bad	
	■ check if bolting is tight and no bolts are missing	present and tight/ missing or loose bolts	
	Check replacement date of valve/last replacement date and whether replacement is due	ok due	
	Was the test tag installed	yes no	
	Check spring condition	good bad	
	Check if valve leakage is within tolerable limits	tolerable out of spec	
	Check drain hole not clogged or plugged and drain piping open	yes no	
Inlet and outlet piping	Check inlet and outlet lines for product build up, if any is evident, clean if possible	yes no	
	Check the outlet line of the PSV is clear and there is no fixed impediment flow installed in the line	yes no	
	Check outline discharges to safe location	yes no	

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Visual inspection sign off			
Inspected by	Name:	Signed:	Date:

Servicing the valve.

Completely disassemble the valve and clean all parts.

Always stand clear of the valve outlet during seat leakage testing as the valve can suddenly open fully.

Lap the nozzle seat and disc seating surfaces to a flat mirror surface.

Replace all gaskets and soft goods eg O-ring seals.

Reassemble the valve, making sure to lubricate all threaded and bearing surfaces.

Testing set pressure

Testing must only be performed using the right testing fluid. PSV–335 is used in vapour service, so the test fluid should be air.

Set pressure testing should be performed prior to seat leakage testing (which is performed at 90% of set pressure).

If set pressure is being changed, the existing spring must be assessed as suitable or replaced with a new suitable spring.

Replacement of PSV

Replace the PSV.

- use a new PSV if required (if it has not passed inspection and cannot be re-certified to correct pressure)

Calibrate the PSV to the set pressure indicated on the nameplate if required.

Pressure safety valve reinstatement

Description/step	Technician
Ensure test gag is removed from valve (if installed)	
Seat PSV in flange connections and align inlet and outlet of valve with relevant pipe connections	
Replace flanges and connections and bolt closed	
Clean all tools used to remove any residual residue	

Leak testing of PSV

Use soap suds around the PSV housing to check for evidence of leakage.

- if leaks are present, dissemble the PSV and re-clean the housing and reassemble
- if leaks are still present, a different PSV may be required

If no leaks are present, put PSV back into service.

All external adjustments should be wire sealed to prevent tampering.

Redo flanges, install bolts and nuts, other steps.

Tidy work area.

	Initial
Description/step	**Technician**
Close off requirements for MOC	

PSV leak tested and returned to service yes/no

Comments

Technician		
Name	Signed	Date

Obtain sign off from Manager that the PSV has been reinstated and the work order is closed off.

Manager reviewed		
Name	Signed	Date

Return all documentation included with this procedure to the maintenance manager.

Maintenance manager reviewed		
Name	Signed	Date

If required, inform HSE/training advisor of failed test and remedial actions taken.

HSE/training advisor advised of failed test/inspection		
Name	Signed	Date

Appendix 3–2

Example procedure review checklist

Title of operating procedure				
Number		**Revision number**	**Review date**	
Person performing review				
Supervisor		**Sign**	**Date**	
Type: new/modification		**Context**		
A. Critical items			**Y/N**	**Comment**
1	Does any procedure step require connection of systems with different design pressures (high pressure/low pressure interfaces)?			
2	Is there potential for variation (over or under) to the design pressure or design temperature in any step?			
3	Does any step in any way affect (isolate or defeat or change functionality) of protection equipment (eg pressure trips, pressure safety valves etc)?			
4	Does any procedure step alter existing or require additional shutdown protection (eg shutdown actions, trip settings)? If in doubt, ask Supervisor.			
6	Is there potential for flow variation to design flows with adverse impact (eg erosion, vibration) due to any procedure step?			
7	Is there potential for a variation in any stream compositions from design (eg introduction of water, dissolved gas etc) in any procedure step?			
8	Could any other inter-connected piping or downstream systems be affected (eg drains, exhaust hood) by execution of any procedure step?			
9	Does any procedure step alter any alarm settings?			
10	Does any procedure step in any way affect (or get affected by) any existing temporary operating procedures (TOP)?			
11	Are any other operating and maintenance procedures affected by any procedure step (eg emergency response procedures, permit to work etc)?			
B. Other items			**Y/N**	**Comment**
12	Are any new chemicals being used in any procedure step? Has testing of the proposed chemicals shown any compatibility problems with other fluids (eg emulsions, scaling, toxicity)?			
13	Is the existing safety system affected or inadequate (eg fire protection; fire, gas or smoke detection) by execution of any procedure step?			
14	Does any procedure step increase the rate of corrosion of any part of the system (eg water)?			
15	Does the procedure step necessitate any modification to existing control system graphics?			
16	Is any procedure step execution cause deviation from technical specification or standards (eg material of construction)?			

17	Does the procedure step require use of portable or skid mounted equipment (ie design checks required for temperature, pressure, materials of construction etc)?		
18	Will the procedure impact location of equipment or pipework affect safe access for personnel during maintenance or operations (eg escape routes)?		
19	Does the procedure step execution have any implications for any other laboratories?		
20	Does the procedure Impact on any regulatory compliance requirement?		
21	Is there need for multi-disciplinary review to identify any potential unknown risk?		
B. Recommendations		**Y/N**	**Comment**
22	Are there any recommended changes based on the review?		If yes, detail below

Appendix 3–3

Example permit to work procedure

University logo	Engineering and Maintenance, Testing Procedure	Doc no.	
		Version no.	01
	Permit to work	Version date	
		Page no.	1 of 4

Purpose/scope

The purpose of this procedure is to define how work conducted under a cold work permit is to be undertaken. This procedure only covers cold work. Other types of work, such as hot work or confined space entry must be undertaken under a different procedure. This procedure is a simplified version of a permit to work system to familiarise people with the concepts.

References

Appendix 2–1 example of hazard identification methods

Appendix 2–3 example of risk matrix

Appendix 3–4 example permit to work form

Records/attachments

Nil.

Definitions

Approval authority.

Person with authority to approve the work to be done. This is typically the laboratory manager.

Authority	Prepared by	Reviewed by	Approved by
Signature and date			
Name			
Role			

Cold work

Cold work is any work that does not introduce any source of ignition. A source of ignition includes spark generating equipment, naked flames or non-intrinsically safety electrical or battery operated devices.

Controls

Controls are barriers put in place to manage the hazards involved in doing the work. This includes such items as emergency response equipment or personal protective equipment. It might include such items as the type of tools (eg spark proof tools).

Permit to work

A formal document that defines the scope of work, controls required and approvals to complete the task.

Permit recipient

Person who is competent in the permit to work system and authorised to undertake the work defined in the scope.

Scope of work to be done

The scope of work is a detailed description of the work to be completed. It needs to include all likely activities to be undertaken.

Work

Work is defined as an activity made up of multiple tasks that interact with the operating equipment. It is different to routine operations. This is because work typically requires interaction across multiple areas, isolation or dismantling of equipment or handing over equipment from one work group to another, such as operations to maintenance.

Responsibility

Approval authority

Shall assess the permit for the clarity of the scope, review the controls to be implemented, assess the task based risk assessment, inspect the isolations and once satisfied that the hazards are adequately addressed, shall approve the work to continue. They are also required to review the work once completed and sign off that the system has been returned to service in a safe state.

Permit recipient

The permit recipient is responsible for planning the scope of the task, including undertaking the task based risk assessment and completing this information on the permit to work form. They are also responsible for complying with all controls stated on the permit to work and the task based risk assessment and undertaking the work. Once the work is complete, they must hand the permit to work form back to the approval authority for close out approval.

Procedure

Scope of work

The scope of work needs to be clearly defined and include all possible work. For example, a scope that says 'inspect gauge' would not allow for the removal, replacement of refurbishment of the gauge, as this has not been stated in scope. The scope should instead say 'inspect gauge, remove and refurbish and replace gauge'. This is because the full scope needs to be risk assessed to ensure all necessary safety controls are in place. If the scope is incomplete, important safety controls may be missed.

Task based risk assessment

The permit recipient shall complete a task based risk assessment that aligns to the scope of work for the permit. Refer to **appendix 2–4** for the task based risk assessment form.

Checks

The permit recipient along with the approval authority shall review the checks together to ensure they are correct and adequate. Any additional action should be noted on the permit to work form.

Controls

The permit recipient along with the approval authority shall review the checks together to ensure they are correct and adequate. Any additional action should be noted on the permit to work form. This includes a review of the task based risk assessment.

Approval

Once all the checks and controls have been put in place, including adequate isolation of the equipment, the approval authority can give approval for the work to commence.

Undertaking the work

All work undertaken shall be in conformance with the scope or work, checks, controls and the task based risk assessment. The permit recipient shall also be competent in the use of the permit system as well as the conduct of the work to be done.

Completion

Once all work has been completed the permit recipient shall return the permit to work form to the approval authority for final sign off. The work area and equipment must be checked to ensure all equipment it safely returned to service and the area is left clean and tidy. Once the approval authority is satisfied with this, they can complete the permit to work form. The form should be filed for future reference.

Appendix 3–4

Example cold work permit form

Note: this form covers cold work only, any hot work, confined space or penetrations into wall cavities needs separate approval and control.

Date			**Permit no.**		
Laboratory			**Equipment**		
Scope of work to be done					
Location					
Checks			**Yes/No/NA**	**Action required?**	
Laboratory staff have been advised					
No hot work to be done (heat, spark or flame producing)					
Emergency response equipment available (eg fire extinguishers and spill kits)					
No electrical equipment or other potential ignition sources to be used					
All required isolations in place (refer **appendix 3–6** Isolation sign off)					
Permit recipient is competent to undertake the task					
Controls			**Yes/No/NA**	**Action required?**	
PPE (glasses, gloves, long sleeves, enclosed shoes, etc)					
Equipment in good working order					
Task based risk assessment attached (refer **appendix 2–4**)					
Procedure available for task					
MOC required for work (refer **appendix 2–5**)					
Approval authority					
This permit is approved from	Date	Time	Until	Date	Time
Approval authority	Name		Signature		Date

Permit recipient			
I understand that I am authorised to undertake only the work specified in this permit. If conditions or the work scope changes, I will stop work and consult with the approval authority.			
Permit recipient	Name	Signature	Date
Completion		**OK/No/NA**	**Action required?**
The approval authority is to re-inspect the work area after the completion of the works.			
All tools and equipment cleaned up and waste disposed of			
All equipment ready for return to service			
All isolations removed			
Approval authority	Name	Signature	Date
Permit recipient	Name	Signature	Date
Notes			

Appendix 3–5

Example isolation procedure

University logo	Engineering and Maintenance, Testing Procedure	Doc no.	
		Version no.	01
	Isolation requirements	Version date	
		Page no.	1 of 5

Purpose/scope

The purpose of this procedure is to define how equipment is isolated for work to be conducted under the permit to work system. This procedure is a simplified version of an isolation procedure to familiarise people with the concepts.

References

Appendix 3–4 example permit to work form

Appendix 3–6 example isolation sign off form

Appendix 3–7 example infographic showing different isolation equipment available for use

Records/attachments

Attachment 1 – isolation standards.

Definitions

Electrical isolation.

Any isolation undertaken on electrical equipment.

Isolation authority.

Person with authority to approve the isolations. This is typically the laboratory manager. This may or may not be the same person who performs the isolation.

Authority	Prepared by	Reviewed by	Approved by
Signature and date			
Name			
Role			

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Permit recipient

Person who is competent in the permit to work system and authorised to undertake the work defined in the scope. Person who receives the isolation sign off document.

Process isolation

Any isolation undertaken on process equipment.

Responsibility

Isolation authority

The isolation authority is responsible for ensuring that the isolation is completed as required. If they perform the isolation themselves, they can sign it off as the progress. If the isolation is performed by a different person, the isolation authority must physically check each isolation and sign off that is it complete on the isolation sign off form. In some situations, the isolations must always be checked by an additional person, to provide a check that they are correct and in place. All isolations must also be locked, and the permit recipient must affix their personal lock to the system to ensure that it cannot be returned to service while they are still working.

Permit recipient

The permit recipient is responsible for affixing their personal lock to the isolation system to ensure that until they remove their lock, no equipment can be returned to service. This is usually done by applying a person's lock to a lock box that contains the key to the process locks. If the permit recipient fails to remove their lock prior to leaving site, they must return to remove it. A personal lock MUST NOT be removed by anyone other than its owner.

Procedure

Process isolation

When preparing to isolate a piece of equipment it is necessary to access the correct isolation sign off form. This will have the appropriate process and instrumentation diagram (P&ID) attached which names all the valves. This form also lists all valves that should be isolated and their required positions, eg open or closed. When the valves have been correctly isolated, they should be tagged referencing the permit number and have a lock attached to prevent inadvertent operation. The key for the isolation locks should be secured in a lock box (refer **appendix 3–7** to see a lock box) so that the permit recipient may apply their personal lock to the isolation system. The form is signed by the Isolating Authority when the tag and lock have been applied.

Electrical isolation

When preparing to isolate a piece of equipment it is necessary to access the correct isolation sign off form. This will have the appropriate process and instrumentation diagram attached which names all the equipment. The form also lists all

electrical isolations that should isolation be completed. All pumps should be electrically isolated at the master control switch and then tested for energy. The key for the isolation locks used on electrical isolations should be secured in a lock box (refer **appendix 3–7** to see a lock box) so that the permit recipient may apply their personal lock to the isolation system. The form is signed by the Isolating authority when the tag and lock have been applied.

Isolation approval and handover

Once the isolation is complete, the permit recipient shall view the isolations and then affix their personal lock on the lock box that contains the key to the process locks. This prevents inadvertent operation of any equipment while the work is still underway. Only the owner of a personal lock is permitted to remove it. This is to ensure they are not put at risk at any stage by the system being operated.

Process de-isolation

When the work has been safely completed the equipment may be returned to service. Once the permit recipient has removed their lock from the lock box, the process locks used to isolate the equipment may be accessed and removed from the valves. This can then be used to unlock the equipment and return it to the correct operating position as stated on the P&ID. Each removal should be initialled by the isolating authority.

Electrical de-isolation

When the work has been safely completed the equipment may be returned to service. Once the permit recipient has removed their lock from the lock box, the process locks used to electrically isolate the equipment may be accessed. This can then be used to unlock the equipment and return it to the correct operating position as stated on the P&ID. Each removal should be initialled by the Isolating authority.

Completion

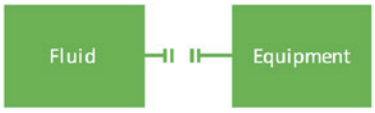
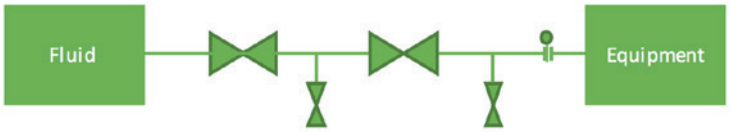
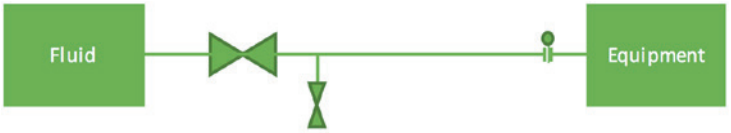
Once all equipment is deisolated the permit recipient shall sign off the form to state that they understand the equipment is de-isolated. The plant can then be returned to service with the isolation sign off form filed with the permit to work.

Attachment 1 – isolation standards

There are several methods of isolation, from electrical isolation, pneumatic/hydraulic isolation and process isolation. Isolations can generally be broken down into three categories, positive isolation, proved isolation, and non-proved isolation. This is all about the degree to which the isolation has been achieved from the energy source. Regardless of the isolation method, they should always be tagged and locked out by the person working on the equipment with a unique person lock. This prevents a second person returning the equipment to service while it is being worked on. Under no circumstances may a lock be removed by anyone other that the lock owner.

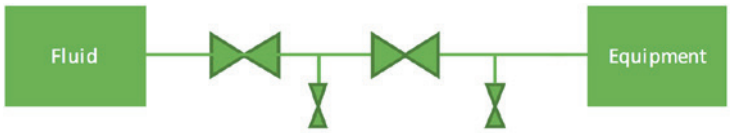
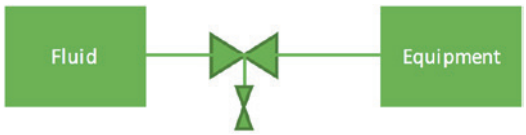
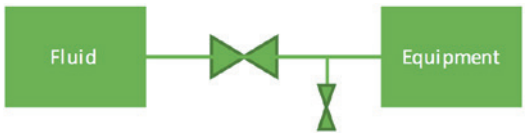
Positive isolation

This is the complete separation of the plant to be worked on from any energy sources. This includes the complete removal of spool pieces, the use of double block and bleed valves with a spade or the use of a single block and bleed valve with a spade. *Note: it is also useful to have pressure indicators in each section to check for pressure in the system.*

Removal of spool	
Double block and bleed with spade	
Single block and bleed with spade	

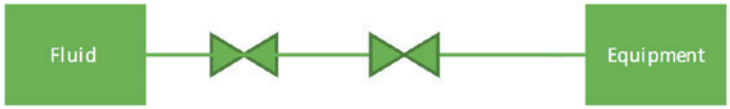
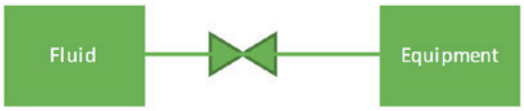
Proved isolation

This required the introduction of an air gap between the valves and the equipment. This could be a double block and bleed arrangement, a single valve with duel seals and a bleed or a single block valve and bleed. In this isolation the bleed must always be open to create the air gap. This also alerts you to any issues with valves passing fluid. *Note: it is also useful to have pressure indicators in each section to check for pressure in the system.*

Double block and bleed	
Single valve with duel seals and bleed	
Single block and bleed	

Non-proved isolation

This is when valves are closed but there is no way to verify that the isolation is proved or if the valves are leaking. This consists of simple closing one or more valves. This is the lowest level of isolation possible. *Note: it is also useful to have pressure indicators in each section to check for pressure in the system.*

Double block valves	
Single block valve	

Electrical isolations

This is where equipment has been isolated from electricity sources. This must be tested by attempting to operate the equipment once the isolation has been put into place. It may also be tested by looking for electrical potential.

Pneumatic/hydraulic isolations

Pneumatic and hydraulic systems have their process fluid isolated in a similar method to other process fluid, such as removing the air supply to the system. It is vital to manage the stored energy in these systems as this can cause unintended energy release.

Appendix 3–6

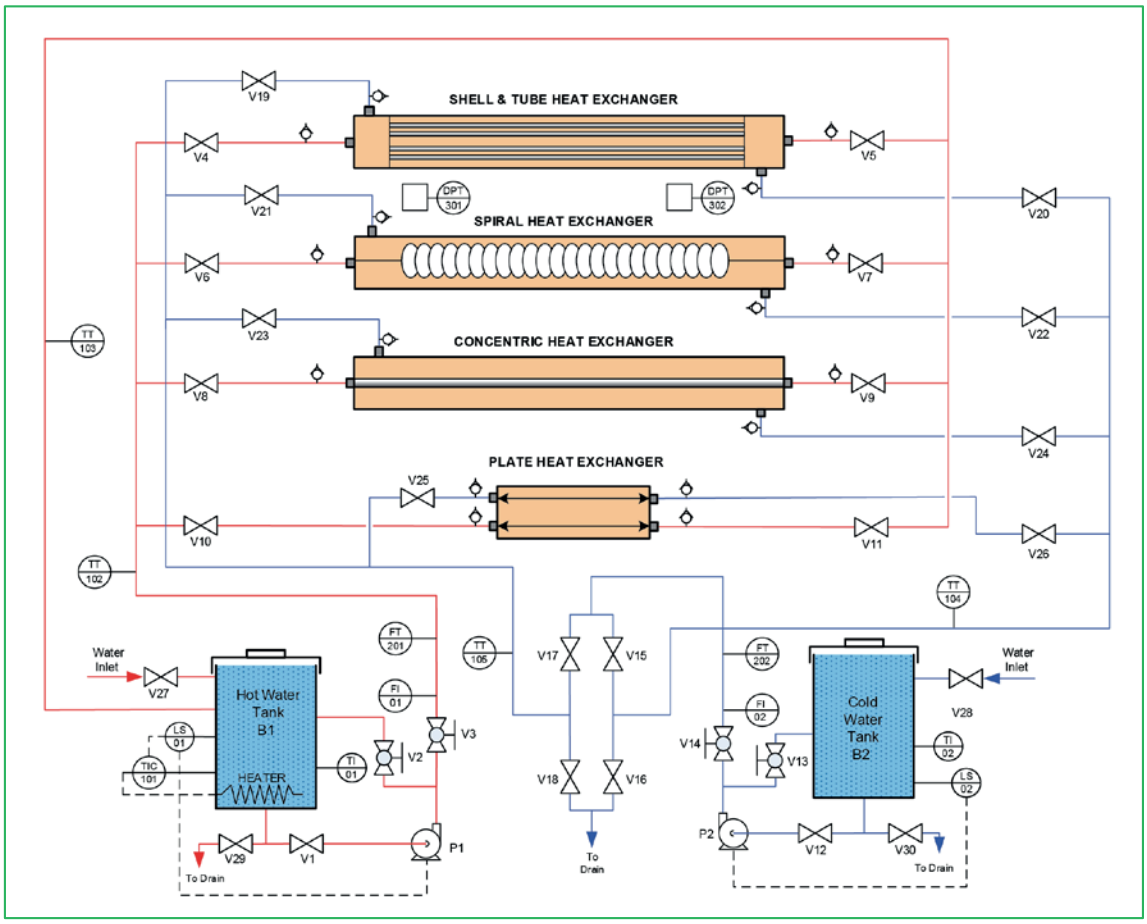
Example isolation sign off form

Note: this form is an example only covers isolation of one piece of equipment. It may not represent the complete isolation requirements. Each piece of equipment must have its own isolation checklist developed.

Date		**Equipment**	**Plate heat exchanger**
Laboratory			
Scope			
This checklist defines the isolation requirements to inspect the plates in the 'plate heat exchanger'. It covers both the physical isolation as well as electrical isolation. Refer figure 1 for process and instrumentation diagram showing the plate heat exchanger. The status stated below needs to be confirmed, tagged and locked, and initialled at each stage by the person performing the isolation.			
Process isolations – item	**Status closed/open**	**Tagged**	**Locked**
Manual operated valve V2	Closed		
Manual operated valve V3	Closed		
Gate valve V10	Closed		
Gate valve V11	Closed		
Manual operated valve V13	Closed		
Manual operated valve V14	Closed		
Gate valve V15	Closed		
Gate valve V16	Open		
Gate valve V25	Closed		
Gate valve V26	Closed		
Electrical isolations – item	**Status isolated/ energised**	**Tagged**	**Locked**
Centrifugal pump P1	Isolated		
Centrifugal pump P2	Isolated		
Isolating authority			
This isolation has been completed as per the above checklist and I have checked it for completeness.			
Isolating authority	Name	Signature	Date and time
Permit recipient			
I understand that the equipment has been isolated, and I have checked the isolations. I have affixed my person lock to the system to prevent inadvertent operation. Should anything change during the work I will consult with the isolating authority.			
Permit recipient	Name	Signature	Date and time

Process deisolations – item	**Status closed/open**	**Tag removed**	**Locked**
Manual operated ball valve V2	Open		
Manual operated ball valve V3	Open		
Gate valve V10	Open		
Gate valve V11	Open		
Manual operated ball valve V13	Open		
Manual operated ball valve V14	Open		
Gate valve V15	Open		
Gate valve V16	Closed		
Gate valve V25	Open		
Gate valve V26	Open		
Electrical deisolations – item	**Status isolated/ energised**	**Tag removed**	**Lock removed**
Centrifugal pump P1	Energised		
Centrifugal pump P2	Energised		
Completion			
All isolations removed, and the equipment has been returned to service.			
Isolating authority	Name	Signature	Date and time
Permit recipient	Name	Signature	Date and time
Notes			

Figure 1. Process and instrumentation diagram – heat exchanger unit



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Appendix 3–7

Example infographic showing different isolation equipment available for use

Commonly used isolation devices

Process isolations

Isolation valve (screw type)

Shutdown valve

Isolation valve (lockable handle type)

Spectacle blind

Mechanical locking devices

Locked box

Hasp and lock

Gate valve lock

Electrical locking devices

Danger/ warning tag

Switchboard lockout

Emergency stop button

Appendix 3–8

Example pre-start up safety review (PSSR) checklist

Pre-start up safety checks are used to ensure that process equipment is started up in a safe manner by approved personnel, ensuring that relevant hazards are managed appropriately. The typical checks you may expect to find in a pre-start up safety check sheet are:

1. Planning of work to be undertaken (understanding hazards, provided safety measures, laboratory emergency response plan (ERP) and location of emergency equipment/evacuation routes).
2. Preliminary preparations of the site and equipment (including removal of foreign materials, general housekeeping, equipment inspections, consideration of surrounding activities, checking safety equipment is functioning or at the ready) .
3. Preparation of auxiliary equipment and services (including checking electrical systems, control systems, cooling water supply are available) .
4. Testing and preparation of unit (including vessel purging, draining, instrument checks) .
5. Bringing process unit online (specific sequence).

Pre-start up checks may also include aspects relating to operational considerations rather than safety related considerations (eg pre-warming of a separation vessel to improve separation efficiency).

The example checklist will help students working in chemical engineering laboratory to conduct experiments in safe manner. This list may be used by the team and should be reviewed, updated or modified for their use and communicated to all involved in the operation. Team members should fill in one copy of the checklist together.

For each question, the appropriate answer should be competed. The three responses are:

- 'yes', the statement has been completed.
- 'no', the statement is incomplete.
- 'NA', the statement is not applicable for the particular experiment being undertaken.

For answers that are 'no', please review with your supervisor and determine the action required to address this before commencing the experiment.

Finally, remember safety first! If you are not comfortable, 'stop work' and do not start the equipment and seek advice from your supervisor.

The PSSR should also be reviewed during operational handover activities to ensure that no conditions have changed.

References

1. BP process safety series: safe ups and downs for process units.
2. WorkSafe Tasmania: safety management toolkit.
3. NSW Department of Planning and Environment: Hazardous industry planning advisory papers (HIPAPs).

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Example pre-start up safety review (PSSR) checklist

Date:	Time:
Laboratory/workshop location: eg building number, name:	
Task:	

Element	Yes/No/NA	Additional comments
General		
Notification given to supervisor and attendance recorded/registered before entering the laboratory		
Induction (covering hazards, provided controls, emergency response) has been provided by the supervisor to safely operate the plant and be in the laboratory		
Laboratory health and safety rules explained by supervisor		
Security arrangements and the system for reporting incidents and hazards advised by supervisor. This includes arrangements if the experiment is conducted after normal hours		
Emergency response procedures (including emergency equipment, evacuation diagrams) for the laboratory are understood		
Safe working procedures/work instructions (including safe operation of equipment) for the laboratory are understood		
All required electrical/mechanical equipment is in a safe condition and tagged		
Surrounding area is free of debris/obstructions which may pose an increased risk		
There is a safe working distance/separation for the operator from the hazards for the duration of the experiment		
Hazards have been communicated to neighbouring third parties		
Fire protection		
Procedure for activation of fire alarm and/or protection systems is understood		
Emergency response training completed for correct use and location of fire protection equipment (eg fire blankets, extinguishers)		
Power points, light fittings and switches are in a safe location and free from obvious defects (eg loose covers or wires, broken or damaged fittings, signs of overheating)		
All electrical equipment to be used has a valid inspection tag		

Electrical equipment		
Power points, light fittings and switches are in a safe location and free from obvious defects (eg loose covers or wires, broken or damaged fittings, signs of overheating)		
All electrical equipment to be used has a valid inspection tag		
Chemicals		
The safety data sheets (SDS) for all hazardous materials involved in the experiment have been read and understood		
PPE has been provided as per the SDS		
Chemicals to be used are clearly labelled		
Eye wash/safety showers are installed and functional		
Spill containment and clean-up kits are available		
Wastes disposal and storage arrangements generated by the experiments are in place		
Machinery and equipment		
Protective guards are installed on all operating equipment		
Emergency stop buttons are clearly marked, operational and accessible		
Ventilation/functional are functional		
Equipment is adequately anchored and supported		
Piping, vessels and hoses		
All pipes and vessels are sealed (including plugs, caps, blind flanges, etc) and there are no signs of leaks		
All hoses free from wear spots and cracking with connections in good condition		
All hoses within test date where applicable		
All valves are in the correct open/closed position for start-up		
Gauges (including sight glasses) are visible		
Utilities are available (eg cooling water, deionized water, etc)		
Vessel has been purged and/or drained as per requirements for pre-start		
Pressure relief valve outlet relieves to a safe location		
Signed		
Attendees	Supervisor	

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Appendix 3–9

Example safety moment – the rainbow experiment

3–9–1 Safety moment notes – the rainbow experiment

Context

The purpose of this document is to showcase an incident that occurred during a laboratory demonstration and highlight the key learnings. This incident is applicable because it shows that a common and simple experiment can lead to serious safety consequences.

As a chemical engineering student, it is important to learn from past incidents, to ensure appropriate controls are in place to prevent similar incidents from occurring in the future. It is also important to consider appropriate safety measures during the planning and execution phases of laboratory experiments.

The ISC Case Study 'Laboratory Experiment' also addresses the Rainbow Experiment and can be used as a additional resource here. Another useful resource is a comic strip that has been based on this incident. It can be found at **https://www.linkedin.com/pulse/rainbow-flames-ramin-abhari-p-e-/**

Introduction

In December 2013, the U.S. Chemical Safety Board (CSB) released the safety video *'after the rainbow'*. The video features an interview with Calais Weber, a victim of an incident occurring in a high school laboratory in Ohio in 2006, (**https://www.csb.gov/videos/after-the-rainbow/**).

In the video, Calais describes the lead up to the incident, what went wrong and the consequences. Lessons should be taken from this incident to help prevent future laboratory incidents.

What happened?

This incident occurred during a 'rainbow experiment' class demonstration at Western Reserve Academy High School in Hudson, Ohio, USA in January, 2006. This demonstration uses chemical salts with an accelerant (often methanol) to show different flame colours due to the different burning light frequencies of the chemical salts.

The teacher set up the demonstration on the front desk in a laboratory. She had arranged the chemical salts, which had been pre-mixed with the methanol accelerant, into small dishes. Students were instructed to gather around the front desk to observe as the dishes were ignited.

Soon after, the red flame began to diminish in size. In response, the teacher decided to add additional methanol to the flame in an attempt to increase the flame size. She did this by pouring methanol directly from a 4 L container onto the flame.

This resulted in the methanol igniting, and the fire spreading back to the container causing an explosion. The blast wave from the explosion caused some students to be thrown backward and to become caught on fire. Some students ended up with burn injuries. Calais, for example, had 40% of her skin burned at age of 15.

Causes

The primary factors as to why the incident occurred that were identified in the CSB video are:

- poor experiment set up
  - fume hood was not used for the demonstration
  - the volume of accelerant added to the flame was excessive for the demonstration
  - students were too close to the demonstration
- poor laboratory practices
  - PPE was not worn by students when observing the demonstration as the teacher had not enforced this as a requirement
- poor decision making by supervisor
  - there was no requirement for the flame size to be increased, yet the supervisor took an action which introduced a hazard
- laboratory culture
  - students did not question the teachers actions as there is 'unspoken sense of you are safe' according to Calais

Lessons learnt

Students should remember that for all laboratory experiments:

- planning
  - all safety information needs to be read carefully prior to starting an experiment
  - ensure that the required safety precautions are in place before starting the experiment
  - communicate with the teacher/supervisor if you have any concerns with conducting the experiment safely
- execution
  - deviation from the experimental procedure should only occur in an emergency and only if all safety risks have been considered and appropriately managed

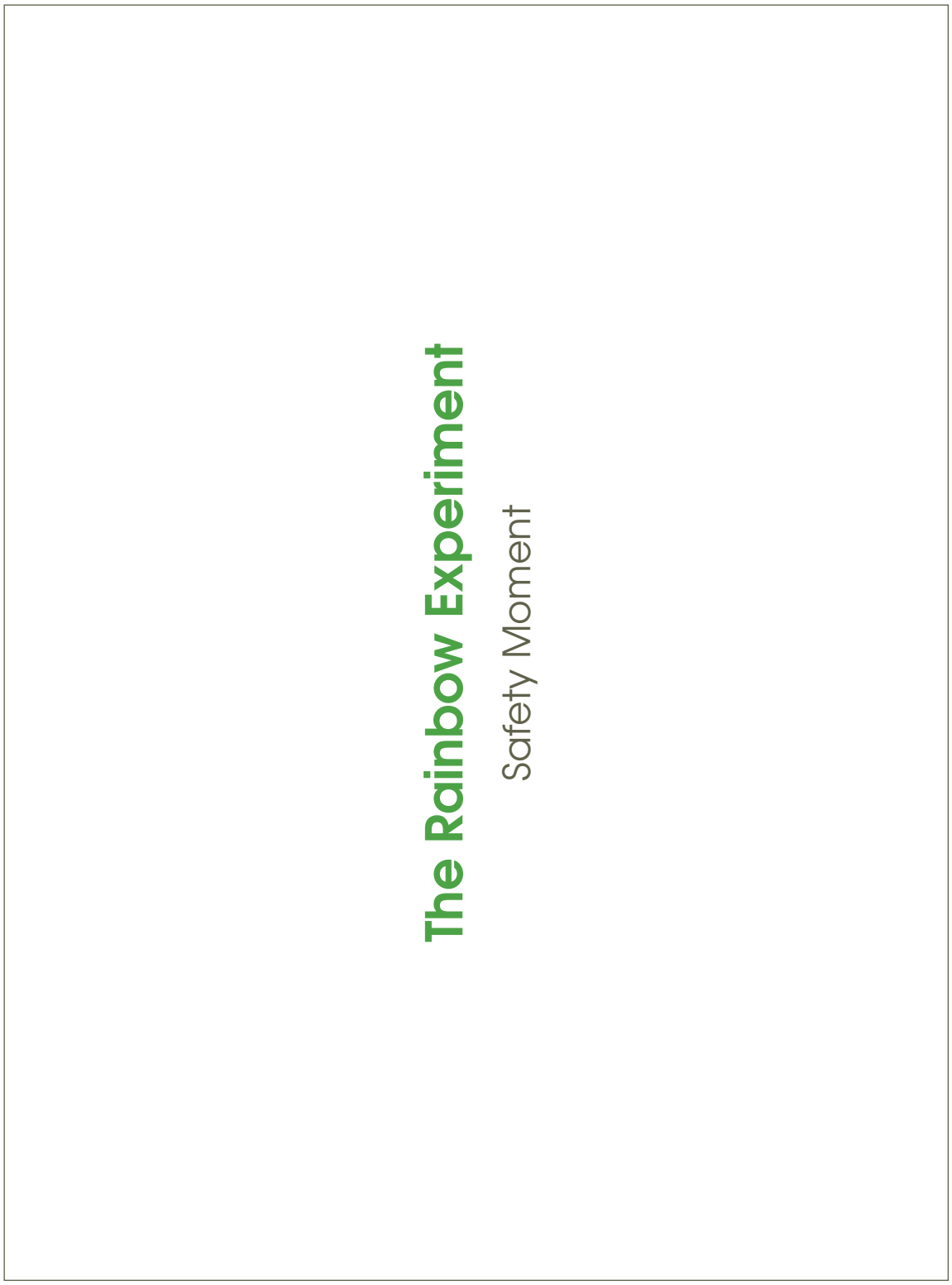
    note: deviations from experimental procedures are strongly discouraged because often the safety considerations have not been made
  - if you feel unsafe at any point during the experiment, speak up!

Remedial measures

Students should remember that for all laboratory experiments:

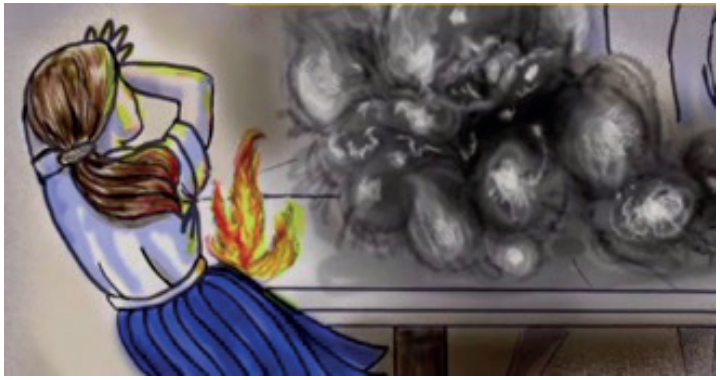
- planning
  - all safety information needs to be read carefully prior to starting an experiment
  - ensure that the required safety precautions are in place before starting the experiment
  - communicate with the teacher/supervisor if you have any concerns with conducting the experiment safely

3–9–2 Safety moment presentation materials – the rainbow experiment



The incident

- flash fire/explosion at high school laboratory during Rainbow Experiment
- where?
  - Western Reserve Academy High School in Hudson, Ohio
- when?
  - January, 2006
- 2 students received third degree burns



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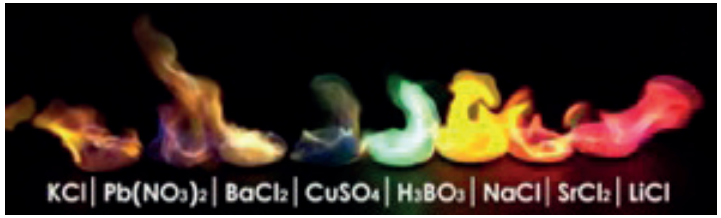
What happened?

- the rainbow experiments use chemical salts and an accelerant to show different flame colours due to the different burning frequencies



- the teacher had set the experiment on the front desk with the salts and methanol (accelerant) premixed
- students gathered around and the teacher ignited the dishes
- the red flame was diminishing, so the teacher poured methanol from an unmarked 4L container onto the flame to increase its size
- the methanol ignited and the fire spread back to the container causing an explosion

Causes and contributing factors

- cause: poor decision making by supervisor by adding excessive quantity of accelerant
  - no experimental instruction to do so
  - no requirement to increase flame size

- additional factors contributing to severity:
  - students too close to desk
  - students not wearing appropriate PPE
  - no fume hood to remove flammable gas and provide potential barrier to explosion

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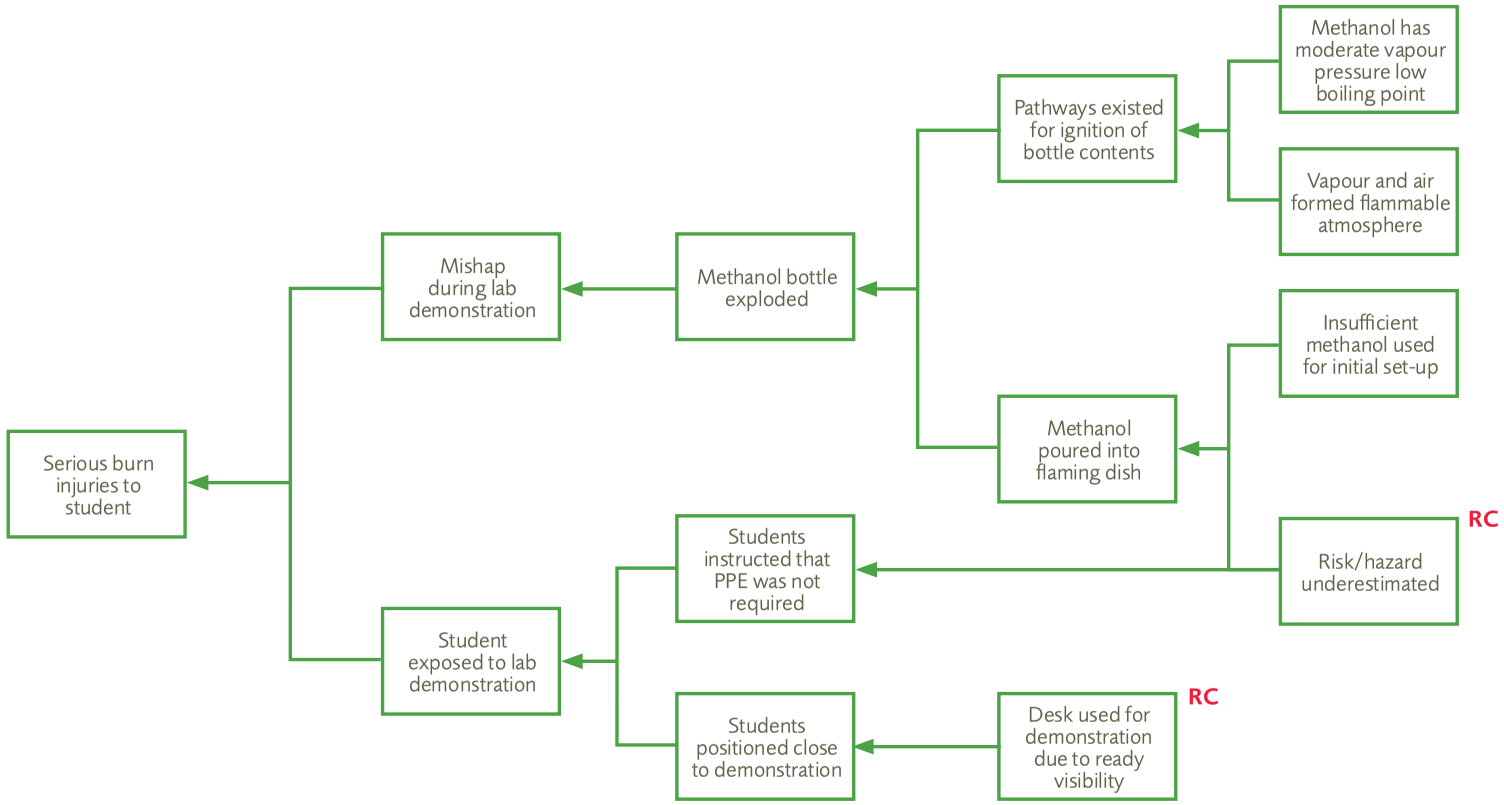
Example root cause diagram



See CBS video *'Experimenting with Danger'*.

Note: above analysis is for illustration and not intended as a strict representation of the incident.

Lessons learnt

- planning
  - read all safety information carefully before starting experiment
  - ensure experimental set up as per procedure, including all safety requirements are being met (eg PPE, fume hood)

- execution
  - follow experimental procedure
  - ONLY deviate from procedure in case of emergency after considering and managing all risks

If you feel unsafe, speak up!

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Appendix 3–10

Example process log

Process log							
Laboratory name							
Participant names							
Reference documents							
Health, safety and environment	Any safety or environmental limits exceeded?						
	Any safe operating limits exceeded?						
	Any disabled or bypassed alarms?						
	Any emergency shut down or relief systems bypassed or blocked in?						
	Any change is conditions that impacts HSE?						
Observations	Parameter inc. units	Time					
	Pressure						
	Flow						
	Temperature						
Additional notes/comments							

Appendix 3–11

Example handover checklist

Handover checklist				Outgoing person initial	Incoming person initial
Laboratory name		**Handover date and time**			
Outgoing person		*Outgoing and Incoming persons to initial each line when handover task is discussed and completed.*			
Incoming person					
Reference documents					
Health, safety and environment	Any safety or environmental limits exceeded?				
	Any safe operating limits exceeded?				
	Any disabled or bypassed alarms?				
	Any emergency shut down or relief systems bypassed or blocked in?				
	Any management of change initiated in last shift? Details discussed				
	Pre start-up safety review (PSSR) checklist completed and attached				
Operations	Any critical activities to be performed in next hour?				
	Current operating status (flow, pressure, samples etc)				
	Operating instructions (changes, special instructions, due in next 4 hours)				
	Increase rates, decrease rates or change in composition				
	Process lineup changes				
	Chemical inventory changes				
	Equipment out of service				
	Equipment in bypass mode				
Maintenance	Any maintenance work in progress or scheduled				
	Any equipment to be prepared for maintenance				
	Any open permit to work documents				
Any new information since last handover?					
Additional notes/comments					

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Appendix 4

Resources

4–1 Example post activity review

Appendix 4–1

Example post activity review

Background

An important aspect of any management system is a review or assurance cycle to see where improvements can be made. The following check list provides guidance on reviewing the laboratory activities at the end of a year (or semester) to understand how the experience could be improved. These questions are not exhaustive, but can be used to prompt discussion. This activity should be completed with feedback from the students that were involved in the activities as well as the laboratory staff. They are broken down into the following areas:

- planning
- safety analysis
- task analysis
- continuing professional development

Questions

Planning	
P1	When was a similar activity previously undertaken by the laboratory or department?
P2	Were the responsibilities of team members clearly defined?
P3	Was the objective of the activity clearly understood by the participants?
P4	Did the initial objectives for the activity have to change once the activity was started (eg because of lack of clarity, suitability)?
P5	Can the participants identify anyone not present who would benefit from undertaking a similar activity?
P6	Was the time spent on the activity appropriate for the activity in question?
P7	Were any supporting materials and documentation provided appropriate for the activity?
P8	Had the participants completed a similar activity before?
P9	Was the activity supported by appropriate expertise?
P10	Did participants achieve the expected outcome from the activity?
Recommendations on planning	
Safety analysis	
S1	Were there any changes to the laboratory safety management system and / or manual identified as required during the activity?
S2	Did the activity highlight or raise awareness of any particular safety hazards?
S3	Was the risk assessment for the activity thought to be fit-for-purpose, identifying key hazards and describing how those hazards should be mitigated?

Recommendations on safety analysis	
Task analysis	
T1	Which activity tasks did the participants find most difficult to complete (eg because of technical challenge, understanding supporting materials, etc)?
T2	Did the participants have to modify any steps because of previously unidentified safety hazards that emerged during the activity (eg identified from knowledge of chemical safety, good laboratory general practice, etc).
T3	Did participants identify any activity steps that were not clearly defined and if so how should the step be improved?
T4	Were the subject objectives met?
Recommendations on task analysis	
Continuing professional development	
C1	Do the participants feel that the activity supported their continuing professional development (CPD) with relevant institutions (eg IChemE)?
C2	Did the activity complement the participant's experience recorded in the laboratory training register – were there any amendments to the training register as a result of the activity?
C3	Has the expertise of participants improved from the activity – if so how?
C4	Which part of the activity was of most value to you?
Recommendations on continuing professional development	

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