Planning guideline State Code 21: Hazardous chemical facilities

Workplace Health and Safety Queensland
worksafe.qld.gov.au

Queensland Government

Table of contents

Part 1 Overview and introduction

1 Introduction

State Code 21: Hazardous chemical facilities (the Code) contained in the State Development Assessment Provisions (SDAP) applies to a material change of use application made under the *Planning Act 2016* for a new or expanding hazardous chemical facility[1]. Assessment against the Code is intended to help protect individuals, communities and the environment from adverse impacts as a result of the operation of the hazardous chemical facility.

Visit the [Department of Infrastructure, Local Government and Planning] (DILGP) to view the SDAP.

State Code 21 purpose statement:

The development is designed and sited, so far as reasonably practicable, to ensure:

1. *human health and safety, and the built environment are protected from off-site risks resulting from physical or chemical hazards*
2. *hazardous chemical facilities are protected from:*
   a. *off-site hazard scenarios at existing hazardous chemical facilities*
   b. *natural hazards.*

1.1 Purpose of the guideline

The purpose of this guideline is to help applicants in demonstrating compliance with the Code.

1.2 Using the guideline

A development complies with the Code when:

- it complies with all the performance outcomes (PO); or
- the development does not meet relevant performance outcome(s) and SARA determines, on balance, that the development complies with the purpose statement.

There are no acceptable outcomes (AO) for this Code.

Further guidance on meeting POs is available in the introductory sections of SDAP.

This guideline is structured as follows:

- Part 1 – provides an overview and introduction to the Code and guideline
- Part 2 – provides an overview of the development assessment process
- Part 3 – aids with interpreting the POs of the Code
- Part 4 – provides assistance in preparing a hazard report used to demonstrate compliance with the Code.

[1] A **hazardous chemical facility (HCF)** means the use of premises for a facility at which a prescribed hazardous chemical is present or likely to be present in a quantity that exceeds 10 per cent of the chemical's threshold quantity under the Work Health and Safety Regulation 2011, schedule 15.

Part 2 Assessment framework

2 Development assessment process

2.1.1 Material change of use (MCU)

Material change of use is defined in the *Planning Act 2016*:

> ***material change of use***, of premises, means any of the following that a regulation made under section 284(2)(a) does not prescribe to be minor change of use:
>
> a) the start of a new use of the premises
> b) the re-establishment on the premises of a use that has been abandoned
> c) a material increase in the intensity or scale of the use of the premises.

Examples of MCU for hazardous chemical facilities include:

- Storing a new type or class of schedule 15 chemical at an existing hazardous chemical facility.
- Increasing the quantity of existing schedule 15 hazardous chemicals by 10 per cent or more.
- Recommissioning a storage tank or processing system that has been out of use for longer than five years.
- Adding processing steps for existing chemicals (e.g. decanting and blending at a facility that was previously for storage only).

When there is doubt as to whether a change is a MCU for a HCF, advice should be sought from the Major Hazard Facilities (MHF) Unit.

2.1.2 State Planning Policy (SPP)

The State Planning Policy (SPP) is a key component of Queensland's planning system. The SPP expresses the state's interests in land use planning and development.

The SPP has effect throughout Queensland and sits above regional plans and planning schemes in the hierarchy of planning instruments under the Act.

Find out more about the State Planning Policy.

2.1.3 State Assessment and Referral Agency (SARA)

The State Assessment and Referral Agency (SARA) is responsible for delivering a coordinated, whole-of-government approach to the state's assessment of development applications. The chief executive of the *Planning Act*, the Director-General of the Department of Infrastructure, Local Government and Planning (DILGP) is the assessment manager or referral agency for development applications where the state has a jurisdiction.

Schedule 10 of the *Planning Regulation, 2017* prescribes that a material change of use for hazardous chemical facility is assessable development. An applicant for a hazardous chemical facility MCU must therefore make an application to SARA in accordance with the development assessment process established under the *Planning Act*.

2.1.4 Major Hazard Facilities (MHF) Unit

The MHF Unit is part of Workplace Health and Safety Queensland. It is a group of safety advisors with chemical industry experience and qualifications who administer the MHF and hazardous chemical provisions of work health and safety legislation. The MHF Unit is also the technical agency that SARA refers to for HCF development application technical assessment.

2.1.5 State planning development provisions (SDAP)

The SDAP provides benchmarks for the assessment of development applications where the chief executive administering the *Planning Act* is the assessment manager or a referral agency.

Development applications will be assessed by SARA against the relevant state Codes within SDAP. For hazardous chemical facilities, the relevant Code is State Code 21: Hazardous chemical facilities (hereafter the Code). Applicants should conduct an assessment against the Code and provide it as part of the application lodged with SARA.

2.1.6 Pre-lodgement and early consultation

A pre-lodgement meeting with SARA and the MHF Unit of Workplace Health and Safety Queensland is strongly recommended prior to lodging the development application. This meeting will help in understanding the requirements for technical assessments against the Code based on the individual circumstances of the proposed development. This meeting will also help to identify other assessment triggers and approvals that may be required (e.g. transport, environmental).

Applicants are encouraged to seek advice from the MHF Unit at any time prior to lodgement.

Part 3 Assessment criteria

The Code specifies performance outcomes (POs) used in the assessment of MCU for a hazardous chemical facility. POs are specific ways of meeting the purpose statement of the Code but provide some flexibility. This part of the guideline helps applicants with demonstrating compliance with the POs.

3 Meeting the performance outcomes

Hazard identification and assessment summarised in a hazard assessment report is typically required to demonstrate compliance with the POs.

Further guidance about the content and format of the report is given in section 4 and 5.

3.1 PO1-PO5: Dangerous dose to human health and individual fatality risk to various land uses and land use zones

3.1.1 Context

As a guiding principle, all reasonably practicable efforts should be taken to ensure that the hazardous chemical facility is designed and sited so that the potential consequence of any chemical release is contained within its boundaries.

3.1.2 PO1 – PO3 Dangerous dose to human health, vulnerable, sensitive and commercial land use and land use zones

To meet these POs, the applicant shall provide evidence that the foreseeable off-site impacts from the worst-case incident scenarios do not create a dangerous dose to human health at the boundary of vulnerable, sensitive and commercial land use or land use zones. Dangerous dose and land use categories are defined in the Code.

A quantitative assessment of the consequences (e.g. dispersion modelling of a toxic plume) is required to determine the potential for a dangerous dose to human health.

3.1.3 PO4 Dangerous dose to human health and individual fatality risk, open space land use and land use zones

This involves the same approach as for PO1-PO3 in demonstrating that a dangerous dose to human health is not exceeded at the boundary to an open space land use or zone. Where it is not reasonably practicable to achieve the dangerous dose criteria through implementing the hierarchy of controls (see section 4.6), a quantitative risk assessment (QRA) shall be used to demonstrate that the risk criteria defined in the Code are not exceeded at the boundary with open space land use.

3.1.4 PO5 Dangerous dose to the built environment and individual fatality risk, industrial land use and land use zones

This involves the same approach as for PO4 in demonstrating that dangerous dose to the built environment and risk criteria are met. The difference is that dangerous dose and risk criteria must both be met.

If dangerous dose to human health criteria is met at the at the boundary with industrial land use or land use zone, then the risk criteria are not applicable and are deemed to be met.

3.1.5 Purpose statement

If compliance with performance outcomes PO1 – PO5 of the Code is not achievable it indicates that the development is likely not appropriate for the selected site. The applicant should consider selecting a different site or changing the proposal to eliminate or reduce hazards to achieve the POs.

If this is not possible, the applicant may attempt to demonstrate compliance with part 1 of the purpose statement:

> The development is designed and sited, so far as is reasonably practicable, to ensure:
>
> 1. human health and safety, and the built environment are protected from off-site risks resulting from physical or chemical hazards.

This may be achieved by providing a structured argument in the hazard assessment report discussing the extent of the excursions from the POs and how human health and safety and the built environment are still protected through the implementation of the hierarchy of controls.

Individual fatality risk criteria are not specified for PO1-PO3. However, in some cases, the results of a QRA may be considered in the assessment of whether the development meets the purpose statement. The applicant should seek advice from the MHF Unit for when this may be appropriate.

In some cases, it may be necessary for a proposed HCF development that is under 100 per cent of WHS Regulation, schedule 15 thresholds to be determined a major hazard facility. This will provide further assurance that when risk controls are being relied on to prevent or limit off-site consequences, they are properly implemented and maintained.

3.2 PO6: Monitored fire detection

3.2.1 Context

The objective of PO6 is to ensure that where fire risk hazardous materials such as flammable liquids are stored, there is a prompt emergency response to a fire.

Early detection of a fire event can help minimise risk to emergency services and property loss. While the Building Code of Australia specifies requirements for fire protection, additional fire protection will usually be required for premises where fire-risk hazardous chemicals are stored and handled. The Work Health and Safety Regulation 2011 (WHS Regulation) also has specific obligations for fire protection and firefighting equipment for hazardous chemicals (section 359).

If large quantities of fire risk chemicals are stored, it is likely that a fire safety study will be required to comply with section 359.

If no fire risk hazardous chemicals are stored, then the PO is not applicable and deemed to be met.

3.2.2 Performance outcomes

PO6 requires a 24-hour monitored fire detection system that can detect a fire in its early stages and notify an emergency responder for early action.

Fire systems must be designed to recognised standards (e.g. AS1670) and ensure that:

- automatic systems are also capable of being manually activated at clearly identified manual alarm call points at convenient and safe locations near work areas
- the alarm signal is sufficiently distinguishable from any other signals to permit ready recognition, and clearly audible throughout the storage installation
- where high noise levels or the use of ear protection may prevent the recognition of an alarm signal, an effective alternative alarm system is also installed, such as a visual system
- the system remains operable when the main power supply fails.

Alarm systems for larger hazardous chemicals storage and handling facilities should be directly linked to emergency services where practical.

System components shall be selected and located to achieve stable and reliable performance. Equipment shall be suitable for the environment in which it is to be located.

The hazard assessment report should provide a summary of how PO6 is met and supporting evidence (e.g. the fire safety study, fire system functional specification, schematics).

3.3 PO7-PO8: Spill containment of fire risk chemicals

3.3.1 Context

The objective of PO7 and PO8 is to limit the consequences of a spill of fire risk chemicals.

Uncontained spills of flammable liquids can spread fire around the site or to neighbouring sites.

The escape of contaminated fire water may harm people and the environment; the fire water may contain the stored chemicals and potentially harmful fire-fighting foam.

3.3.2 Performance outcomes

PO7 requires that storage and handling areas for packages of liquid or solid fire risk hazardous chemicals are provided with a spill containment system with a working volume capable of containing a minimum of 100 per cent of all packages (prescribed hazardous chemicals and/or non-hazardous chemicals) within the area plus the output of any fixed firefighting system provided for the area over a minimum of 90 minutes.

PO8 requires that storage and handling areas for liquid or solid fire risk hazardous chemicals in tanks are provided with a spill containment system with a working volume capable of containing a minimum of:

a) 110 per cent of the largest tank within a spill compound or 25 per cent of the aggregate where multiple tanks are located within a spill compound, whichever is the greater: and
b) the output of any fixed firefighting system provided for any bulk tank within a spill compound over a minimum of 90 minutes.

For both PO7 and PO8, the containment system should be designed and constructed so that it is resistant to attack by the hazardous chemicals being stored, is impervious and fire resistant. Penetrations through the containment system wall (e.g. pipes, drain valves) should be avoided where practical, otherwise they should be prevented from being left open. Profiling and apron bunds should be considered where close containment of fire risk chemicals is undesirable.

The details of the containment system including drawings and calculations that demonstrate compliance with PO7 and PO8 should be included in the hazard assessment report.

3.4 PO9 Prevent mixing of reactive chemicals

3.4.1 Context

During emergencies such as spills or fires, mixing of chemicals that react dangerously with each other can escalate the initial incident.

3.4.2 Performance outcome

PO9 Requires that the facility is designed to prevent chemicals that react dangerously from mixing with each other during normal operation and incidents such as spill or fires.

If no such chemicals are stored, PO9 is not applicable and deemed to be met.

The facility should be designed with containment systems which are segregated by impervious walls resistant to chemical degradation and fire. Containment systems should not be able to contact each other by pumps, piping or drainage systems.

Further guidance can be found in the Australian Standards regarding the storage and handling of specific types of hazardous chemicals.

The details of the containment system(s) including drawings and calculations that demonstrate compliance with PO9 should be included in the hazard assessment report.

3.5 PO10: The facility is designed to mitigate the impacts of natural hazards

3.5.1 Context

The objective of PO5 is to minimise the potential for the release of hazardous chemicals arising from:

- flood
- bushfire
- erosion
- storm tide inundation
- landslide
- earthquake

- wind action.

3.5.2 Performance outcome

Locating hazardous chemicals outside of the natural hazard zone is always preferable, however this may not always be practical. Many existing and proposed facilities near ports or rivers have a risk of flood or storm tide inundation. In such cases, mitigation must be put in place to eliminate or minimise the adverse consequences.

Flood and storm tide inundation

Floodwaters and storm tide inundation have buried, moved or damaged hazardous chemical containers causing them to end up in various and sometimes unexpected locations, often outside the boundary of the facility at which they were originally held. Flooding can have the following consequences:

- buoyancy of the container leading to lifting/floating
- erosion and land scour from rapidly moving water causing undermining of structures
- product displacement
- water ingress into static storage systems (e.g. via fill pipes, vents, damaged bund walls)
- electrical system damage
- rendering protective systems such as fire water pumps or cooling pumps inoperable.
- wetting chemicals that react dangerously with water.

Historically, flood events and storm tide inundation have a relatively high frequency in Queensland. Hazardous chemicals displaced by floodwaters have damaged the downstream environment and created a public safety risk. New developments need to consider the potential for flooding and incorporate mitigation measures in the design.

Example control measures include installing flood barriers such as raised bunds, elevating the chemical storage and handling areas above the flood or storm tide inundation levels, securing tanks to prevent them from floating up with the rising flood or tide, and designing the system to prevent water ingress.

Flood hazard areas are available from local council online maps / planning schemes and Queensland Globe interactive mapping system. Such flood hazard areas should be referred to when determining the likelihood of the proposed development being inundated by flood waters or storm tide events.

Erosion prone areas and storm tide inundation

Erosion prone areas and areas with the potential for storm tide inundation are the width of the coast, rivers and estuaries that are vulnerable to coastal erosion and tidal inundation. Like flood waters, erosion prone areas have the potential to move or damage chemical storage containers, undermine foundations and render protective systems inoperable.

The risk of damage in erosion prone areas is much higher than for areas subject to creeping floods due to strong currents and or wave action.

The *Coastal hazard technical guide* provides additional information on coastal erosion and storm tide inundation. Visit the Department of Environment and Heritage Protection to view the guide find out more about erosion prone areas.

Erosion prone areas may be also be identified on council mapping (e.g. areas subject to overland flow during flash flooding).

Development on land subject to strong currents, flash-flooding, wave action, erosion is unlikely to be approved.

The hazard assessment report should include:

- details of the flood and erosion hazards (e.g. map overlays, property flood reports from local government, hydrological modelling reports)
- details of the mitigative controls (e.g. drawings of proposed structures, engineering specifications).

Bushfire

Storing or handling hazardous chemicals in **bushfire zones** poses several risks including ignition caused by burning embers, radiant heat or flames, damage or failure of containers, power cuts, and damage of protective systems.

Hazardous chemicals come in a variety of packaging types including plastic and cardboard. Bulk hazardous chemicals are often in IBCs (Intermediate bulk containers) constructed from plastic or in metal containers such as tankers (on trailers and trucks) or in ISO-tanks.

Bushfire embers move with the wind and can affect areas ahead of the fire front. The embers can enter buildings and ignite the contents of the building and/or the building itself. Plastic containers can melt. Metal containers can heat to a point where they explode. The fire then rapidly intensifies.

Mitigation of the effects of bushfire attack shall be demonstrated using appropriate standards for construction of buildings, ember proofing and fire breaks.

Examples of control measures include fire breaks, fire walls, fire insulation on containers, firewater sprinkler systems, and buried or mounded tanks.

Development on land subject to high or very high bush fire risk is unlikely to be approved.

The hazard assessment report should document that any relevant bush fire hazard overlay from the local council has been consulted and provide details of the controls. A bushfire study may be required, based on risk.

Landslide hazard areas

Landslides are the downward and outward movement of slopes composed of natural rock, soils, artificial fills, or combinations thereof. Landslide types include slump, rockslide, debris slide, lateral spreading, debris avalanche, earth flow, and soil creep.

The rock and soil in a landslide move by falling, sliding, and flowing along surfaces marked by differences in soil or rock characteristics. A landslide will happen when there is a decrease in the resistance between the earth mass decreases or by an increase in the force acting on the earth mass. Often this is associated with rain events. Mud and water may increase the force, or water under the soil cause the resistance to be reduced, allowing the earth mass to flow.

Landslides can occur very quickly and cause significant damage to buildings, and storage and handling areas.

Further information on landslide hazards can be obtained from the Australian Government Department Geoscience Australia.

Development on land directly subject to slippage or subsidence is unlikely to be approved.

The hazard assessment report should document that any relevant landslide map or overlay from the local council has been consulted. Mitigation of the effects of landslide shall be demonstrated by describing the potential landslide hazards above the facility, below or adjacent to the facility and the mechanism of landslide which could impact upon the hazardous chemicals storage and handling. Justification for the selection of the area must then be provided and along with the demonstration that the risk has been mitigated.

Earthquake

Hazardous chemical storage systems, supporting infrastructure, buildings and structures must be designed to withstand earthquake loads as per the National Construction Code and Australian Standard AS1170.4 `Earthquake actions in Australia'.

Large structures such as petroleum tanks, refrigerated storage tanks, large pressure vessels, chimney stacks may require specialist engineering studies to ensure their integrity is maintained under earthquake loads.

The hazard assessment report should document that earthquake hazards have been identified and designed for.

Wind action

Hazardous chemical storage systems, supporting infrastructure, buildings and structures must be designed to withstand wind loads including tropical cyclones as per the National Construction Code and Australian and New Zealand Standard AS/NZS1170.2: Structural design actions: Part 2, Wind actions.

Large structures such as petroleum tanks, refrigerated storage tanks, large pressure vessels, chimney stacks may require specialist engineering studies to ensure their integrity is maintained under wind loads.

The hazard assessment report should document that wind hazards have been identified and designed for.

3.6 PO11: Development is designed and sited to mitigate the risks from hazard scenarios occurring at existing hazardous chemical facilities

3.6.1 Context

The aim of PO11 is to minimise the impact of an incident at an existing nearby hazardous chemical facility by optimising the new facility's layout or including controls to limit the impact of an external incident or in cases of very high risk considering an alternative site.

If there are no hazardous chemical facilities in the vicinity, then this PO is not applicable and deemed to be met. If there are no impacts arising from hazardous chemical facilities in the vicinity, then the PO is met.

3.6.2 Performance outcome

The hazard assessment report must identify nearby hazardous chemical facilities that may affect the development. The report must state how the development considers and responds to the effects of potential incidents at an existing nearby hazardous chemical facility.

The locations of hazardous chemical facilities in the area can be obtained from the Major Hazard Facilities Unit or by consulting nearby businesses. The MHF Unit can facilitate communication if required.

Similar to the response to PO1-PO5, the applicant should determine the worst-case consequences of incidents at external facilities. This can be done by calculation, considering the types and quantities of hazardous chemicals stored at the external facility or by obtaining this information directly from the facility if available.

If there are consequences which could affect the new facility, the following should be considered:

a. Altering the layout of the facility to minimise the effects (e.g. moving hazardous chemicals out of the effect zone).
b. Providing controls to mitigate the effects (e.g. installing fire walls, blast walls or blast resistant buildings to protect chemical storage areas and occupied areas).
c. In case of extreme external hazard, when an external facility may produce a consequence that knocks-on to the new facility causing an even worse incident, an alternative location should be sought (e.g. a new ammonia or LPG tank should not be located in a zone subject to destructive overpressure that could arise from an explosives magazine).
d. The emergency plan for the new facility should include contingencies to protect people and plant from external hazards.

Example scenario:

- Situation: A new tank farm is to be located within 50m of an existing tank farm's boundary fence. The existing tank farm has its flammable liquid tanks along the fence line at distances less than those required under the current Australian Standard AS1940 (it was compliant when built 60 years ago). The new tank farm will hold category three and four flammable liquids (category 4 flammable liquids are materials like diesel). The land parcel does not allow a large space to be left along the boundary to the existing tank farm to comply with the Australian Standard. A fire study indicates that heat radiation could impact the new tanks even with compliance to AS1940.
- Possible solution: To minimise the effects from the adjacent tank farm the new facility will store its diesel (less likely to ignited if heated) closest to the boundary and cooling rings will be fitted to protect the tank from any heat radiation arising from an incident at the adjacent tank farm.

Part 4 Preparing a hazard assessment report

4 Advisory notes to interpreting State Code 21

It is a fundamental principle of State Code 21, the authorising State Planning Policy and work health and safety legislation that hazardous chemical facilities are designed according to sound engineering principles, relevant Australian Standards and other good-industry-practice to eliminate or minimise health and safety risks, so far as reasonably practicable (SFARP).

A hazard assessment report should be provided that identifies foreseeable hazard scenarios with the potential to create off-site physical or chemical effects. Any off-site impact shall be estimated using suitable software modelling, calculations, look-up tables etc.

Applicants should demonstrate that they have taken all reasonably practicable measures to minimise the likelihood of any off-site hazards from materialising and to limit their physical and chemical effects if they did occur. As a guiding principle, development should be designed so that the effects of any hazards can be contained within its boundaries. Where a development cannot be designed following this principle, it must be designed to meet the criteria in PO1-PO5 of the Code.

4.1 Role of the designer

A designer is anyone who designs buildings, processes, plant and structures, or who modifies the design of existing hazardous chemicals development that triggers a MCU. Examples include:

- designing a hazardous chemical warehousing facility on a greenfield site or at an existing facility
- designing a new manufacturing plant or an extension to an existing one
- designing a hazardous chemicals storage and handling system for a new or existing facility.

The designer is responsible for ensuring that risk controls are adopted according to the hierarchy of controls described in the WHS Regulation chapter 3, see section 4.6 Review of risk control measures for further detail.

4.2 Engineering activities

In Queensland, the *Queensland Professional Engineers Act 2002* (QPE Act) requires that any engineering work be undertaken by, or supervised by, a Registered Professional Engineer of Queensland (RPEQ). Design according to a ‘prescriptive standard’ does not require RPEQ qualifications. More information is available at bpeq.qld.gov.au.

4.3 Preparing an application triggering State Code 21

Hazard identification and assessment, consequence assessment and quantitative risk assessments require specialist training and qualifications. They generally cannot be attempted by a layperson.

The applicant should employ suitable people to perform the hazard assessments and write the hazard assessment report.

View a list of agencies and contacts. Placement on the list is not an endorsement by the agency.

4.3.1 Hazard identification

This process involves the systematic and comprehensive identification of all possible scenarios that could lead to a hazardous incident at the facility.

There is no single method of hazard identification prescribed. The choice of method(s) will depend on the type of facility being studied, information availability and the expertise of the analyst.

It is essential that the analysts be experienced in hazard identification, and that, where possible, plant designers and company personnel with relevant operating experience are involved in the identification process.

The identification process should not be limited to the activities at the facility, but should also consider:

- natural events such as floods, tropical cyclones, earthquakes or lightning strikes
- malicious acts
- hazardous events on neighbouring sites.

The results of the hazard identification should document (e.g. a table, list, diagram) the:

- identified physical and chemical hazards (e.g. flammable liquids, pressurised gas, toxic gas)
- types of incidents that could result from each hazard (e.g. leak, vessel rupture)

- possible causes of each incident (e.g. corrosion, overpressure, dropped container)
- possible effects of each incident (e.g. toxic gas cloud, fire, explosion)

The methods and results of the hazard identification process should be presented in the report.

Bow-tie diagrams are a popular tool for performing/documenting hazard identification. They are not mandatory and other tools are accepted if effective.

4.3.2 Hazard analysis

In the context of land use safety planning, the hazard analysis involves determining the expected impacts of incidents on people (e.g. fatality, permanent injury, acute injury) and property outside the facility boundary. Careful attention should be given to identifying worst case credible scenarios.

The first stage is to screen the hazards and identify scenarios with off-site effects. The second stage estimate the consequences. Hazard scenarios should not be dismissed because they are thought to be unlikely. All credible incident scenarios with offsite effects shall be assessed.

4.4 Consequence scenarios

The consequences of the following scenarios should be determined, where relevant and not limited to:

- pool fires
- jet fires
- flash fires
- vapour cloud explosion (VCE), not to be excluded because of low congestion as VCE have been known to occur with little or no congestion.
- BLEVE
- other explosive effects such as:
    - dust explosions
    - detonation of explosives
    - detonation of oxidisers such as nitrates, chlorates, perchlorates
    - explosive decomposition (e.g. acetylene, ethylene oxide)
    - rapid phase transition of cryogenic liquids
    - pressure vessel rupture without ignition
    - runaway reactions
- warehouse fires which liberate toxic smoke
- toxic gas or dust dispersion resulting from leaks, ruptures, adverse reaction, decomposition by fire or other heat source
- escalation / knock-on where an initial incident such as a small explosion damages equipment leading to worse consequences (e.g. a small explosion that damages a toxic gas piping leading to a large toxic release).

4.4.1 Heat radiation effects

The effects of heat radiation from jet, pool, and flash fires and BLEVEs must be estimated using contemporary techniques as applicable. The preferred format of presenting the results is effect contours overlayed on a map clearly showing the contours relative to the various land use categories.

Areas outside the facility boundary shall not be exposed to heat radiation exceeding 4.7 kW/m^2, except industrial land use which should not exceed 12.6 kW/m^2.

Table 1 Consequences of heat radiation

Heat radiation (kW/m^2)	Effect
1.2	Received from the sun at noon in summer.
2.1	Minimum to cause pain after 1 minute.
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second degree burns will occur).
12.6	Significant chance of fatality for extended exposure. High chance of injury. Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure. Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
23	Likely fatality for extended exposure and chance of fatality for instantaneous exposure. Spontaneous ignition of wood after long exposure. Unprotected steel will reach thermal stress temperatures which can cause failure. Pressure vessel needs to be relieved or failure would occur.
35	Cellulosic material will pilot ignite within one minute's exposure. Significant chance of fatality for people exposed instantaneously.

4.4.2 Explosion overpressure

The overpressure effects of vapour cloud explosions, explosive reactions, rapid phase transitions, BLEVEs and accidental detonation of explosives must be estimated using contemporary techniques as applicable. The preferred format of presenting the results is effect contours overlayed on a map clearly showing the contours relative to the various land use categories.

Areas outside the facility boundary shall not be exposed to an overpressure greater than 7kPa, except industrial land use which shall not exceed 14 kPa.

Table 2 Effects of explosion overpressure

Explosion overpressure	Effect
3.5 kPa (0.5 psi)	% glass breakage. No fatality and very low probability of injury.
7 kPa (1 psi)	Damage to internal partitions and joinery but can be repaired. Probability of injury is 10%. No fatality.

14 kPa (2 psi)	House uninhabitable and badly cracked.
21 kPa (3 psi)	Reinforced structures distort. Storage tanks fail. 20% chance of fatality to a person in a building.
35 kPa (5 psi)	House uninhabitable. Wagons and plants items overturned. Threshold of eardrum damage. 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open.
70 kPa (10 psi)	Threshold of lung damage. 100% chance of fatality for a person in a building or in the open. Complete demolition of houses.

4.4.3 Toxic dispersion

The dispersion of toxic gases, vapours, mists, smoke and dusts must be estimated using contemporary techniques as applicable. The Code requires distances to AEGL-2 to be determined. The preferred format of presenting the results is effect contours overlayed on a map showing contours relative to the various land use categories.

Vapour clouds that form over pools of volatile liquids should not be overlooked.

4.5 Conducting the consequence and risk assessments

Consequence and risk modelling is a specialised skill. A developer or owner should choose a competent person or business to conduct the work. They will have the software and experience required to conduct the modelling. Modelling software can estimate the thermal effects of fire and explosion, the pressure-wave effects of explosions and the dispersion and effects of toxic releases.

Modelling assumptions should be clearly stated in the hazard assessment report.

4.5.1 Failure rate/frequency data

The failure rate data for QRA should be taken from recognised sources such as Lees, United Kingdom Health and Safety Executive, or the US Centre for Chemical Process Safety.

Use of proprietary data should be clearly justified in the hazard assessment report.

4.5.2 Weather

Consequence modelling should include a plausible range of local weather conditions and determine those that that result in the highest consequences.

4.5.3 Modelling software

Modellers should use software validated for use with the chemicals and release conditions specific to the development. The limitations of the selected modelling software must be understood. The hazard assessment report should include the parameters chosen, the modelling limitations and the assumptions made.

4.5.4 Quantitative risk assessment (QRA)

Quantitative risk assessments require specialised knowledge. Selection of scenarios, models, assumptions, failure rates and interpretation of results requires skill and judgment. QRAs are resource intensive. They are only required when the consequence criteria cannot be met.

QRAs require a quantitative analysis of the likelihood and effects of each hazard scenario. The hazard scenarios are then assessed cumulatively. The results are then presented as risk contours which may be compared against the risk criteria.

The analyst shall justify the selected methodology by referencing reputable publications such as:

- *Guidelines for Chemical Process Quantitative Risk Analysis*, 2nd edition, October 1999, published by Centre for Chemical Process Safety (CCPS) available at aiche.org.
- *Lee's Loss prevention in the process industries: Hazard Identification, Assessment and Contro*l, 3rd edition, 2005 published by Elsevier.
- Manual for the Classification and Prioritisation of risks due to major accidents in process and related industries, 1996, published by International Atomic Energy Agency, IAEA-TECDOC-727.
- Hazardous Industry Planning Advisory Paper #6: *Guidelines for Hazard Analysis*, January 2011, published by NSW Department of Planning and Environment.

4.5.5 Assumptions/limitations

Information sufficient for clear understanding and reproducibility on the inputs and assumptions for the calculations and analysis should be provided in the hazard assessment report. It should include:

- the various methods of frequency and probability assessment used
- all failure data and sources
- assumptions for probabilities used
- relevant fault trees and/or event trees
- details of wind, weather, topographical, population, hydrological and other data used
- the details of all other assumptions
- names and purposes of computer software used in the calculations.

Quantitative assessments are subject to considerable variability due to the range of possible input assumptions, particularly in component failure rate data, event probabilities and ignition probabilities. Reasonable efforts should be made to consult various credible of sources input data and assumptions and assess the sensitivity of the outputs to these.

Quantitative analyses should not rest on a particular set of convenient inputs that achieve a PO when other valid inputs would result in it not being achieved.

4.6 Review of risk control measures

Hazard analysis is likely to identify scenarios where risk is not controlled so far as reasonably practicable.

Whether or not a hazard can produce an off-site consequence, or POs are met, the WHS Regulation, chapter 3 requires that a designer implement the hierarchy of controls in the order as listed below:

(1) Substitute (wholly or partly) the hazard(s) giving rise to the risk with a lesser hazard. For example:

- Use non-toxic refrigerant instead of ammonia.
- Reduce the quantities of hazardous chemicals to the minimum needed.
- Store hazardous chemicals in smaller containers to reduce the consequences of one container leaking.

(2) Isolate the hazard(s) from people. For example:

- Choose a site away from residential or high-density commercial areas. Industrial precincts are the preferred location for hazardous chemical facilities.
- Locate the hazardous chemicals on-site away from boundaries with incompatible land use.
- When selecting a site, consider future land use intensification – a current industrial land use may be zoned residential which will allow residential development in future.

(3) Implement preventative engineering controls. For example:

- Safety instrumented systems including overfill protection, high temperature and high-pressure protection.
- Mounded or buried LPG tanks.
- Vehicle impact barriers.
- Heat protection of hazardous chemical containers.

(4) Implement mitigative engineering controls. For example:

- Secondary containment systems.
- Closed pressure relief systems.
- Automated gas detection and shut-off.
- Automated fire suppression systems.
- Firewalls and vapour barriers.
- Deluge systems.

If the POs are met, no further review of controls is required to comply with the Code. If the POs are not met, but the applicant wants to demonstrate compliance with the purpose statement, the hazard assessment report should contain a detailed summary of control selection and an argument as to how and why the selected controls meet the purpose statement.

5 Format for hazard assessment reports

The applicant should present the results of the assessment in a logical manner that demonstrates that the performance outcomes are met. As a minimum, the report should contain the information listed below so that the claims about meeting the Code can be reviewed by the MHF Unit. Failure to provide sufficient information in the report may lead to requests for further information and cause unwanted delays.

5.1 Title page

The title page should clearly identify the facility covered by the hazard assessment and the location of the facility. The title sheet should also show who performed the hazard assessment, their qualifications and professional membership (e.g. RPEQ/AIDGC), and the date of the report.

5.2 Table of contents

The report should include a table of contents with page numbers. The table of contents should include a list of figures and appendixes.

5.3 Summary

The purpose of the hazard assessment, along with an overview of the approach used, should be clearly stated. The summary should highlight major findings of the hazard assessment.

It is important to demonstrate a good understanding of the hazards and risks for the proposed development with the foreseeable hazard scenarios identified. A brief comment on data limitations, assumptions and other uncertainties that could affect the conclusions of the analysis should also be included. The interaction between the hazard assessment and any other safety studies (e.g. fire study) that have been carried out for the facility should be highlighted.

5.4 Site description

This section should present an overview of the location of the site and operations carried out. It should present all relevant information available about the planned development. A layout plan should be included which is sufficiently detailed so that equipment and operational areas can be found and linked to the hazard assessment studies.

The report should also include the number of people on site at various times and describe site security arrangements.

5.5 Location

The report should provide a description and evaluation of the site location and industrial and natural hazards. The report should describe surrounding land uses and zones and population density. Maps of the facility location and of surrounding land should be included. QLD Globe and local government online mapping will be useful.

5.6 Hazardous chemicals

Include a complete list of hazardous chemicals including the following information:

- Chemical name
- UN Number
- GHS classification
- Australian Dangerous Goods Code class and packaging group
- Identify WHS Regulation, schedule 15 chemicals
- Total quantity in tonnes
- Largest container size

Site plan showing main inventories, tanks and vessels.

5.7 Process

A brief process description should summarise the processing steps and operations involving hazardous chemicals.

Process flow diagrams should be included if available.

5.8 Hazard identification methods and hazard analysis

The methodology and results of the hazard identification and analysis should be presented in a logical sequence demonstrating that a comprehensive assessment has been done. Detailed results of consequence assessments or QRAs should be included as appendices.

Assumptions and data sources should be described.

5.9 Risk control measures

The report should include a description of the risk control measures relied on to meet the POs.

5.10 Code compliance statements

The report should include itemised statements about how each PO has been met. Section 3 gives more detail about what information should be provided for each PO.

PN12195