GOOD PRACTICE GUIDELINES

HEALTH AND SAFETY BY DESIGN

xxxxx (date)

Guide to Health and Safety by Design

DISCLAIMER

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ACKNOWLEDGEMENTS

WorkSafe would like to acknowledge and thank stakeholders who have contributed to the development of these guidelines.

KEY POINTS

> Designers have an important role in eliminating and minimising health and safety risks

> There are key principles of Health and Safety by Design that designers should follow

> There are specific things to consider when designing structures, plant or substances

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01 / INTRODUCTION

Who is this guidance for?

These good practice guidelines are for persons conducting a business or undertaking (PCBUs) with a role in designing structures, plant or substances - known as 'designers'. These people may include:

- PCBUs who are engaging designers of structures, plant or substances to be used, or could reasonably be expected to be used, in a workplace
- people who make decisions about the design or redesign of structures, plant or substances
- external experts who contribute to design projects.

What does it cover?

Designers are 'upstream PCBUs'. An upstream PCBU's duties are important because they can influence the safety of products before they're used in the workplace. These guidelines explain these designer duties, and describe how designers can eliminate or minimise health and safety risks (called 'Health and Safety by Design').

The guidelines:

- begin with general concepts that cover the Health and Safety at Work Act 2015 (HSWA)
- look at the key principles of Health and Safety by Design
- outline Health and Safety by Design - what is good practice when considering the design of structures, plant and substances.

These guidelines are largely based on guidance produced by Safe Work Australia[1]. Key elements of good practice have been adapted for a New Zealand audience.

[1] Principles of Good Work Design – A work health and safety handbook (2015)
Guide for Safe Design of Plant (2014)
Safe Design of Structures – Code of Practice (2012)

02 / WHAT IS HEALTH AND SAFETY BY DESIGN?

2.1 Health and Safety by Design

‘Health and Safety by Design’ is when designers think about how they can eliminate or minimise health and safety risks, throughout the lifecycle of a structure, plant or substance. These designers are in a strong position to help create healthy and safe workplaces from the start of the design process.

Figure 1 shows the decrease in ability to influence safety that a PCBU has over the lifecycle of a product.

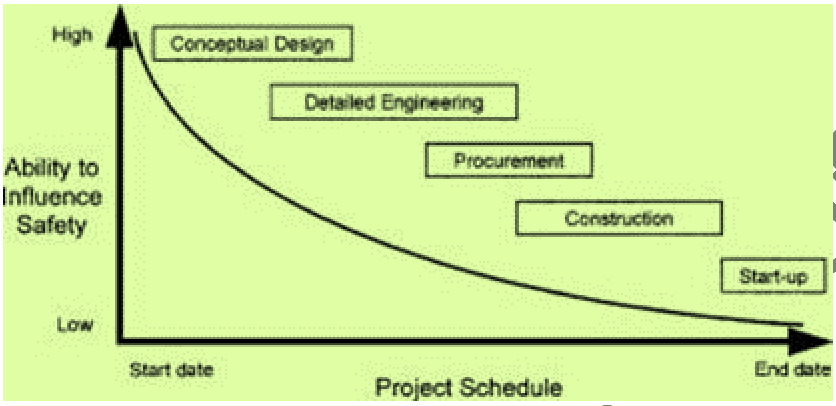


Figure 1: Symberszki chart of influence over a product’s lifecycle

2.2 Why is Health and Safety by Design important?

It is important to think about health and safety risks at the design stage of a product. Here is why:

Smart design of products can help provide a high level of protection for end users

Workers have the right to the highest level of protection, so far as reasonably practicable. Eliminating or minimising risks in the design stage of a product is an effective way of providing the best protection. It is more effective than, for example, retrofitting a product later in its lifecycle.

Smart design of products makes good business sense

Eliminating health and safety risks before they happen makes good business sense for PCBUs. People who work in safe, healthy conditions are less likely to take time off work and will be more engaged and positive in their job. This may mean that productivity is increased in the long run.

03 / HEALTH AND SAFETY DUTIES

3.1. What is HSWA?

The Health and Safety at Work Act 2015 (HSWA) is New Zealand's workplace health and safety law. It sets out the principles, duties and rights in relation to workplace health and safety.

There are different groups of people that hold health and safety duties under HSWA, called 'duty holders'. They are:

- persons conducting a business or undertaking (PCBUs)
- officers
- workers
- other persons at workplaces.

A person may have more than one duty (eg a person can be a PCBU and a worker).

More than one person may have the same duty (eg different PCBUs may have the same duty towards the same worker).

> For more information on duty holders and their duties, see the Glossary or WorkSafe's special guide *Introduction to the Health and Safety at Work Act 2015.*

3.2 Duties of all PCBUs

3.2.1 Primary duties

A PCBU must ensure, so far as is reasonably practicable, the health and safety of workers, and that other people are not put at risk by work carried out as part of the conduct of the PCBU. This is called the 'primary duty of care'. Figure 2 below illustrates the people who may be affected by a PCBU's work.

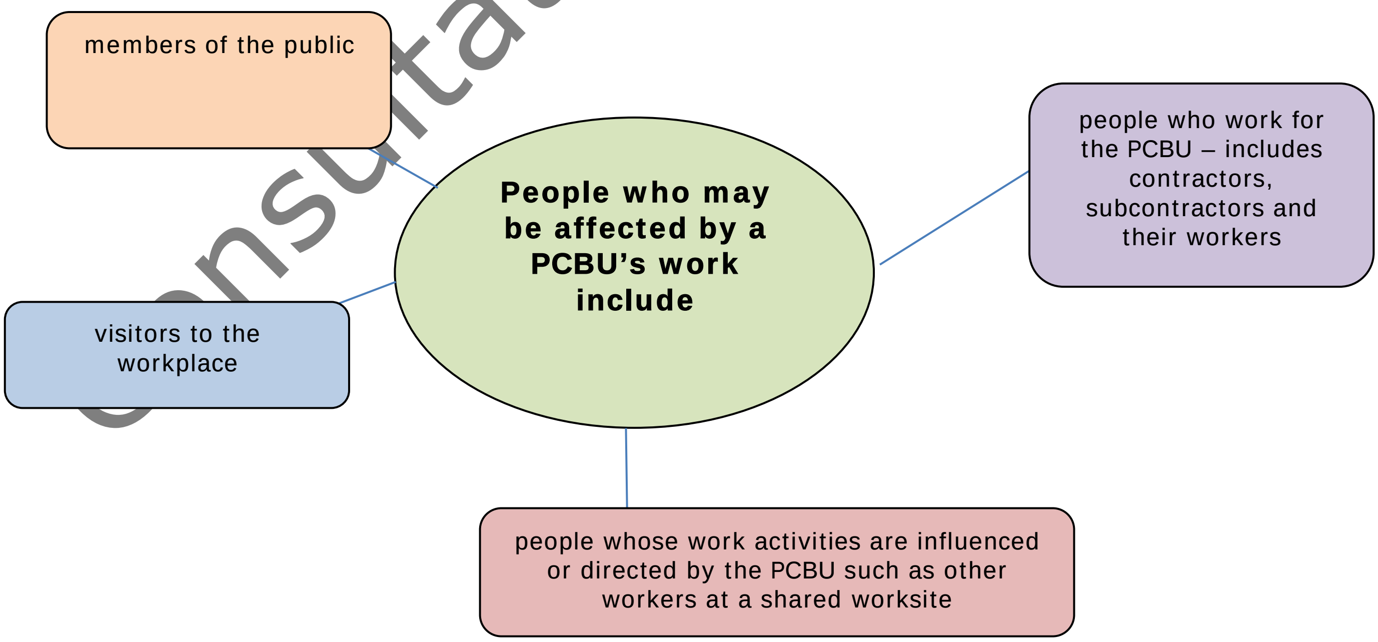


Figure 2: People who may be affected by a PCBU's work

3.2.2 Worker engagement, participation and representation

PCBUs have duties under HSWA to:

- so far as is reasonably practicable, engage with workers on health and safety matters that affect them
- give workers reasonable opportunities to participate in the ongoing improvement of workplace health and safety.

Both duties involve two-way communication about health and safety. Everyone involved must be able to contribute. PCBUs should plan ways to engage and support participation.

For further guidance on worker engagement, participation and representation see WorkSafe's good practice guidelines *Worker Engagement, Participation and Representation*.

3.2.3 Overlapping duties

More than one PCBU can have a duty around the same matter. This might happen in a contracting chain, or when different PCBUs work on the same site. This is known as having 'overlapping duties'.

PCBUs must carry out their overlapping duties to the extent they have the *ability to influence and control the matter*. They must also, so far as is reasonably practicable, consult, co-operate and co-ordinate with each other.

Although PCBUs can't contract out of their health and safety duties, contractual agreements can be one way of setting out health and safety expectations for each PCBU.

Responsibility to consult, co-operate and co-ordinate with the designer also applies to contractors and sub-contractors who win a tender.

For more information, see WorkSafe's quick guide *Overlapping Duties.*

3.2.4 Eliminating and minimising risk

Risks to health and safety arise from people being exposed to hazards (anything that can cause harm). Managing risks involves identifying and then assessing risk to determine which work risks to deal with first, and how the risks should be dealt with.

PCBUs must eliminate health and safety risks arising from work so far as is reasonably practicable. If it's not practicable to eliminate, they must minimise risks, so far as is reasonably practicable. This applies for matters that are within their ability to influence or control.

More information on how designers can carry out risk assessments and eliminate/minimise risks can be found in section 4 of these guidelines.

3.3 Additional designer PCBU duties

There are further duties for PCBUs who are designers, manufacturers, suppliers, importers and installers (so called upstream PCBUs). Table 1 below provides an overview of these duties for designers.

Duties of designer PCBUs	
Duty to, so far as is reasonably practicable, make sure that structures, plant and substances are without health and safety risk	Make sure, so far as is reasonably practicable, the plant, substance or structure designed is without health and safety risks to people who: ➢ use the plant, substance or structure at a workplace for its designed purpose ➢ handle the substance at a workplace ➢ store the plant or substance at a workplace

	➢ construct the structure at a workplace ➢ carry out reasonably foreseeable workplace activities (such as inspection, cleaning, maintenance or repair) in relation to: • the manufacture, assembly or use of the plant, substance or structure for its designed or manufactured purpose • the proper storage, handling, decommissioning, dismantling or disposal of the plant, substance or structure ➢ are at or near a workplace, and are exposed to the plant, substance or structure, or whose health and safety may be affected by a work activity listed above.
Duty to test	Carry out calculations, analyses, tests or examinations needed to make sure the structure, plant or substance designed is without health and safety risks so far as is reasonably practicable (or arrange the carrying out of such tests).
Duty to provide information	Provide adequate information to people who are provided with the design of the plant, structure or substance. This includes information about: ➢ each purpose for which the plant, substance or structure was designed ➢ the results of any calculations, analyses, tests or examinations carried out to make sure the plant, substance or structure is without health and safety risks (in relation to a substance, this includes any hazardous properties of the substance identified by testing) ➢ any conditions necessary to make sure the plant, substance or structure is without health and safety risks (when used for its designed purpose, or when being handled, stored, constructed, or other foreseeable activities (such as inspection, cleaning, maintenance, or repair in relation to: • the manufacture, assembly or use of the plant, substance or structure for its designed or manufactured purpose • the proper storage, handling, decommissioning, dismantling or disposal of the plant, substance or structure On request, make reasonable efforts to give the current relevant specified information on the purpose, results of calculations, analysis, testing and examination, conditions necessary to make sure it is without risk to a person who carries out or is to carry out work activities listed above with the plant, structure or substance.

Table 1 – Duties of Designer PCBUs (based on the requirements in sections 39-43 of HSWA)

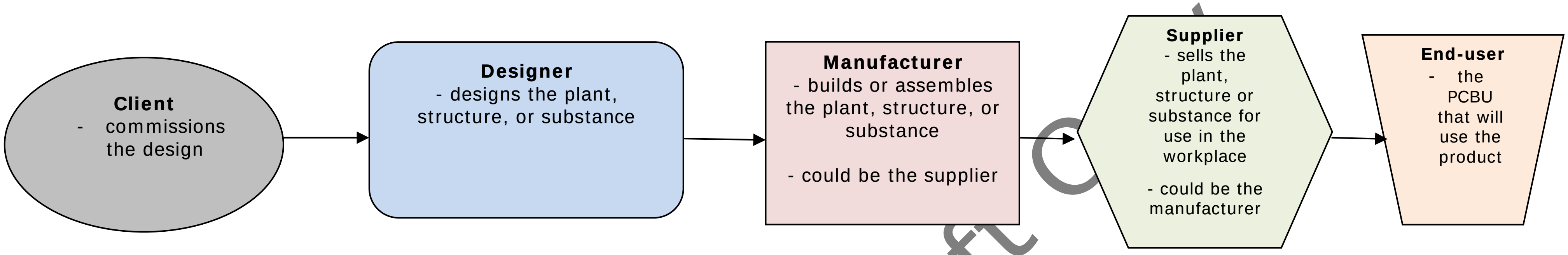
For further guidance on HSWA, see WorkSafe’s special guide *Introduction to the Health and Safety at Work Act 2015.*

For information on what ‘reasonably practicable’ means, see WorkSafe’s fact sheet *Reasonably Practicable.*

3.4 Roles and responsibilities in the supply chain

Throughout the design process of a structure, plant or substance, different people contribute ideas, solutions and knowledge to help eliminate or minimise health and safety risks. PCBUs involved in the design process must consult, co-operate and co-ordinate with each other, so far as is reasonably practicable. In general the more influence and control a PCBU has over a health and safety matter, the more responsibility it is likely to have.

Figure 3 describes the roles of designers, the manufacturer of the design, the supplier of the manufactured product and the end-user.



Consults, co-operates and coordinates with the designer, so far as is reasonably practicable.	Consults, co-operates and coordinates with the manufacturer of their design, so far as is reasonably practicable. Provides information to the manufacturer about the purpose of the plant, structure or substance, the results of any calculations, testing etc to make sure it is without risks, and any conditions necessary to make sure it is without risks (when used for its designed purpose or when being inspected, cleaned maintained or repaired). On request, provides information as described above to those who will manufacture or supply the structure, plant or substance.	Consults, co-operates and coordinates with the designer, so far as is reasonably practicable. Health and safety risks they identify are referred back to the designer for review. On request, provides information as described above to those who sell or use the plant, structure or substance in the workplace.	On request, provides information as described in Table 1 to those who use the plant, structure or substance in the workplace. Should tell manufacturer of any faults they become aware of that may create health and safety risks.	Should tell supplier of any faults that may create health and safety risks. Can ask the supplier or manufacturer (may be the same PCBU) for information on a structure, plant or substance.

Figure 3: Roles in the supply chain

04 / ELEMENTS OF HEALTH AND SAFETY BY DESIGN

4.1 Key principles of Health and Safety by Design

As shown in Figure 4, there are five key principles that make up Health and Safety by Design. They are discussed in more detail below.

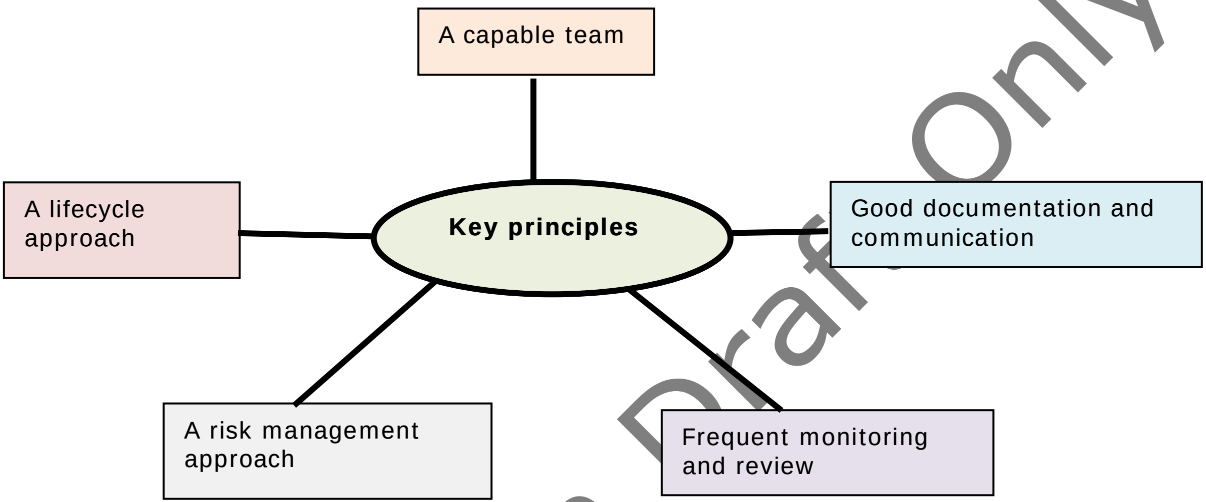


Figure 4: Key principles

A capable team

Combining great design and risk management can be achieved with a capable team of people. Consultation, coordination and cooperation are essential, particularly between the client and the designer. Teams need strong leadership, technical knowledge, and an understanding of the workplace that products will be used in including how they will be used. A capable team should be made up of people with a variety of different skills and knowledge, and should include workers who will use the structure, plant or substance.

Figure 5 shows what people a capable team could include.

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Figure 5: Potential team members

Teams could include:

- an effective facilitator who has experience in Health and Safety by Design
- workers
- managers
- designers
- supply chain stakeholders
- health and safety advisors
- technical experts
- builders
- owners
- insurers
- project managers
- installers
- maintenance staff
- human resources staff
- information technology designers and systems engineers
- those responsible for designing shift rosters, organisational structures, computer systems and work layout and configuration.

People who have responsibility for designing work processes and systems have a key role in Health and Safety by Design. This includes a wide range of workplace health and safety staff such as:

- generalist health and safety practitioners
- occupational hygienists
- hazardous substances professionals
- safety, risk and reliability engineers
- occupational health physicians and nurses
- human factors professionals/ergonomists.

For further information on competency in Health and Safety by Design, see HSE's Competency Guide:

http://www.hse.gov.uk/construction/areyou/designer.htm

A lifecycle approach

When a designer is considering work health and safety risks, they should look at the different stages of that product's lifecycle. At every stage there are opportunities to eliminate or minimise risk. Choosing the healthiest and safest option should be the initial consideration when selecting which solution or technology to apply, even before entering the design process.

Health and Safety by Design is most effective when applied at the earliest stage and continued throughout the lifecycle of the structure, plant or substance. Health and Safety by Design includes considering all costs associated with the project at this stages, along with the benefits gained.

Figure 6 shows the different lifecycle stages of a structure, plant or substance.

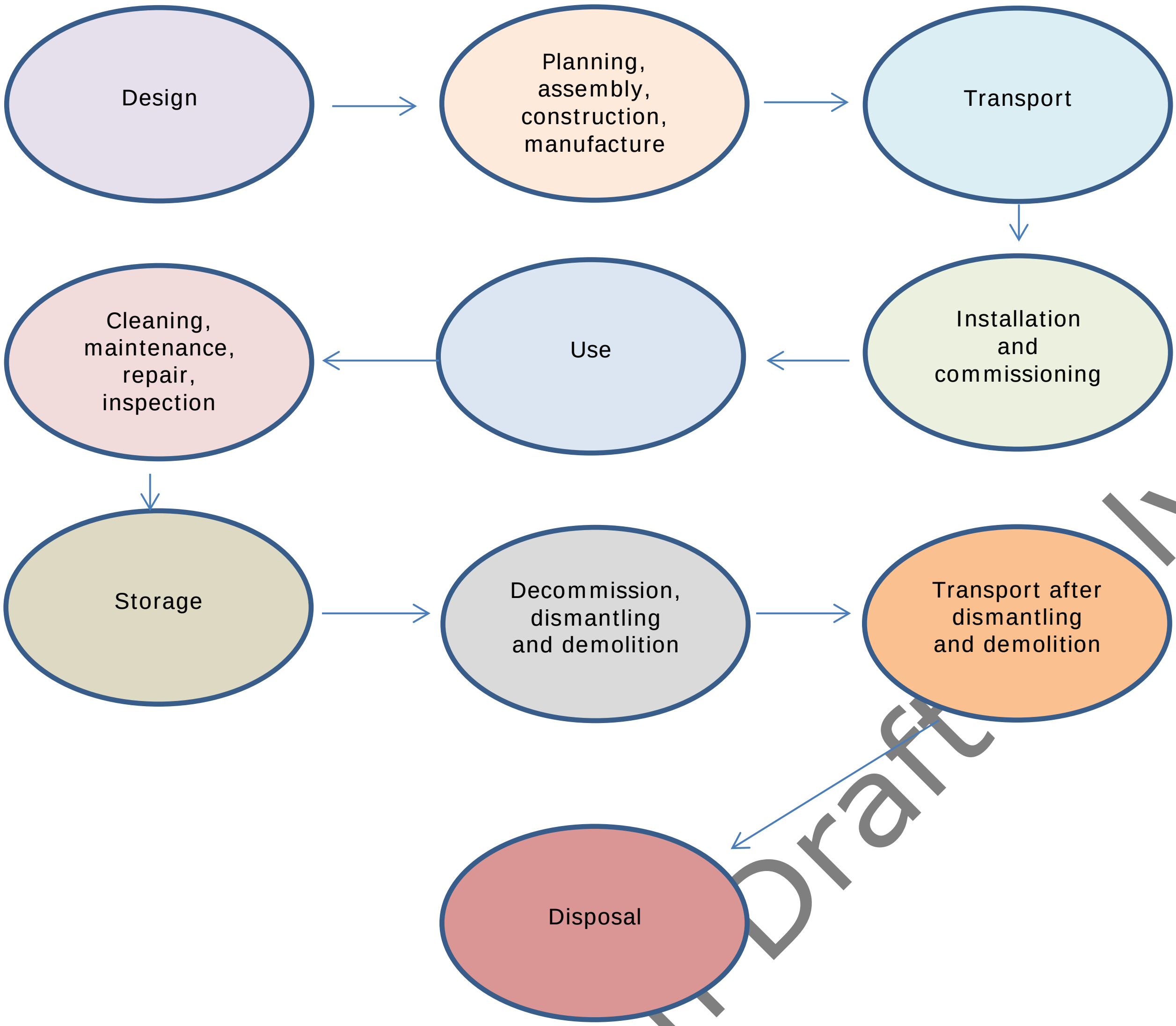

Figure 6: Life cycle

A risk management approach

Risks to health and safety arise from people being exposed to hazards (anything that can cause harm).

Designers must eliminate health and safety risks arising from work so far as is reasonably practicable. If it's not practicable to eliminate, they must minimise risks, so far as is reasonably practicable.

Designers should take a systematic approach when identifying and eliminating/minimising work risks that are within their ability to influence or control. Figure 7 outlines an approach that can be taken.

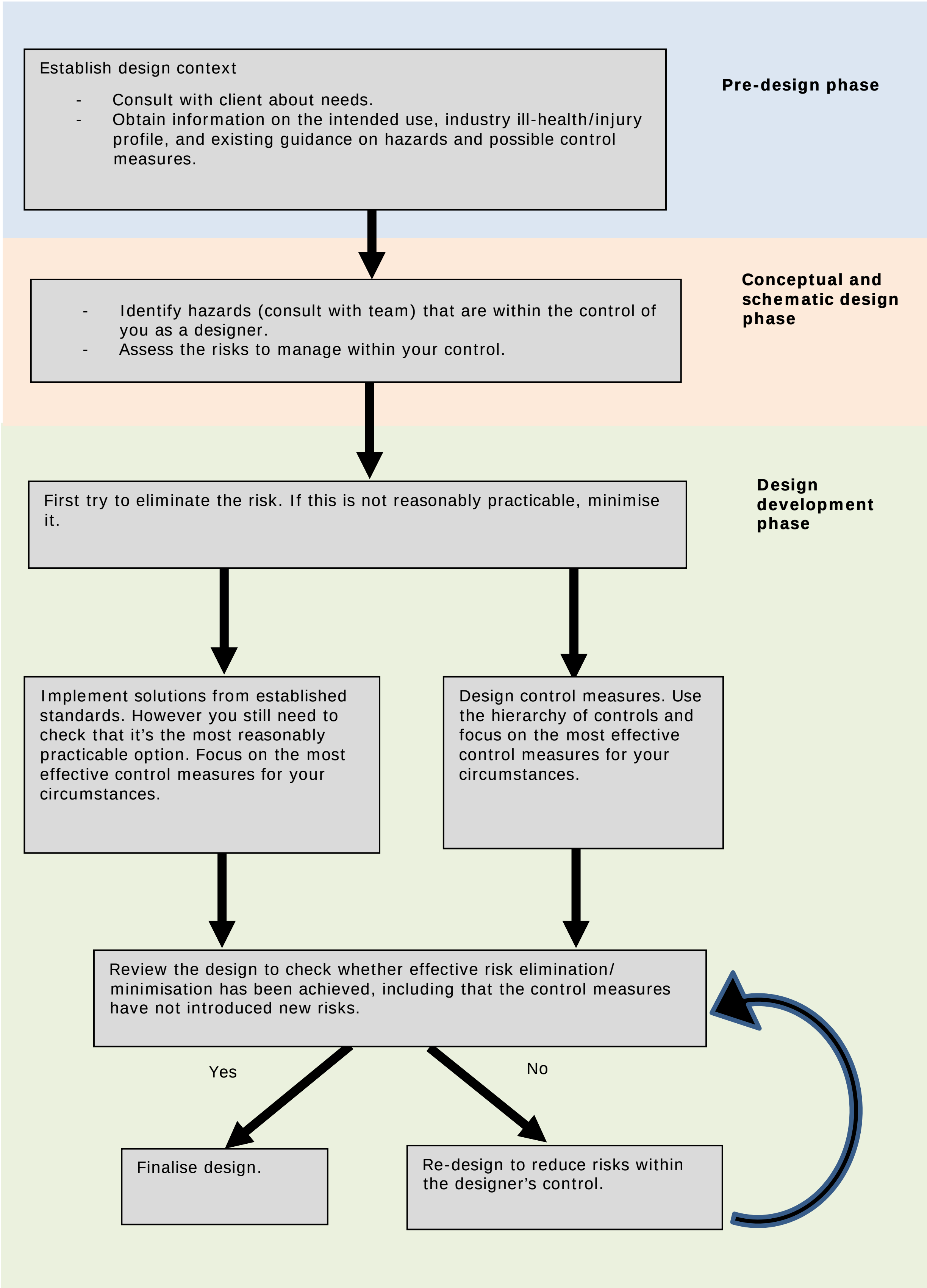

Figure 7: A risk management approach

Wherever possible, design safety reviews should involve the people who will eventually construct or manufacture the structure, plant or substance. If this is not possible, the client and designer should include people with knowledge and experience in the construction and maintenance processes in the design safety reviews. Their expertise will help with identifying health and safety issues which may have been overlooked in the design.

Designers can use the hierarchy of controls (Figure 8) to help them work out the most effective control measures, so far as is reasonably practicable. Table 2 describes the types of control measures.

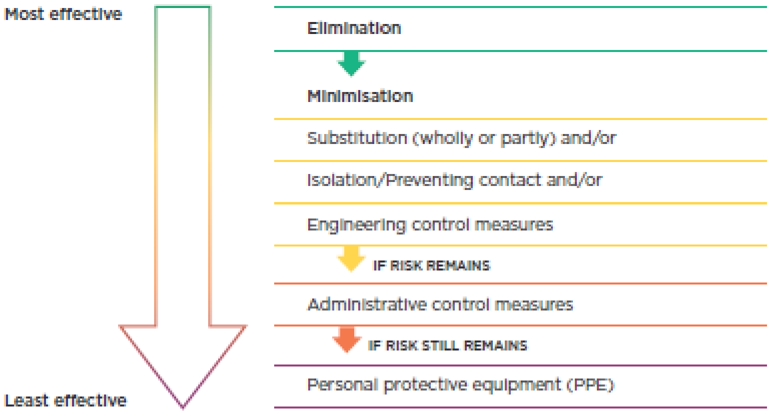

Figure 8: Hierarchy of controls

	ACTION	WHAT IS THIS?	EXAMPLE
Eliminating		Removing the sources of harm (eg equipment, substances or work processes).	Removing a trip risk or getting faulty equipment repaired. Prefabrication of components to eliminate cutting (to eliminate risks from airborne contaminants, vibrations and noise). Using non-toxic glue instead of a toxic glue. Using water-based paint instead of solvent-based paint.
Minimising	**Substituting**	Substituting (wholly or partly) the hazard giving rise to the risk with something that gives rise to a lesser risk (eg using a less hazardous thing, substance or work practice).	Buying quiet plant, equipment and vehicles. Using methods that produce less vibration (eg using a cut off saw instead of an angle grinder).
	Isolating/ preventing contact	Isolating the hazard giving rise to the risk to prevent any person coming into contact with it (eg by separating people from the hazard/preventing people being exposed to it). Isolation focuses on boxing in the hazard or boxing in people to keep them away from the hazard.	Fitting screens or putting up safety barriers around the hazard for example: – welding screens to isolate welding operations from other workers – barriers and/or boundary lines to separate areas where forklifts operate near pedestrians. Using fully automated processes, for example: – an automated arm to remove objects from degreasing baths – fully automated spray booths that don't require anyone to enter.
	Using engineering control measures	Using physical control measures including mechanical devices or processes.	Modifying tools or equipment, or fitting guards to machinery. Using extraction ventilation to remove harmful substances.
Minimising	**Using administrative control measures**	Using safe methods of work, processes or procedures designed to minimise risk. It does not include an engineering control measure, or the wearing or use of personal protective equipment.	Requiring all people to walk only within the painted pedestrian zones when on the factory floor. Having emergency plans and evacuation procedures in place. Having exclusion zones so workers don't unnecessarily go near noisy or dangerous equipment or tasks.
	Using personal protective equipment (PPE)	Using safety equipment to protect against harm. PPE acts by reducing exposure to, or contact with, the hazard.	Using safety glasses, overalls, gloves, helmets, respiratory gear and ear muffs associated with jobs such as handling chemicals or working in a noisy environment. PPE is the least effective type of control and should not be the first or only control measure considered.

Table 2: Types of control measures

When considering control measures, designers should think about the capability of the workers who will use the structure, plant or substance. They should give preference to control measures that protect multiple people at once.

The hazards that designers of structures, plant and substances may encounter and possible control measures are discussed in sections five, six and seven of these guidelines.

For more general advice on managing risks, see WorkSafe's quick guide *Identifying, assessing and managing work risks*.

Good documentation and communication

Health and safety aspects of the design should be reflected in the requirements of contract documents for the construction/manufacture stage and help with the selection of suitable and competent contractors for the project.

Designers must provide adequate information to people who will be using the design. Information about identified health and safety risks, how they were assessed during the design process, and the control measures determined should be documented, and applicable standards and decision pathways recorded throughout the design process.

Providing this information to others involved later in the lifecycle is necessary to make them aware of any leftover risks and methods used to minimise risk. This includes training needed at any stage of the structure, plant or substance's lifecycle.

Points for designers to consider when providing information include:

- making notes on drawings, as these will be immediately available to construction workers
- providing information on significant hazards, hazardous substances or flammable materials
- heavy or awkward prefabricated elements likely to create handling risks
- features that create access problems
- temporary work required to construct or renovate the building as designed
- features of the design essential to safe operation
- methods of access where normal methods of securing scaffold are not available
- any parts of the design where risks have been minimised but not eliminated
- noise and vibration hazards from plant.

Frequent monitoring and review

On-going monitoring and review throughout the lifecycle improves outcomes and allows for changes to be made if unexpected risks arise. It also confirms whether the Health and Safety by Design intent is being achieved.

When construction/manufacture is complete, the effectiveness of safety in design should be evaluated. This will help designers to identify good practice, and any new design ideas that could be used on other projects. The review may be carried out in a post-construction/manufacture workshop attended by all relevant parties involved in the project.

05 / SPECIFIC CONSIDERATIONS WHEN DESIGNING STRUCTURES

5.1 Designing structures

This section provides information to designers of structures. Figure 9 below illustrates who these people could be:

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PCBUs who design and work with structures could be:

- architects
- building designers
- engineers
- clients
- developers
- builders.

Figure 9: PCBUs who are designers of structures

For the purposes of these guidelines, 'structures' means anything that is constructed, whether fixed or moveable, temporary or permanent, and includes:

- buildings, masts, towers, framework, pipelines, bridges, rail infrastructure and underground works (shafts or tunnels)
- any component or part of a structure.

Design includes:

- the design of all or part of the structure
- the alteration of a design.

Design output includes:

- drawings in any form
- design detail
- design instruction
- scope of works documents relating to the structure.

5.2 Systematic steps for designing structures

Designing structures is a process with a series of steps. These are separated into three distinct phases, which are explained in more detail below:

- **Pre-design phase**
- **Conceptual and schematic design phase**
- **Design development phase**

Once risks have been identified, designers need to work out how they will manage them to eliminate or minimise harm.

For more information on how to eliminate or minimise risk, see Figure 8 (hierarchy of controls) in section 4 of these guidelines.

Pre-design phase

Figure 10 illustrates what is involved in the pre-design phase, starting with identifying the purpose of the structure:

Figure 10: The pre-design phase

Consultation

The client should prepare a project brief that includes the safety requirements and objectives for the project. This will create a shared understanding of safety expectations between the client and designer.

The client should give the designer all available information relating to the site that may affect health and safety.

Designers should ask their clients about the types of activities likely or intended to be carried out in the structure, including the tasks of those who maintain, repair, service or clean the structure as part of its use.

Research

Information can be found from various sources to help with identifying hazards and assessing and controlling risks, including:

- HSWA and building laws, technical standards and WorkSafe or industry guidance
- industry statistics regarding injuries and incidents
- hazard alerts or other reports from: relevant statutory authorities, unions and employer associations, specialists, professional bodies representing designers, and engineers' research and testing done on similar designs.

Table 3 below illustrates some possible information sources for identifying hazards.

Step	Possible techniques
Initial discussions	Get information on the: • purpose of the structure, including plant, ancillary equipment and tasks • industry injury profile and statistics and common hazards and safety issues • guidance from health and safety authorities and relevant industry associations, and standards • known hazards and the consultation arrangements between the client and designer.
Pre-design preliminary hazard analysis	Useful techniques may include the client doing a combination of these things: • holding workshops and discussions with people using or working on similar structures within the client company, including health and safety representatives • holding an onsite assessment of an existing similar structure with feedback from its users • researching information on similar structures, their associated hazards and relevant sources and stakeholder groups, then completing an analysis for their own design needs • holding workshops with experienced people who will construct, use and maintain the new structure • holding workshops with specialist consultants and experts in the hazards.
Determine what hazards are 'in-scope'	Workshops/discussions to determine which hazards are affected, introduced or increased by the design of the structure.

Table 3: Information sources for identifying hazards

<u>Conceptual and schematic design phase</u>

Hazard identification should take place as early as possible in this phase. It is important that the hazard identification is systematic and not limited to one or two people's experiences of situations.

Broad groupings of hazards should be identified before design scoping begins. (Appendix C of these guidelines provides a checklist of issues that should be considered). The designer and others involved should then decide which hazards are 'in scope' of the steps of the risk management process, and should be considered in the design process. A hazard is 'in scope' if it can be affected, introduced or increased by the design of the structure.

A system of work may also be classed as a hazard if it is part of the construction method or intended use of the structure. The nature of the structure should also be taken into account.

Potential hazards relating to structures are illustrated in Table 4 below:

Site of structure	Potential design issues that may cause health and safety risks are: • how close the structure is to nearby properties or roads • what the surrounding land is used for • special clearances needed for construction equipment • existing structures that may need to be demolished • nearby underground or overhead services • nearby traffic flow • condition of the work site

	• safety of the public near the work site.
High risk hazards	• the storage, handling or work with high energy and health hazards.
Systems of work	Systems of work that could pose health and safety risks are: • rapid construction techniques such as prefabrication • dangerous materials that are used in construction • other work in the area • vehicles and equipment used where there are pedestrians • restricted access for building and plant maintenance • manual tasks that could cause injuries and health problems • exposure to violence • technical and human factors, including how the structure could be misused.
Environmental conditions	• adverse natural events such as cyclones, earthquakes and floods • poor ventilation or lighting • high noise levels • poor welfare facilities.

Table 4 – Framework for the preliminary hazard identification

Design development phase

In this phase, the designer coverts concepts for the structure into detailed drawings and technical specifications. They decide on control measures and prepare construction documentation. At that stage, the design is complete and can be handed to the client.

Figure 11 illustrates what this phase involves:

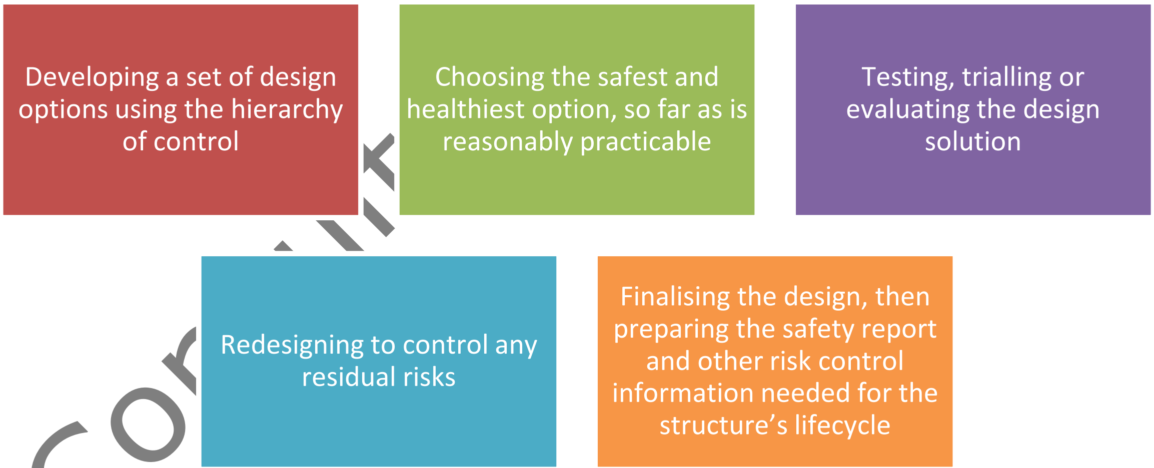

Figure 11: The design development phase

Control measures for common hazards may be chosen from known solutions. For new or complex hazards, a risk assessment may help to figure out what are the most effective control measures.

Implement solutions from recognised standards

Laws that cover the design of buildings and structures in New Zealand include the building laws in each region. There are also technical and engineering guidelines/standards produced by government agencies, Standards New Zealand and other relevant professional bodies.

The main focus is to make sure that structures meet acceptable standards for structural soundness, safety, health and amenity.

The design should include technical provisions for:

- structural soundness
- fire spread within and between buildings
- building occupant entry and exit
- fire-fighting equipment
- smoke hazard management and
- fire brigade access to buildings.

Health and safety amenity aspects such as ventilation, lighting, *Legionella* controls, sanitary facilities and damp and weatherproofing measures should also be covered.

For information about preventing Legionnaires' disease see WorkSafe's fact sheet *Preventing Legionnaires' disease from cooling towers and evaporative condensers*

Assessing risk

A risk assessment looks at what could happen if someone is exposed to a hazard, and how likely this is to happen. The more serious the risk of harm, the more time and effort should be dedicated to eliminating or minimising the risk. It is important that those involved in a risk assessment have the information, knowledge and experience of the work environment to make informed decisions.

If similar tasks or processes apply for a number of projects, a general risk assessment model may be appropriate.

Risk assessment methods for assessing design safety may include:

- fact finding to determine if there any existing controls
- testing design assumptions to make sure that no aspect of it is based on incorrect beliefs or anticipations on the part of the designer
- testing of structures or components specified for use in the construction, end use and maintenance
- talking with key people who have the knowledge to control or influence the design (such as the architect, client, construction manager, engineers, project managers, and health and safety representatives)
- talking with key people who have the knowledge to identify and assess risks
- talking directly with other experts, (such as specialist engineers, manufacturers and product or systems designers) who have been involved with similar constructions
- when designing for the renovation or demolition of existing buildings, reviewing previous design documentation or information recorded about the design structure and any alterations to address safety concerns
- talking with professional industry or employee associations who could help with risk assessments for the type of work and workplace.

When thinking about which control measures to implement:

- look specifically at risks that a capable builder or user would not be expected to be aware of
- look at where leftover risks remain, and make sure the builder and other relevant stakeholders are aware of these
- look at the interaction of hazards in the assessment of their risks and implementation of control measures
- assess alternative control measures for their suitability.

Table 5 below outlines the design process.

Step	Possible techniques	By whom
Identify solutions from regulations, codes of practice and recognised standards	Talk with all relevant people to figure out which hazards can be addressed with recognised standards. Plan the risk management process for other hazards.	Designer led. Client approval of decisions.
Apply risk management techniques	Further detailed information may be needed on hazards, for example by: • using checklists and referring to codes of practice and guidance material • job/task analysis techniques. A variety of risk assessment measures can be used to check the effectiveness of control measures. These may be qualitative or quantitative. Scale models and talking with experienced industry members may be necessary to come up with solutions to longstanding safety issues.	Designer led. Client provides further information as agreed in the planned risk management process.
Discuss design options	Take into account how design decisions influence risks when discussing control options.	Designer led. Client contributing.
Design finalisation	Check that the evaluation of design risk control measures is complete and accurate. Prepare information about risks to health and safety for the structure that remain after the design process.	Designer led. Client and designer agree with final result.
Potential changes in construction stage	Make sure that changes which affect design do not increase risks.	Construction team in consultation with designer and client.

Table 5: The design process

Design Considerations

There are different design options to eliminate or minimise risks throughout a structure's lifecycle. Figure 12 illustrates these, and examples are given below.

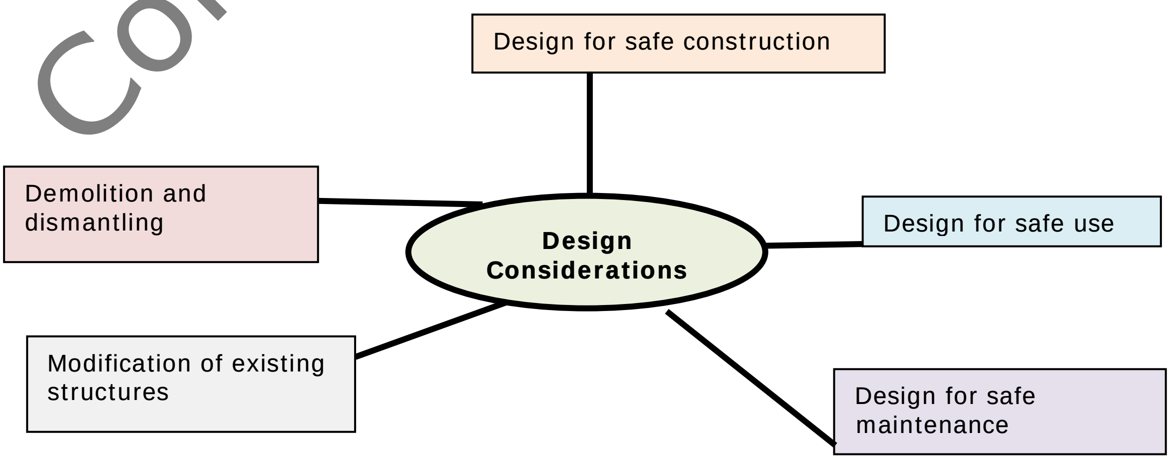

Figure 12: Design considerations for structures

Design for safe construction

Control measures relating to the construction of a structure may include:

- providing enough clearance between the structure and overhead electric lines by burying, disconnecting or re-routing cables before construction begins
- designing components that can be made off-site or on the ground - this reduces worker exposure to falls from heights or being struck by falling objects
- designing parapets to a height that complies with guardrail requirements - this eliminates the need to construct guardrails during construction
- using continual support beams for beam-to-column double connections. This will provide continual support for beams during erection, to reduce the risk of falls due to unexpected vibration, unexpected construction loads and misalignment.
- designing and constructing permanent stairways to help prevent falls and other hazards associated with temporary stairs and scaffolding
- reducing the space between roof trusses and battens to reduce the risk of internal falls during roof construction
- choosing construction materials that are safe to handle
- designing in aids for lifting during construction (eg provision of lifting lugs to roof-top air conditioning plants)
- limiting the size of pre-made wall panels where site access is restricted
- selecting paints or other finishes that emit low levels of dangerous vapours
- indicating, where practicable, the position and height of all electric lines to help with site safety procedures.

Design for safe use

Risks relating to a structure's use can be eliminated or minimised by:

- designing traffic areas to separate vehicles and pedestrians
- using non-slip materials on floor surfaces in areas exposed to the weather or dedicated wet areas
- providing enough space within the structure to safely install, operate and maintain plant
- providing enough lighting for intended tasks in the structure
- designing spaces in which workers can use mechanical plant or tools to reduce manual task risks
- designing access to structures that will serve a specific purpose, such as wide corridors for wheelchairs in hospitals
- designing effective noise barriers and acoustical treatments to walls and ceilings
- designing the structure to isolate noisy plant
- designing floor loadings to accommodate heavy machinery that may be used in the structure
- clearly indicating on documents design loads for the different parts of the structure.

Design for safe maintenance

Risks relating to cleaning, servicing and maintaining a structure can be eliminated or minimised by:

- designing the structure so that maintenance can be performed at ground level or safely from the structure. For example, positioning air-conditioning units and lift plant at ground level, designing inward opening windows, and integrating window cleaning bays or gangways into the structural frame.
- designing features to avoid dirt or moisture traps
- designing and positioning permanent anchorage and hoisting points into structures where maintenance needs to be completed at height

- designing safe access (such as fixed ladders) and enough space to complete structure maintenance activities
- eliminating or minimising the need for entry into confined spaces
- using long-life components such as LED lighting that don't require frequent replacement
- using durable materials that do not need to be re-coated or treated.

Modification of existing structures

Design can involve the alteration of an existing structure. Modification may mean partial or full demolition. At this stage, designers should consult with key stakeholders to eliminate or minimise risks, and follow the key principles of Health and Safety by Design.

Demolition and dismantling

A structure should be designed so it can be demolished using existing techniques. The designer should provide information so that potential demolishers can understand the structure, load paths and any features incorporated to help with demolition. They should also provide information on any features that require unusual demolition techniques or sequencing.

Designers of new structures should design-in facilities such as lifting lugs on beams, or columns and protecting inserts in pre-cast panels, so they can be used for disassembly. Materials and finishes specified for the original structure may require special attention at the time of demolition, and any special requirements for the disposal and/or recycling of those materials or finishes should be advised through the risk assessment documentation.

5.3 Reviewing control measures

Wherever possible, design safety reviews should involve the people who will eventually construct the structure. If this is not possible, the client and designer should include people with knowledge and experience in the construction and maintenance processes in the design safety reviews. Their expertise will assist in identifying safety issues which may have been overlooked in the design.

On completion of construction, the effectiveness of health and safety in design should be evaluated. This will help the designer to identify the most effective design practices and any design innovations that could be used on other projects. Feedback from users to help designers in improving their future designs for structures may be provided through:

- post-occupancy evaluations for buildings
- defect reports
- accident investigation reports
- information regarding modifications
- user difficulties
- changes from intended conditions of use.

Section 4 of these guidelines outlines some ways that designers can review control measures to make sure that risks are being effectively eliminated or minimised.

06 / SPECIFIC CONSIDERATIONS WHEN DESIGNING PLANT

6.1 Designing plant

This section provides information to designers of plant to be used in a workplace. Plant includes:

- machinery
- equipment
- appliances
- containers
- implements
- tools and components.

Examples of plant are illustrated in Figure 13 below.

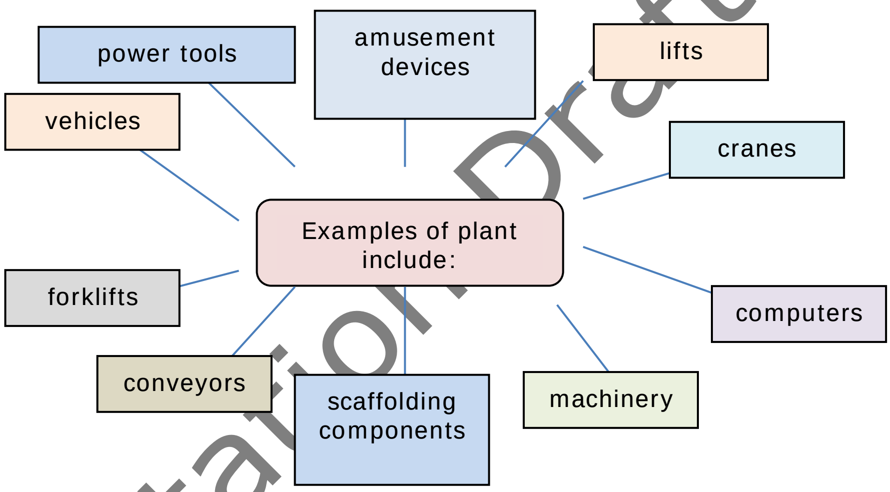

Figure 13: Examples of plant

This section also applies to the design of structures where items of plant are designed as a structural component or are assembled to form a structure.

6.2 Systematic steps for designing plant

Designing structures is a process with a series of steps. These are separated into two distinct phases, which are explained in more detail below:

- **Pre-design and concept development phase**
- **Design development phase**

Once risks have been identified, designers need to work out how they will manage them to eliminate or minimise the risks.

<u>Pre-design and concept development phase</u>

This phase involves:

- deciding on the intended use of the plant, its functions and limitations

- identifying the roles and responsibilities for the project
- establishing co-operative relationships with clients, manufacturers and users of the plant, including those who maintain and repair the plant and
- researching and consulting to help with identifying hazards, and assessing and controlling risks.

Intended use of plant

Designers can decide on the intended use of the plant, including its functions and limitations, by looking at:

- the expected place of use
- intended functions and operating modes
- safe use requirements, including reasonably foreseeable misuse
- planned service life
- relevant standards and specifications
- possible malfunctions and faults
- testing, maintenance and repair requirements
- the people interacting with the plant, and
- other products interacting with or related to the plant.

Identifying the hazards

The first step in the risk management process is to identify all hazards, so far as is reasonably practicable. Hazard identification should be done as early as possible in the concept development and design phases. Hazards relating to plant are often caused by the plant itself, and how and where the plant is used.

Hazards may be identified by looking at the workplace and how work is carried out. Designers could talk to workers, manufacturers, importers, suppliers and health and safety specialists, and review relevant information, records and incident reports.

Table 6 lists things to consider when looking for plant hazards.

Table 7 shows examples of potential plant hazards and phases of the plant lifecycle after the design has been completed where people might be exposed to plant hazards.

Things to consider to identify plant hazards	
Hazards	• Can the plant cause injury from entanglement, crushing, trapping, cutting, stabbing, puncturing, shearing, abrasion, tearing or stretching? • Can the plant create hazardous conditions from pressurised content, electricity, noise, radiation, friction, vibration, fire, explosion, temperature, moisture, vapour, gases, dust, ice, or hot or cold parts? • Can the plant cause injury from lack of guarding of moving parts? • Can the plant cause injury as a result of unexpected start-up? • Can the plant cause injury or ill health from poor ergonomic design?
Suitability	• Is the plant fit for its intended purpose? What is likely to happen if it is used for a purpose other than the intended purpose? • Are the materials used to make the plant suitable? • Are plant accessories fit for their intended purpose? • Is the plant stable? Could it roll over?

Things to consider to identify plant hazards	
	• If the plant is intended to lift and move people, equipment or materials, is it capable of doing this?
Access	• Is access to the plant necessary when installing, using and maintaining the plant or in an emergency? • Can workers access the plant safely without being injured by the plant or the risk of slips, trips and falls (eg by a walkway, gantry, elevated work platform or fixed ladder), or having to enter a dangerous environment to access plant?
Location	• Does the plant affect the safety of the area where it will be located? • Does the location affect the safety of the plant (eg environmental conditions, terrain and work area)? • Will there be people or other plant nearby? What effect would this have?
Systems of work	• Do the systems of work for the plant create hazards? • Does the plant's safety depend on the competency of its users? • Will users and others working near the plant need relevant training, information, instruction and supervision needed to make sure they are safe?
Unusual situations	• What unusual situations or misuse could occur? • What would happen if the plant failed? Would it result in loss of contents, loss of load, unintended ejection of work pieces, explosion, fragmentation or collapse of parts? • Is it possible for the plant to move or be operated accidently?

Table 6: Things to consider to identify plant hazards

Potential hazards	Phases of the plant lifecycle
• mechanical (eg crushing, cutting, trapping, shearing and high pressure fluids) • electrical • thermal • noise • vibration • radiation • hazardous chemicals • slipping, tripping and falling • manual handling • confined spaces • environmental conditions • hazards resulting from a combination of the above.	• manufacture • storage • packing and transportation • unloading and unpacking • assembly • installing • commissioning • using • cleaning and adjustment • inspection • planned and unplanned maintenance or repair • decommissioning • dismantling • disposal and recycling.

Table 7: Examples of plant hazards and phases of the plant lifecycle

6.3 Design phase

Figure 14 illustrates what is involved in this phase:

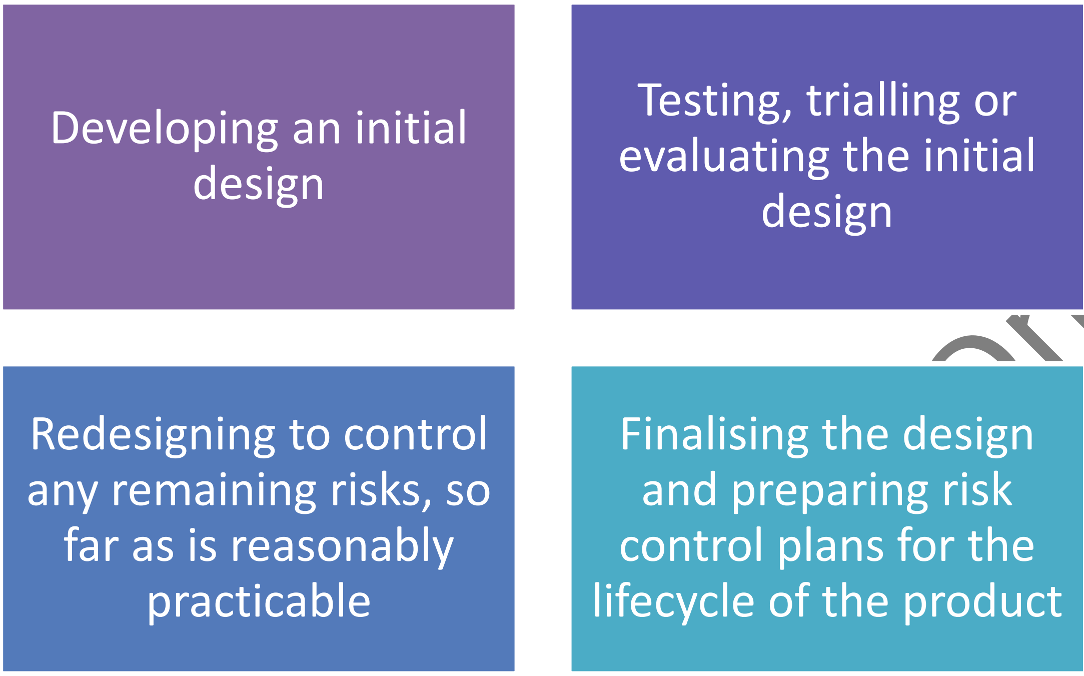

Figure 14: The design phase

Control measures for common hazards may be chosen from known solutions. For new or complex hazards, a risk assessment may help to figure out what are the most effective control measures.

Technical standards

A plant designer may use technical standards, or a combination of standards and engineering principles relevant to the design requirements (as long as the design meets regulatory requirements). Engineering principles could include mathematical or scientific procedures outlined in an engineering reference or standard.

Testing and examining plant

The designer should carry out any analysis, testing or examination that may be necessary to make sure the plant is without health and safety risks (so far as is reasonably practicable).

Testing may include developing a prototype to:

- simulate the normal range of operational capabilities
- test design features to ensure 'fail safe' operation
- measure imposed stresses on critical components to make sure maximum design stresses are not exceeded
- test critical safety features under both normal and adverse operational conditions and
- develop overload testing procedures to ensure plant safety when plant is misused.

Records of tests and examinations must be kept by the designer.

For more information on duties for designers, see section 3.3 of these guidelines.

Design Considerations

There are several different factors to think about when looking to identify and manage risks throughout plant’s lifecycle. Figure 15 illustrates some of these, and they are explained in further detail below.

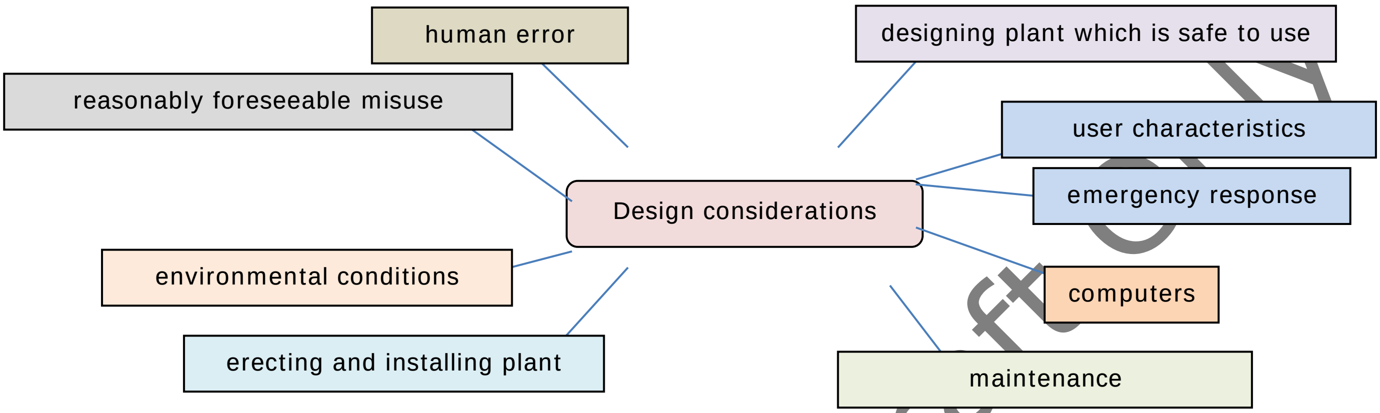

Figure 15: Plant design considerations

Designing plant which is safe to use

A designer should consider:

- the required skill levels to use or maintain the plant
- the complexity of functions a user can be expected to perform
- the need for and the location of items such as aids, guides, indicators, guards, mounted instruction, signs, symbols and name plates to make sure the plant is used correctly
- making sure plant design is ‘fail-safe’ to the category, performance and safety level determined by the plant risk assessment
- the layout of work stations
- instrumentation needed at each work station or cabin and the layout of the instrumentation
- devices, tools or controls the user and support people need to carry out their jobs safely
- the options available to maintain the safety and integrity of the system if the user makes a mistake, or if the plant fails
- whether the user of the plant is accessible if they need help
- environmental conditions that may weaken user performance
- separating people, including the user, from entrapment when using plant.

Designers should also consider predictable human behaviour. Where user error is likely, higher order control measures should be incorporated into the design.

Example: for power operated plant with a seat belt, there may be a risk that operators regularly getting on and off the plant may not wear the seatbelts. If the plant is designed so a seat belt in-use sensing system and the engine are interlocked, then the operator will need to use the seat belt.

User characteristics

When designing plant, designers should consider the range of physical and intellectual characteristics of likely users. Things like height, weight, reach and physical ability should be considered. If future user information is available, the designer could tailor the plant design to meet the needs of specific people.

A designer should:

- apply ergonomic design principles so risks to health and safety are eliminated or minimised, so far as is reasonably practicable
- take into account the ability of workers
- consider whether the plant could be misused or how uncontrolled physical movements could impact how the plant operates.

Human error

Human error is not always the result of people being careless. Sometimes workers may want to finish a job quickly or make a task easier. This can lead to workers making poor decisions that can lead to an increase in health and safety risks.

Workers have a responsibility to take reasonable care for their own health and safety and must not negatively affect the health and safety of others. They must comply with any reasonable instruction and co-operate with any reasonable policy or procedure. Workers should not use unsafe practices or deliberately avoid guarding on plant.

Designers should be aware of the factors contributing to human error when designing plant including:

- forgetfulness
- workers' conscientiousness to 'get the job done' or to 'find a better way'
- ability to understand information
- psychological or cultural environment
- habit
- accepted practice
- fatigue and
- level of training.

Reasonably foreseeable misuse

When designing plant, designers should assess the risk of reasonably foreseeable misuse by users, and incorporate appropriate control measures into their design. One way of identifying potential misuse is by reviewing incident reports for similar types of plant.

Environmental conditions that the plant will be used in

A designer should consider the risks created by the physical, environmental and operational conditions that plant could be exposed to during its lifecycle. These conditions may include:

- ice
- water
- wind
- UV rays
- dust
- lightning

- temperature
- positioning of the plant.

A designer can also contribute to minimising the environmental hazards by providing instructions to erectors and installers of plant about positioning of the plant. If a user is physically uncomfortable using the plant this may lead to inattention, carelessness or fatigue, which can cause incidents.

Erecting and installing plant

A designer should, so far as is reasonably practicable, make sure that health and safety risks arising from erecting and installing plant are eliminated or minimised. These risks may include:

- working at dangerous heights, leading to falls
- stretching or bending at an unnatural angle, leading to injuries.

Designers should also consider the stability of plant when it is assembled, erected or installed and whether special supports are required.

Maintenance

A designer's responsibility extends to eliminating or minimising the risks associated with maintaining the plant, so far as is reasonably practicable. Any reasonably foreseeable hazards with future plant maintenance and repair should be identified and designed out.

If the plant needs to be operated during cleaning or maintenance, the designer should design the operator's controls so the plant cannot be operated by anyone other than the person maintaining or cleaning the plant.

Where a worker has to maintain plant, a designer should:

- design places for adjusting, lubricating and maintaining the plant outside danger zones
- incorporate interlocks into the design so the plant cannot be activated while maintenance work is carried out in the danger zones
- design safe entry points, like walkways and guardrails for maintaining and inspecting cooling towers or storage silos
- pass on relevant information to the manufacturer for inclusion in the manufacturer's instructions for maintenance
- design parts of the plant where workers move or stand to eliminate or minimise the risk of slips, trips and falls, and
- design the plant to eliminate or minimise the risk of accidently touching hot, sharp or moving parts.

6.4 Eliminating or minimising risks

There are several specific hazards associated with plant. Designers should consider as many factors as possible to eliminate or minimise the health and safety risks that these hazards present. Table 8 below outlines some common specific plant hazards, and design considerations to eliminate or minimise the risks associated with them.

Hazard (alphabetised)	**Explanation**	**Design considerations**
Confined spaces	Confined spaces pose a health and safety risk to users of plant.	When designing plant that contains a confined space, designer should include: • use of lining materials that are durable,

	For further guidance on confined spaces, see WorkSafe's fact sheet *Confined Spaces.*	require minimal cleaning and do not react with materials contained in the confined space • mechanical parts that provide for safe and easy maintenance • provision for ventilation of the confined space, such as removable panels • large, practical access points to permit the rescue of people who may become trapped in the confined space Where it is not reasonably practicable to eliminate confined spaces from the plant, the designer should make sure that: • they design the space with a safe means of entry and exit • the space does not allow the build-up of hazardous contaminants, or allow dangerous levels of oxygen to occur • risks to the health and safety of people who enter the space are eliminated or minimised, so far as is reasonably practicable.
Control circuit failure	If the control circuit fails, this may pose a health and safety risk to users. For further guidance on circuit controls, see WorkSafe's guidelines *Safe Use of Machinery.*	A control circuit used to control the plant should be designed to the requirements of the category, performance level or safety integrity level determined by a risk assessment. In particular: • the plant should not start unexpectedly • the plant should not be prevented from stopping if such a command has already been given • no moving part of the plant should fall or be ejected • automatic or manual stopping of moving parts should not be impeded • the protection device should remain fully effective or fail to a condition that does not create a risk.
Emergency stops	An emergency stop is a device installed on or next to plant to bring it to a stop when other control measures fail or cannot be used in an emergency. It could be a button, grab wire or foot pedal.	Designers should consider the number of emergency stops, features of the plant operation and the location and number of operators during the risk assessment. Emergency stops do not remove the need for acceptable guarding. The designer should make sure that: • once engaged, the emergency stop controls should remain in place until a risk assessment is done

		• it is only possible to disengage the emergency stop controls using a deliberate action • the emergency stop control cannot be adversely affected by electrical or electronic circuit malfunction • the emergency stop is not the only method of controlling risks – they should be designed as a backup to other control measures • the emergency stop system should be compatible with the operational characteristics of the plant • the type of emergency stop design is chosen following the requirements of the category, performance level or safety integrity level determined by a risk assessment • if the plant is designed to be operated by more than one person and more than one emergency stop control is fitted, the designer of the plant should make sure that the multiple emergency stop controls are of the 'stop and lock-off' type. This is so the plant cannot be restarted after an emergency stop control has been used unless the emergency stop control is reset. The emergency stop control should be prominent, clearly and durably marked. Warning devices can include: • audible alarms • motion sensors • lights • rotary flashing lights • air horns • percussion alarms • radio sensing devices.
Energy sources	Designers should consider the possibility of a dangerous situation where the energy source to the plant becomes irregular. This could take the form of	Designers should make sure: • the plant should default to the 'off position' • the plant should not be able to restart automatically after power fluctuations • protective devices should remain fully

	a power surge or fluctuation.	effective before, during and after power fluctuation. Where electrical equipment has been designed for use within certain voltage limits, only those specific requirements addressing the design requirement should apply. Where plant is powered by an energy source other than electricity, it should be designed to allow the plant to be constructed and equipped to eliminate or minimise, so far as is reasonably practicable, potential hazards associated with that particular type of energy.
Entanglement	Some plant carries a risk of entanglement.	Designers should make sure that moving parts of machines are designed in a way that prevents user contact that may cause injury. Older plant like radial drills, surface planers and milling machines commonly operate with the rotating tool unguarded. This presents a risk of entanglement should the user or their clothing contact the rotating part. For modern metal-working machines, designers should consider these things: • incorporating protective guards that surround the cutter • providing lubricant and swarf removal that could eliminate the need for user invention • ensuring plant is computer controlled where possible. For older woodworking machinery, designers should consider: • using powered feed equipment to provide a safe distance between the user and the revolving cutters or blades • fitting barriers like mesh guards or tunnel guards for close-contact plant like grain augers or tree-limb mulchers. Older style machines should be protected by the use of physical barriers, pressure sensitive mats or presence sensing devices. Operator controls for plant capable of entanglement should be able to bring the plant quickly to a complete stop. The braking system on the plant should, so far as is reasonably

		practicable, prevent further movement once the plant has stopped.
Fire and explosion	Certain types of plant hold the risk of fire, explosion or overheating.	A designer should, so far as is reasonably practicable, eliminate or minimise risks posed by the plant itself or by gases, liquids, dusts, vapours or other substances produced or used by the plant or other plant nearby.
Guarding	The designer should ensure, so far as is reasonably practicable, that guarding will prevent access to the danger point of the plant.	The guarding should be a permanently fixed barrier or an interlocked physical barrier. If neither of these options is reasonably practicable, the guarding should be a physical barrier that can only be altered or removed using a tool. If this option is not practicable, a presence-sensing safeguarding system should be used. The designer should also make sure that: • the guarding can be removed to allow maintenance and cleaning of the plant • the guarding can only be removed when the plant is not in normal operation • if the guarding is removed, the plant cannot be restarted unless the guarding is replaced. The mechanisms and operator controls forming part of a machine guard should be of failsafe design. The guarding should not: • weaken the structure of the plant • cause discomfort to users • introduce new hazards like pinch points, rough edges or sharp corners. The designer should review the regulatory requirements for guarding at each phase of the design development. The guard should be designed considering: • the placement of the guard (eg to allow the user to observe the operation) • removal or ejection of work pieces • lubrication • inspection • adjustment and • repair of machine parts. Where some form of physical barrier is provided to prevent access to dangerous parts, the size and position of the barrier should take into account the physical characteristics of likely users. Figure 17 below shows an example of good guard design on a press brake.

		When choosing a guard, designers should consider the environment it will be used in. Physical barrier guarding should be: • constructed from material strong enough to resist normal wear and shock • able to withstand long use with a minimum of maintenance • made from corrosion-resistant materials, if it is likely to be exposed to corrosion. When an enclosure is used to prevent access to mechanical, chemical and electrical hazards there may be an opportunity to control other risks. For example, risks associated with exposure to dust may be controlled by replacing a sheet metal guard with a mesh guard—however, the accumulation of dust within the guard should not create another hazard. Where there is a risk of jamming or blocking moving parts, the designer should document the work procedures, devices and tools to clear the plant in a way that minimises the risk. This information should be passed on to the manufacturer and supplier. The designer should carry out safety integrity testing for presence-sensing safeguarding systems to check that a safety function will perform as intended. A risk assessment determines the safety integrity requirements—the higher the level of safety integrity, the lower the likelihood of failure which can cause harm. If applicable, the designer should specify the safe systems of work for using and maintaining the guarding and the maintenance of the components being guarded in the information provided to the manufacturer.
Hazardous chemicals	Hazardous chemicals may create health and safety risks for people who handle them.	Plant should be designed and manufactured to eliminate or minimise the release of substances which are hazardous. This includes controlling hazardous waste and airborne substances.
Lighting	Lighting should be provided to enable safe use of plant. Poor lighting can lead to poor visibility, user fatigue, wrong decisions and incidents.	Lighting may be internally or externally installed. Emergency lighting should use its own power supply and not be subject to power cuts. If external lighting is needed to ensure the safety of workers at or near the plant, the designer should provide written information to the installer and the end user. Designers should consider control panel lighting when designing plant. Designers should, by applying appropriate Standards, look into lighting requirements for plant use and maintenance including:

		• the direction and intensity of lighting • the contrast between background and local illumination • the colour of the light source, and • reflection, glare and shadows.
Lightning	Lightning poses a risk of severe burns to people working in conditions where it is present.	Plant likely to be exposed to lightning while being used should incorporate a system for conducting resultant electrical charges to earth.
Manual tasks	Manual tasks can pose a risk to workers' health and safety if performed incorrectly.	Designers should: • make sure that the plant is designed to eliminate or minimise, so far as is reasonably practicable, the need for any hazardous manual task to be carried out in connection with the plant • take reasonable steps to provide information on hazardous manual tasks associated with the plant. For example, this information may be in user manuals and manufacturer's instructions. It should be in plain English and include pictures or drawings where possible while also maintaining the accuracy and quality of the technical information. Designers should consider: • characteristics of the plant such as weight, size, shape and stability • vertical and horizontal reach distances of future users • conditions in which the plant will be used, serviced, maintained and repaired. Designers should consider the following methods to minimise risks associated with manual tasks: • modular components designed to be dismantled so they can easily be carried or repaired. • attachments like handles or designated lifting points to make lifting easier • wheels to make moving easier. • using lightweight materials.
Mechanical or structural failure during use	Parts of plant should be able to withstand typical stresses during intended use and reasonably	Materials used to make the plant should suit the specified working environment. While deciding which materials to use, designers should consider the possible effects of fatigue, ageing, corrosion

	foreseeable misuse.	and abrasion. The design specification should indicate: • the type and frequency of inspection and maintenance required to keep the plant in a safe condition • the parts subjected to wear • the criteria for determining replacement of these parts. Where risk of rupture or disintegration of parts remains after control measures are taken, the parts should be designed, so far as is reasonably practicable, to be mounted, positioned or guarded so if they rupture their fragments will not put the user or others at risk. Rigid and flexible hoses and pipes carrying fluids like gases or liquids, particularly those under high pressure, should be able to withstand foreseen stresses and be firmly attached and protected against them. Where material to be processed is automatically fed to moving parts of the plant, the design should include a way to avoid risks to the user and others which may arise from the material being ejected or being blocked in the moving parts of the plant. This may include: • allowing the moving parts to reach normal working condition before material comes into contact with the moving parts and • co-ordinating the feed movement of the material and the moving parts of the plant including on start-up and shut-down, regardless of whether the use is intentional or unintentional.
Noise	Designers should design plant so that noise emission is as low as is reasonably practicable.	To eliminate or minimise the risks associated with noise emission, the designer should consider: • preventing or reducing the impact between machine parts • replacing metal parts with quieter plastic parts • combining machine guards with acoustic treatment • enclosing noisy machine parts • selecting power transmission which permits the quietest speed regulation • isolating vibration-related noise sources within machines • using effective seals for machine doors • machines with effective cooling flanges which reduce the need for air jet cooling

		• quieter types of fans or placing mufflers in the ducts of ventilation systems • quiet electric motors and transmissions • pipelines for low flow speeds - maximum 5 metres per second • ventilation ducts with fan inlet mufflers and other mufflers to prevent noise transfer in the duct between noisy and quiet rooms.
Operator controls	Operator controls can pose a risk if they are difficult to use.	Designers should design plant operator controls so they are: • identified on the plant to indicate how to use them • located in an accessible place on the plant • located or guarded to prevent accidental activation • able to be locked into the "off" position to enable the disconnection of all motive power. Control devices should be designed: • so the plant is fail safe to the category, performance level and safety integrity level determined by a risk assessment • to be located within easy access of the user • with extra emergency stops which can be used from other parts of the plant • so they are clearly visible, identifiable and suitably marked • to clearly indicate the function of the control and control operations are as indicated • using symbols and written instructions • so they can be easily read and understood including dials and gauges • so the control moves consistent with established convention • so the desired effect can only occur by intentionally operating a control • to withstand normal use, undue forces and environmental conditions • to be outside danger zones • to be located or guarded to prevent unintentional activation • so they can be locked in the ‘off’ position to isolate the power and • to be readily accessible for maintenance.

		It should only be possible to start plant by deliberately moving or operating a control provided for that purpose, including after a stoppage. Each item of plant should be designed to include a control which completely stops the plant or its relevant components safely.
Plant combinations	Plant that is designed to work in combination with other plant can pose a health and safety risk if not used correctly.	Plant arranged to work in combination with other plant should be designed so when the stop controls, including the emergency stop control, are activated, all the plant being used is stopped simultaneously. Where production lines are separated into zones, designers should indicate to the user that the stop controls will only work for that zone. Separate zones should be clear and intrusions into adjoining zones should be made as difficult as possible. Designers should provide information and instructions about combined plant to the manufacture.
Powered mobile plant	Powered mobile plant includes tractors, forklifts, quad bikes and other plant that is commonly used to transport people or materials.	There are various risk controls that may need to be considered in their design. These may include: • roll over protective structures (ROPS) • falling object protective structures (FOPS) • seat belts • reversing alarms.
Radiation – Electro-magnetic	Electro-magnetic radiation can pose a health and safety risk. It may occur at workplaces that perform: • forging • annealing • tempering • brazing or soldering • sealing of plastics • glue drying • curing particle boards and panels • heating fabrics and paper • cooking with a microwave. Pregnant women and people with metallic implants or cardiac pacemakers may be at particular risk from electro-magnetic radiation. Plant that produces a	Designers should consider the effects of plant that generates electro-magnetic radiation. Design control measures to minimise exposure to electro-magnetic radiation may include: • shielding • interlocking doors on industrial microwave ovens • installing remote operator controls when stray radiation could be produced from an induction or dielectric heater. Information on exposure limits for low frequency radiation can be found in the New Zealand Standard *NZS 2772.1:1999 Radiofrequency fields – Maximum Exposure Levels – 3 kHz to 300 GHz.*

	magnetic field may include: • devices • appliances • equipment containing wires that carry a direct current. Technologies that use magnetic fields may include: • aluminium production • electrolytic processes • magnet production • nuclear magnetic resonance imaging • spectroscopy. Low frequency radiation is man-made, low frequency electromagnetic fields.	
Radiation - Ionising	Radiation hazards are produced by a variety of sources and can be generated by non-ionising or ionising radiation. For more information on ionising radiation, see the Ministry of Health's Radiation Safety page http://www.health.govt.nz/our-work/radiation-safety	Designers should design plant: • to eliminate or minimise, so far as is reasonably practicable, personal exposure to radiation • so that external ionising radiation does not affect people working with or near the plant • so that ionising radiation levels are not higher than what is necessary to use the plant, even in an emergency • so that ionising radiation levels do not exceed relevant exposure limits set by the Radiation Safety Act 2016 and Radiation Safety Regulations 2016.
Radiation (non-ionising) - Lasers	Lasers are devices that produce optical radiation with unique properties. They have varying power and applications. High power laser devices can present a hazard over considerable distances from the source. Exposure to some higher powered laser products may cause skin burn and eye damage.	Designers of plant with laser equipment should make sure that: • laser equipment on plant is designed to prevent harm • laser equipment on plant is protected so that users are not exposed to direct radiation, radiation produced by reflection or diffusion or secondary radiation • visual equipment used for observation or adjustment of laser equipment on plant does not create health and safety risks. Designers should consult with manufacturers, suppliers, owners and end users to make sure that the correct strength of laser is used and the housing of the laser unit is designed according to

		safe design principles. The designer should make sure that written information on how to use laser products safely is provided to the relevant PCBUs and workers. Designers of lasers and plant with lasers should provide information about how to use the lasers safely. This could be a label with both the classification details and the warnings-for-use relevant to that classification. The warning labels relevant to that classification should be permanently attached to the housing of the plant in a highly visible position. Laser devices in New Zealand should be classified following AS/NZS IEC 60825.1:2011: *Safety of laser products.*
Radiation – Ultraviolet	Excessive exposure to ultraviolet (UV) radiation from the sun can cause sunburn, lasting skin damage, premature skin aging and an increased risk of developing skin cancer. Exposure also increases the risk of ultraviolet induced damage to the lens and cornea of the eye. Exposure can also come from artificial sources like germicidal lamps and quartz-halogen lights, UV curing of printing inks and some forms of welding .	Designers should consider ultraviolet risks associated with the plant they are designing. For example, a designer of mobile plant should safeguard the driver from exposure to ultraviolet radiation from the sun by incorporating an effective canopy into the design. They should make sure that UV radiation created by the plant is not released to prevent exposure to workers.
Risk of being trapped	Becoming trapped in plant poses a risk or injury or even death to users.	Where there is a risk of a person becoming trapped or enclosed within the plant, designers should incorporate control measures in the design to allow the plant to come to an immediate stop or prevent the plant being activated while a person is in that position. For mobile plant, the risk of the user being trapped if the plant overturns can be minimised with rollover protection structures.
Software	If software is difficult to use, it can lead to health and safety risks for users.	Designers considering the use of interactive software for the user to control the plant should make sure the software is as easy-to-use as possible. Designers should investigate any potential Standards they may need to reference when designing software for plant.
Stability	Unstable plant can cause a risk to health and safety. It can topple, parts can fall	Designers should design plant to be stable under all expected conditions. Detailed written instructions should be provided by the designer to

	off or it can unexpectedly move and result crush or impact injuries.	the relevant PCBUs. Detailed written erection, modification and dismantling procedures should be provided to the manufacturer by the designer. Stability testing requirements for the plant can be developed and specified at the design phase and verified after manufacture.
Static Electricity	Static electricity may cause an electric shock to a person, as well as unintended combustion where flammable fumes are present.	Plant should be designed to prevent or limit the discharge of electrostatic charges. To eliminate or minimise health and safety risks arising from static electricity, designers can incorporate control measures into their design such as spark detection and suppression systems.
Vibration	Vibration can be transmitted to the whole body and through the hands and arms when using plant. This can lead to muscle damage and other injuries.	Plant should be designed to eliminate or minimise risks resulting from vibration. Two approaches to control vibration are: • preventing vibration happening in the first place, or • separating the vibration from the person using the plant. Ways that designers could minimise health and safety risks that may arise from vibration are: • designing commercial vehicles to have suspended cabs • designing in vibration isolation (eg the use of rubber blocks or mounts on an engine) • tool design that isolates the handles from the percussive action • incorporating an electric drive into the design.
Warning devices		If the plant design includes an emergency warning device the designer should position the device on the plant to make sure the device will work to best effect. Warning devices can include: • audible alarms • motion sensors • lights • rotary flashing lights • air horns • percussion alarms • radio sensing devices.

Table 8 – Plant hazards and design considerations

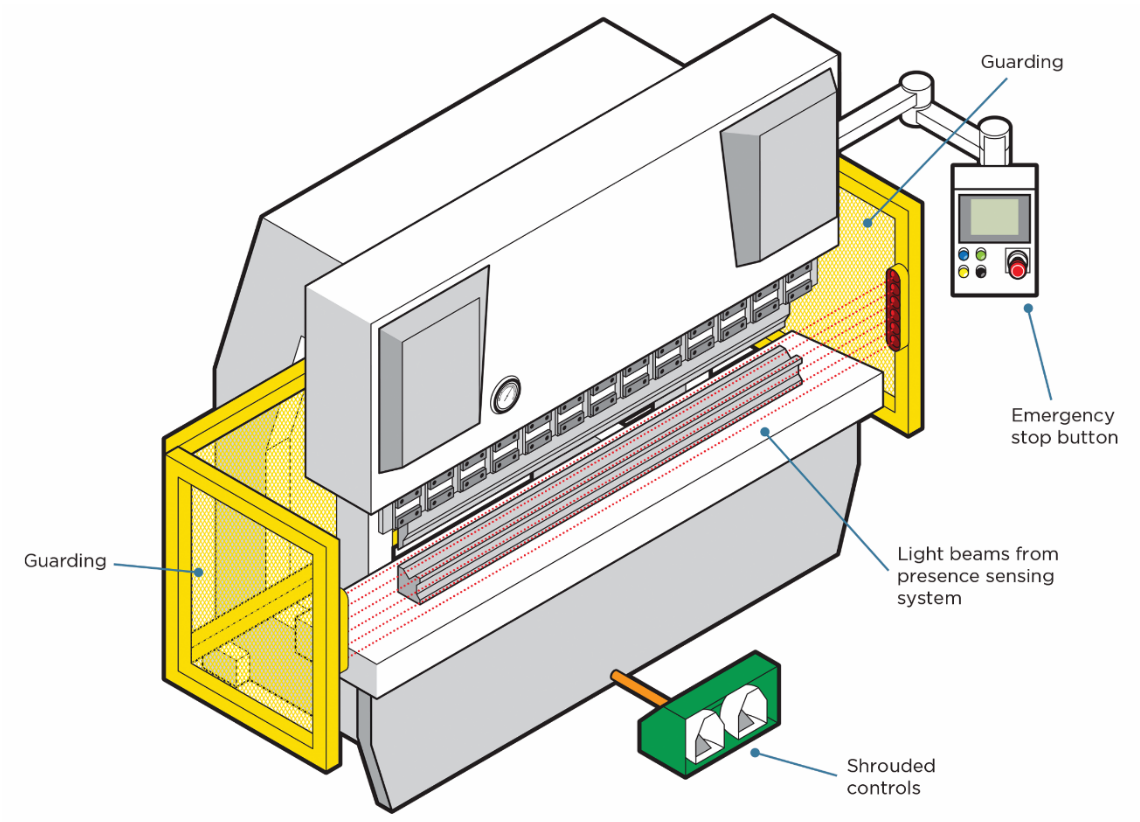

Figure 16: Examples of guards on a press brake

[Credit: Safe Work Australia]

6.5 Design information for the manufacturer

Designers should provide specific information to the manufacturer, so that the plant is manufactured following the design specifications.

They should provide information on:

- installing, commissioning, using, handling, storing, decommissioning and dismantling the plant
- hazards and risks associated with using the plant
- testing or inspections to be carried out
- systems of work and competency of users necessary for the plant to be used safely
- emergency procedures if there is a malfunction.

If the manufacturer tells the designer there are safety issues with the design, the designer should revise the information to take account of these concerns, or they could tell the manufacturer in writing why revisions are not needed. Designer information that can be provided to the manufacturer is in Table 9.

Designer information that can be provided to the manufacturer	
Manufacturing plant	• specific conditions relating to the method of manufacture • instructions for fitting or refitting plant parts and their correct location • instruction where hot or cold parts or material may create a risk • specifications of material

Designer information that can be provided to the manufacturer	
	• wiring diagrams • specifications for proprietary items (eg electric motors) • component specifications including drawings and tolerances • assembly drawings • assembly procedures including specific tools or equipment to be used • manufacturing processes • details of hazards presented by materials during manufacturing • safety outcomes for programming.
Transporting, handling and storing plant	• dimensions and weight • handling instructions • conditions for storage.
Installing and commissioning plant	• exposure to dangerous parts before installing guards • lifting procedures • plant interacting with people • plant interacting with other plant • stability during installation • the proposed method for installing and commissioning • using special tools, jigs, fixtures and appliances necessary to minimise risk during installation • concealed installations • environmental factors affecting installation and commissioning.
Using, inspecting and testing plant	• intended uses for the plant including prohibited uses • operating procedures • safe entry and exit • requirements for maintenance and repair • emergency situations • exposure to hazardous chemicals • how environmental conditions affect using the plant • the results or documentation of tests carried out on the plant and design • de-commissioning, dismantling and disposing of plant • known leftover risks that cannot be eliminated or sufficiently minimised by design • details of control measures to further minimise the risks associated with plant • information on administrative control measures • requirements for special tools needed to use or maintain plant.

Table 9: Designer information that should be provided to the manufacturer

6.6 Design Verification

The Health and Safety in Employment (Pressure Equipment, Cranes, and Passenger Ropeways) Regulations 1999 require the design of this type of plant to be verified before it can be certified and first used.

For plant under these Regulations, the information that the designer should provide to the manufacturer should include the design verified drawings and certification.

This provides evidence the plant design has been verified under the Regulations.

See www.legislation.govt.nz for more information.

6.7 Design Verifier

A design should only be verified by a competent person.

In general, people who are competent to verify the design of plant are those who:

- are employed or engaged by a Recognised Inspection Body
- hold Chartered Professional Engineer Status recognised by the Institution of Professional Engineers New Zealand (IPENZ) and are deemed competent to carry out design verification (or similar overseas), and
- have educational or vocational qualifications in an engineering discipline relevant to the design to be verified, and
- have knowledge of the technical standards relevant to the design to be verified, and
- have the skills necessary to independently verify that the design was produced following the published technical standards and engineering principles used in the design, and
- are authorised by a body accredited or approved by the Joint Accreditation System—Australia and New Zealand or an equivalent overseas body to carry out conformity assessments of the design against the relevant technical standards. In New Zealand this body is International Accreditation New Zealand (IANZ).

The design verifier may be in-house or an independent contractor. They must not have been involved in the plant design process unless that PCBU has an accredited and documented quality system in place that has been certified by IANZ (or a body accredited or approved by the Joint Accreditation System – Australia and New Zealand).

6.8 Intended use of plant

The intended use of the plant, including its functions and limitations, can be determined by looking at:

- the expected place of use (eg environment and supporting surfaces)
- intended functions and operating modes
- safe use requirements including reasonably foreseeable misuse
- planned service life
- relevant standards and specifications (eg what is produced and materials to be used)
- possible malfunctions and faults
- testing, maintenance and repair requirements
- the people interacting with the plant
- other products interacting with or related to the plant.

6.9 Design sources of human error

Poorly designed plant can lead to inadvertent or inappropriate actions from the people using the plant. Examples of these are in Table 10 below.

Unintended outcome	Possible causes due to poor design
Inadvertent activation of plant	• Lack of interlocks or time lockouts. • Lack of warning sign against activating equipment under specified damaging conditions.
Errors of judgement, particularly during periods of stress or high job demand	• Critical displays of information are too similar or too close together. • Job requires user to make hurried judgements at critical times, without programmed back-up measures.
Critical components installed incorrectly	• Design and instructions on installing components are difficult to understand. • Lack of configurations or guides on connectors or equipment.
Inappropriate use or delay in use of operator controls	• Critical operator controls are too close, similar in design or awkwardly located. • Readout instrument blocked by arm when making adjustment. • Labels on operator controls are confusing or missing. • Information is too small to see from user's position.
Inadvertent activation of operator controls	• Operator controls can be activated accidentally. • Lack of guards over critical operator controls.
Critical instruments and displays not read or information misunderstood because of clutter	• Critical instruments or displays not in an obvious area. • Design of all displays is too similar.
Failure to notice critical signal	• Lack of acceptable warning to attract user's attention to information.
Plant use results in unexpected direction or response	• Direction of operator controls conflicts with normal operation.
Lack of understanding of procedures	• Instructions are difficult to understand.
Following prescribed procedures results in error or incident	• Written prescribed procedures are wrong and have not been checked.
Lack of correct or timely actions	• Available information incomplete, incorrect or not available in time. • Response time of system or plant too slow for making the next correct action. • Lack of automatic corrective devices with fast fluctuations.
Exceeding prescribed limitations on load or speed	• Lack of governors and other parameter limiters. • Lack of warnings on exceeding parameters.

Table 10: Design Sources of human error

07 / SPECIFIC CONSIDERATIONS WHEN DESIGNING SUBSTANCES

7.1 What is a hazardous substance?

A hazardous substance is any substance with one or more of the following properties:

Figure 17: Properties of hazardous substances

In addition, if a substance gains any of the above properties when it comes into contact with air or water, it is considered hazardous.

'Substance' applies to any of the above definitions and this section focuses on the design, redesign or modification of a substance.

7.2 Approval of hazardous substances

All hazardous substances need to be approved under the HSNO Act (Hazardous Substances and New Organisms (HSNO) Act 1996). The approvals are given by the Environmental Protection Authority (EPA). When a substance is approved, controls to manage any risk that may arise during the substance's lifecycle are applied.

The Health and Safety at Work (Hazardous Substances) Regulations 2017 are a set of workplace controls developed for each class of hazardous substance, and for particular phases of a substance's life cycle. These Regulations will come into effect in December 2017 and will replace the workplace controls set under the HSNO Act 1996.

7.3 Control measures for managing substances

The specific control measures required by law may help manage the risks associated with manufacturing, using, handling or storing hazardous substances in the workplace.

7.4 Design considerations for substances

The intrinsically hazardous properties of a substance may be unavoidable, as they are integral to the function of the substance in a workplace. However, the principles of Health and Safety by Design should still be applied.

Designers of substances should consider:

- their understanding of chemistry principles, toxicology and environmental science
- looking at whether hazardous properties can be removed while still maintaining the functionality and efficacy of the substance
- looking at whether the toxicity or reactivity of the substance can be eliminated or minimised by varying these things:
    - the molecular weight
    - volatility
    - particle size
    - solubility
    - reactivity
    - thermos-reactivity
    - shape
    - molar mass.
- Looking at whether the substance's potential for the following things can be eliminated or minimised through good chemical design:
    - bioaccumulation
    - environmental persistence
    - receptor binding.
- ensuring that there is reliable well tested data for all relevant routes of exposures, no observed adverse effect levels or concentrations (NOAEL/NOAEC) and lowest observed adverse effect levels/concentrations (LOAEL/LOAEC)
- understanding the process of metabolism or degradation of the substances in the body and in the environment
- taking a product stewardship approach - making health, safety and environmental protection an integral part of the life cycle of chemical products, in partnership with others involved in the product.

7.5 Inherently safer substances

When designing and developing safer substances for use in the workplace, the designer needs to find a balance between eliminating or minimising health, safety or environmental risks, and maintaining the effectiveness of the substance. If a less hazardous version of the substance is designed that s not as effective as those currently being used, the health and safety benefits may outweigh this reduction in effectiveness.

So far as is reasonably practicable, the designer should consider is able to be done to ensure health and safety, taking into account:

- the likelihood of risk
- the degree of harm
- the ways of eliminating or minimising risk and
- the cost and whether it is grossly disproportionate to risk be considered.

Information on how PCBUs can make safer choices around substances to use in the workplace is available on WorkSafe's website: www.worksafe.govt.nz

More information on how designers can communicate, cooperate and coordinate with other relevant stakeholders is outlined in section 3 of these guidelines.

Information on safe substitution of substances is also available from the following resources:

https://www.osha.gov/dsg/safer_chemicals/basics.html

https://www.ontario.ca/document/ontario-toxics-reduction-program-reference-tool-assessing-safer-chemical-alternatives-0

Minimising chemical risk to workers' health and safety through substitution, European Commission Directorate-General for Employment, Social Affairs and Inclusion Unit Health, Safety & Hygiene at Work (2012)

08 / CASE STUDIES

- Noise control for shearing clippers
- Lighting in the archive room
- Thermographic surveying windows
- Remote monitoring systems

Noise control for shearing clippers

Shearing equipment can generate high levels of noise during the shearing of sheep, meaning that shearers can be exposed to high noise levels for long periods during the season. Extended periods of exposure to high levels of noise can lead to partial or full hearing loss, both temporary and permanent.

Research completed at Canterbury University demonstrated that noise levels could be reduced by simple redesign of the shearing equipment, such as the prevention of the core hitting the downtube. This was a simple, inexpensive and reasonably practicable fix to reduce the noise emission to shearers and minimise a health and safety risk.

To view this report in full, see:

Mahn, J. (2010). *Noise of sheep shearing systems. Part 2. Noise Source Identification*. Christchurch. Canterbury University: Acoustic Research Group. Report 120).

Lighting in the archive room

One engineering business recently replaced the lighting in a document archive room which was used only occasionally but when it was used, file boxes needed to be carried in and out. The light switch was inside the room, which meant the operators had to enter the dark room carrying a file box and then try to find the light switch. This was a potentially hazardous activity. The business installed a low-energy, long-life LED light system which has movement sensors and eliminated the need for a light switch. When there is no movement, the lights stay on a dim setting to allow some visibility in the room. When movement is sensed, the lights come to full brightness for a set period of time. The long-life LED fittings mean that lamp changing is reduced.

Thermographic surveying windows

One engineering business carries out thermographic surveys of electrical switchboards to look for hot spots, which are early indicators of failure. The problem is that the switchboard has to be opened to carry out the survey, which exposes the surveyor to an arc-flash risk in the event of an equipment fault. The business has started to offer special 'windows' in their switch board designs which allow maintenance of the arc-flash integrity but are transparent to IR radiation. This allows the thermographic surveying to be done without opening the panels and exposing the operators to additional arc-flash risk. The windows are supplied by a third party and certified as arc-flash resistant.

Remote monitoring systems

One engineering business works with clients who use automated effluent treatment systems. These need to remain in compliance with resource consents for discharge volume and quality. Any upsets in these plants have the potential to cause environmental harm, as well as stopping production processes when hold-up ponds are limited in capacity. The engineering business has designed and installed remote monitoring systems which transmit alarms and fault messages to operators' cell phones via text messages or apps. This allows the operators to have timely warning of impending problems, and in some cases allows them to take corrective actions remotely. This function is useful out-of-hours when the speed of response may be critical.

09 / APPENDICES

In these Appendices:

A) Glossary
B) Health and Safety by Design Checklist

Appendix A – GLOSSARY

The following terms are used in these guidelines.

Term	Legal definition (as noted) or brief explanation
Control measure	Is a way of eliminating or minimising risks to health and safety.
Duty holder	Means a person who has a duty under HSWA. There are four types of duty holders – PCBUs, officers, workers and other persons at workplaces.
Hazard (section 16 of HSWA)	Includes a person's behaviour where that behaviour has the potential to cause death, injury, or illness to a person (whether or not that behaviour results from physical or mental fatigue, drugs, alcohol, traumatic shock, or another temporary condition that affects a person's behaviour).
Health and Safety at Work Act 2015 (HSWA)	HSWA is the key workplace health and safety law in New Zealand. This covers nearly all work and workplaces.
Other person at workplace	Examples of other persons include workplace visitors and casual volunteers at workplaces.
Overlapping PCBU duties	Means when more than one PCBU has health and safety duties in relation to the same matter.
PCBU (section 17 of HSWA)	• (a) means a person conducting a business or undertaking– o (i) whether the person conducts a business or undertaking alone or with others; and o (ii) whether or not the business or undertaking is conducted for profit or gain; but o (b) does not include– o (i) a person to the extent that the person is employed or engaged solely as a worker in, or as an officer of, the business or undertaking: o (ii) a volunteer association: o (iii) an occupier of a home to the extent that the occupier employs or engages another person solely to do residential work: o (iv) a statutory officer to the extent that the officer is a worker in, or an

Term	Legal definition (as noted) or brief explanation
	officer of, the business or undertaking: o (v) a person, or class of persons, that is declared by regulations not to be a PCBU for the purposes of this Act or any provision of this Act.
Plant (section 16 of HSWA)	Includes– • (a) any machinery, vehicle, vessel, aircraft, equipment (including personal protective equipment), appliance, container, implement, or tool; and • (b) any component of any of those things; and • (c) anything fitted or connected to any of those things.
Reasonably practicable (section 22 of HSWA)	In relation to a PCBU's primary duty, the duty of PCBUs who manage or control a workplace, or who manage or control fixtures, fittings or plant at workplaces, and the upstream PCBU duty means that which is, or was, at a particular time, reasonably able to be done in relation to ensuring health and safety, taking into account and weighing up all relevant matters, including– • (a) the likelihood of the hazard or the risk concerned occurring; and • (b) the degree of harm that might result from the hazard or risk; and • (c) what the person concerned knows, or ought reasonably to know, about– o (i) the hazard or risk; and o (ii) ways of eliminating or minimising the risk; and • (d) the availability and suitability of ways to eliminate or minimise the risk; and • (e) after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.
Risk	Risks arise from people being exposed to a hazard (a source of harm).
Structure (section 16 of HSWA)	• (a) means anything that is constructed, whether fixed, moveable, temporary, or permanent; and • (b) includes–

Term	Legal definition (as noted) or brief explanation
	o (i) buildings, masts, towers, frameworks, pipelines, quarries, bridges, and underground works (including shafts or tunnels); and o (ii) any component of a structure; and o (iii) part of a structure.
Upstream PCBUs	In this guide means PCBUs who design, manufacture, import or supply plant, substances or structures, or who install, construct or commission plant or structures. 'Design' is defined in HSWA as including– • (a) the design of part of the plant, substance, or structure; and • (b) the redesign or modification of a design. See Section 3.5 for more information about upstream PCBU duties.
Worker (section 19 of HSWA)	• Means an individual who carries out work in any capacity for a PCBU, including work as– o (a) an employee; or o (b) a contractor or subcontractor; or o (c) an employee of a contractor or subcontractor; or o (d) an employee of a labour hire company who has been assigned to work in the business or undertaking; or o (e) an outworker (including a homeworker); or o (f) an apprentice or a trainee; or o (g) a person gaining work experience or undertaking a work trial; or o (h) a volunteer worker; or o (i) a person of a prescribed class. • A constable is– o (i) a worker; and o (ii) at work throughout the time when the constable is on duty or is lawfully performing the functions of a constable, but not otherwise. • A member of the Armed Forces is–

Term	Legal definition (as noted) or brief explanation
	o (i) a worker; and o (ii) at work throughout the time when the member is on duty or is lawfully performing the functions of a member of the Armed Forces, but not otherwise. A PCBU is also a worker if the PCBU is an individual who carries out work in that business or undertaking.
Workplace (section 20 of HSWA)	• (a) means a place where work is being carried out, or is customarily carried out, for a business or undertaking; and • (b) includes any place where a worker goes, or is likely to be, while at work. In this section, **place** includes– • (a) a vehicle, vessel, aircraft, ship, or other mobile structure; and • (b) any waters and any installation on land, on the bed of any waters, or floating on any waters.

Appendix B – HEALTH AND SAFETY BY DESIGN CHECKLIST

The following list may be used to help with identifying hazards and controlling risks associated with the design of a structure throughout its lifecycle.

Electrical safety

- Earthing of electrical installations
- Location of underground and overhead power cables
- Protection of leads/cables
- Number and location of power points

Fire and emergencies

- Fire risks
- Fire detection and fire fighting
- Emergency routes and exits
- Access for and structural capacity to carry fire tenders
- Other emergency facilities

Movement of people and materials

- Safe access and egress, including for people with disability
- Traffic management
- Loading bays and ramps
- Safe crossings
- Exclusion zones
- Site security

Working environment

- Ventilation for thermal comfort and general air quality and specific ventilation requirements for the work to be performed on the premises
- Temperature
- Lighting including that of plant rooms
- Acoustic properties and noise control, for example, noise isolation, insulation and absorption
- Seating
- Floor surfaces to prevent slips and trips
- Space for occupants

Plant

- Tower crane locations, loading and unloading
- Mobile crane loads on slabs
- Plant and machinery installed in a building or structure
- Materials handling plant and equipment
- Maintenance access to plant and equipment
- The guarding of plant and machinery
- Lift installations

Amenities and facilities

- Access to various amenities and facilities such as storage, first aid rooms/sick rooms, rest rooms, meal and accommodation areas and drinking water

Earthworks

- Excavations (for example, risks from earth collapsing or engulfment)
- Location of underground services

Structural safety

- Erection of steelwork or concrete frameworks
- Load bearing requirements
- Stability and integrity of the structure

Manual tasks

- Methods of material handling
- Accessibility of material handling
- Loading docks and storage facilities
- Workplace space and layout to prevent musculoskeletal disorders, including facilitating use of mechanical aids
- Assembly and disassembly of pre-fabricated fixtures and fittings

Substances

- Exposure to hazardous substances and materials including insulation and decorative materials
- Exposure to volatile organic compounds and off gassing through the use of composite wood products or paints
- Exposure to irritant dust and fumes
- Storage and use of hazardous chemicals, including cleaning products

Falls prevention

- Guard rails
- Window heights and cleaning
- Anchorage points for building maintenance and cleaning
- Access to working spaces for construction, cleaning, maintenance and repairs
- Scaffolding
- Temporary work platforms
- Roofing materials and surface characteristics such as fragility, slip resistance and pitch

Specific risks

- Exposure to radiation, for example, electromagnetic radiation
- Exposure to biological hazards
- Fatigue
- Working alone
- Use of explosives
- Confined spaces
- Over and under water work, including diving and work in caissons with compressed air supply

Noise exposure

- Exposure to noise from plant or from surrounding area

[Credit – Safe Work Australia]