PLANT
DESIGN
MAKING IT SAFE

A guide for designers, manufacturers, importers, suppliers and installers of plant

OCCUPATIONAL SAFETY AND HEALTH ACT 1984
and
OCCUPATIONAL SAFETY AND HEALTH REGULATIONS 1996
November 2001

WorkSafe Western Australia COMMISSION

Government of Western Australia

COMMISSION

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1. Legislative Framework

The objective of the *Occupational Safety and Health Act 1984* is to promote and improve safety and health standards in Western Australian workplaces. The Act sets out broad duties for people at workplaces and those who design, manufacture, import or supply plant or manufacture, import or supply substances for use at workplaces. It also includes duties of those who design or construct buildings or structures for use at a workplace. The Act is supported by more detailed requirements in the *Occupational Safety and Health Regulations 1996*. The Act and Regulations are further supported by a range of guidance material such as approved codes of practice and guidance notes as shown below.

Occupational Safety and Health Act

Major provisions:
- The General Duties
- Resolution of Issues
- Safety and Health Representatives
- Safety and Health Committees
- Enforcement of Act and Regulations

supported by

Occupational Safety and Health Regulations

The Occupational Safety and Health Regulations set minimum requirements for specific hazards and work practices, including reference to National Standards developed by the National Occupational Health and Safety Commission and Australian Standards developed by Standards Australia.

and

Guidance Material

- Codes of Practice approved for Western Australia in accordance with section 57 of the Act
- Guidance Notes developed by the WorkSafe Western Australia Commission
- National Codes of Practice and National Standards developed by the National Occupational Health and Safety Commission
- Australian Standards developed by Standards Australia

What are your legal obligations?

The Occupational Safety and Health Act sets out particular 'duties' for designers, manufacturers, importers, suppliers, installers and users of plant. Plant includes any machinery, equipment, appliance, implement, or tool and any component or fitting thereof or accessory thereto (Section 3 of the Occupational Safety and Health Act 1984).

Familiarising yourself with the material in this guide for designers, manufacturers, importers, suppliers and installers of plant is a good place to start in understanding these duties.

If you have additional responsibilities as an employer, a companion guide for employers, self-employed persons and employees is available to help you implement a risk management system for plant in your own workplace.

Note that this and the companion guide are not intended as statements of law; they do not waive or modify any legal obligations.

'Plant' means more than you might think

Plant is a general name for machinery, tools, appliances and equipment. It can include things as diverse as presses in a foundry and computers in an office. It can range from electric drills to lifts and escalators; from tractors to hand trolleys; cranes to commercial fishing nets and arc welding gear.

Plant can be hazardous

Since 1995/96 there have been at least 3 work-related deaths and around 6,000 workers' compensation claims involving plant in Western Australia each year.

Providing safe plant to the workplace

Thoughtful design of plant can eliminate many of its risks to safety and health from the beginning. Careful manufacture can ensure it is as safe as the designer intended it to be, and suppliers can then carry through to deliver safe plant to the workplace – significantly reducing the chances that people using it will be harmed. Providing information on hazards and safe use of plant is vital. This can make users aware of any risks the designer has been unable to eliminate, and ensure they don't create any new risks by not using the plant properly.

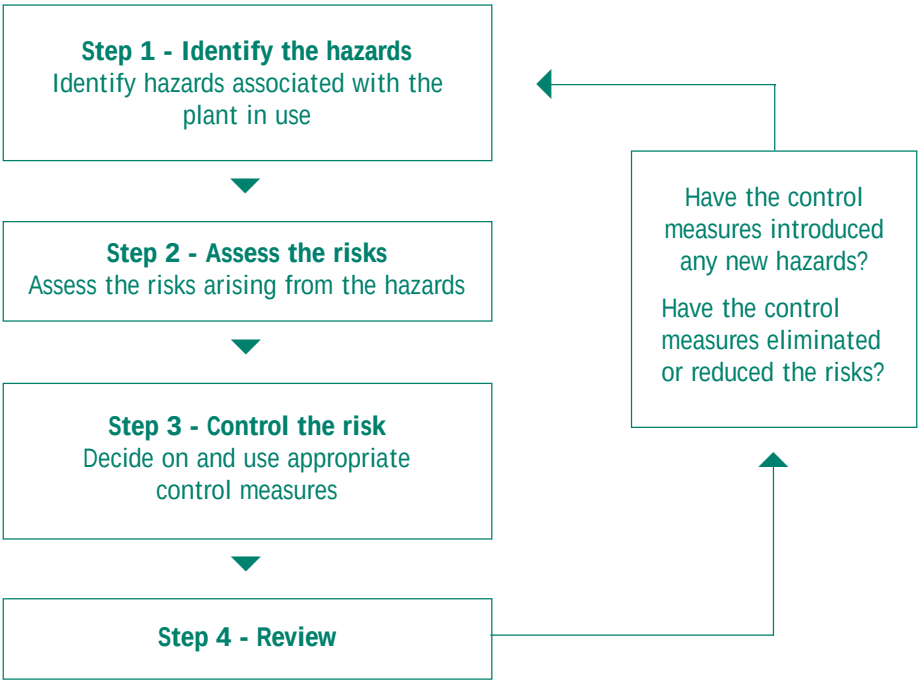
2. Overview of the Risk Management Process

A risk management process is a systematic way of making plant as safe as possible.

Various risk management methodologies have been developed - formalised analysis techniques may be useful, depending on the type and complexity of the plant, and the kind of information available.

The process may also be implemented differently according to who is doing it. A designer, for example, may continuously modify a design as hazards are identified until arriving at a final product with all risks minimised. If, on the other hand, an importer intending to bring in an existing piece of plant identifies a hazard which can only be addressed by modifying the design, the 'control measure' may simply be not to import the plant at all.

But whatever the plant, whoever is responsible for it, and whatever the particular risk management system used, the basic steps in the process remain the same. The risk management process is shown below.



2.1 What is a hazard?

Hazard, in relation to a person, means anything that may result in -

(a) injury to the person; or

(b) harm to the health of the person (**Section 3** of the *Occupational Safety and Health Act*).

There are three broad sources of hazards relevant to plant design:

Hazards relating to the plant itself: An item of plant is likely to have a range of hazards that need to be identified. For example, hazards associated with a forklift would include hazards relating to its mobility; its electrical, hydraulic and mechanical power sources; its moving parts; its load-carrying capacity and operator protection.

Hazards relating to the way the plant is used: The forklift, for example, may have hazards stemming from the kind of loads it is used to lift, the size of the area in which it is used and the slope or evenness of the ground.

You might think work practices like these would be beyond the scope of a designer or supplier, however, if the plant has been designed to be used safely in a particular way, this needs to be communicated to potential users. In the case of the forklift, a 'tilt alarm' might be provided to warn the driver when the slope is too great.

Hazards relating to the environment where the plant will be used: Elements in the environment - whether indoors or outdoors - can affect plant and may increase the risk of an employee being harmed when using it. For example, a photocopier may present a greater hazard in a poorly ventilated room. And again, this kind of constraint must be made clear to users.

2.2 Tools for carrying out the process effectively

Consultation: For people involved in the design, manufacture and supply of plant, consultation with users - employers, employees, their health and safety representatives, and owners - can be a great help in identifying hazards and effectively controlling risks.

The *Occupational Safety and Health Regulations* require certain kinds of information to be exchanged, and this should be supported by direct discussion.

Designers and manufacturers can consult with potential users of their proposed new product - as well as with suppliers, importers, installers and users of similar plant - while doing their technical and market research.

Suppliers should encourage employers and owners to use the regular contact they have with them to discuss relevant safety and health issues associated

with the plant. The supplier can then pass on this information to designers and manufacturers.

Research: All sorts of information can help identify the hazards and assess and control the risks associated with a piece of plant or a plant design - from injury and incident data kept by manufacturers and users of similar plant to records of research and testing done for previous designs. **Resource 1** in **Section 8** lists possible sources of this kind of information.

A note on standards

The Occupational Safety and Health Regulations require certain items of plant to be designed, manufactured, inspected or tested according to particular standards (eg., from Standards Australia).

Other product standards and guidelines, although not prescribed, may also be useful starting points. You could find out about these from your local occupational safety and health agency.

Do not assume a design that meets a standard or guideline is without risk. The objective is safe plant as well as plant that conforms with standards.

Testing: Testing plant is essential to identify hazards as well as assess the risks associated with those hazards. Among other things, test results may provide data on the operating limits of the plant, the probability of failure and its likely consequences. For example, material may be ejected if a failure causes plant to break up. Certain testing procedures may also be specified as part of quality control during manufacture.

Keeping records: Systematic records of each stage of the process will help you - and others - keep track of what has been done and what needs to be done.

You might like to develop a type of master document to list the hazards you have identified along with your assessments of the risks they present and whether or not you have worked out ways to control them.

Other records you might keep could be: research and test results as required by **Section 23** of the Act, details of the method used to assess risks, details of control measures and reviews of their effectiveness, and feedback from users or potential users.

2.3 What next?

As mentioned, there are various risk management methodologies available which may be appropriate to your particular situation. Covering them all is beyond the scope of this guide, but the next section describes one simple way of moving through the process.

We then take a look at the responsibilities of each group involved in providing plant to the workplace - designers, manufacturers, importers, suppliers and installers.

3. Step by Step

3.1 Identifying hazards

An item of plant may have the potential to cause harm in a number of ways. There may be hazards arising from the plant itself, its associated work practices and the environment in which it will be used.

When trying to identify hazards it is important not to limit yourself to situations you have experienced yourself. The idea is to try and anticipate how human behaviour, plant and 'system' failures could combine to create a harmful situation.

Be systematic:

- Use the tools described in **Section 2.2** - consultation, research and testing;
- Use checklists - **Resource 2** in **Section 8** is a checklist of the kinds of things to consider when looking for hazards;
- Keep records of the hazards you identify.

3.2 Assessing risks

What you are trying to do here is assess the risk each hazard presents so it can be controlled, that is, eliminated or minimised.

One way of assessing risk is to consider the chance of the hazardous situation occurring (the **likelihood**) and the extent of the harm that would result (the **consequence**). You then combine these to arrive at an assessment of how serious the risk is.

You could rate the likelihood as:

- Very likely (could happen frequently);
- Likely (could happen occasionally);
- Unlikely (could happen, but only rarely); or
- Highly unlikely (could happen, but probably never will. Be very careful about judging anything as 'highly unlikely'. This should be reserved for very rare situations).

And you could rate the consequence as:

- Fatality;
- Serious injuries (normally irreversible injury or damage to health);

- Minor injuries (normally reversible injury or damage to health needing several days off work); or
- Negligible injuries (first aid).

You could then combine them using a table like this:

	LIKELIHOOD			
Consequence	Very Likely	Likely	Unlikely	Highly Unlikely
Fatality	HIGH	HIGH	HIGH	MEDIUM
Serious Injuries	HIGH	HIGH	MEDIUM	MEDIUM
Minor Injuries	HIGH	MEDIUM	MEDIUM	LOW
Negligible Injuries	MEDIUM	MEDIUM	LOW	LOW

Situations assessed as very likely with fatal consequences are the most serious (HIGH risk); those assessed as highly unlikely with negligible injuries are the least serious (LOW risk).

Be systematic:

Judging how likely it is that something will happen and its potential consequences is like predicting the future. You can't really be sure; you can only make a 'best estimate' on the basis of the information available. You can, however, be systematic about the way you arrive at your 'estimate'.

- Use the tools described in **Section 2.2** - consultation, research and testing;
- Consider work practices which might be associated with the plant, taking particular note of:
  - how often and for how long people would be exposed to each of the potentially hazardous situations you have identified (this affects likelihood as the longer and the more frequent the exposure to a potential hazard, the more likely it is to cause harm);
  - how many people would be exposed to the potential hazard at the same time (this affects the consequence); and
- Keep records of your assessments.

3.3 Controlling the risks

Where a risk to safety and health has been identified, controls must be introduced to eliminate or minimise it.

There are a number of ways of doing this and the following 'hierarchy' can be used as a guide. In many cases a combination of controls will be necessary to reduce a risk to the required level.

A hierarchy of controls

The idea is to select controls from the highest level possible. The way you do this may depend on the role you play - a designer, for example, may be able to minimise the risk by modifying the design of the plant; a manufacturer may have to go back to the designer for 'higher order' controls; an importer may not have the option of modifying the plant and, if the risk is serious, may decide that the only way to control it adequately is not to import the plant at all.

Hierarchy or preferred order of control

elimination - removing the hazard or hazardous work practice from the workplace. This is the most effective control measure;

substitution - substituting or replacing a hazard or hazardous work practice with a less hazardous one; a manufacturer may be able to replace the hazardous aspects of the plant with a safer option, eg., use a component with higher heat tolerance;

isolation - isolating or separating the hazard or hazardous work practice from people involved in the work, or people in the general work areas from the hazard. This can be done by installing screens or barriers or marking off hazardous areas; the plant could be specified for use in an isolated or controlled environment such as placing air conditioning plant on the roof, for example, locating a photocopier in a room with its own ventilation system;

engineering control - if the hazard cannot be eliminated, substituted or isolated, an engineering control is the next preferred measure. This may include modifications to tools or equipment, or providing guarding to machinery or equipment; an importer could have a frame retrofitted to a tractor, for example, for rollover protection. Such things as cut-out switches, screens and guards could be retrofitted;

administrative control - includes introducing work practices that reduce the risk. This could include limiting the amount of time a person is exposed to a particular hazard; and

personal protective equipment – should be considered only when other control measures are not practicable or to increase protection.

Administrative controls and personal protection should be seen as 'back-up' controls. No matter what other control measures are implemented, safe work practices are essential, and personal protective equipment may be advisable, depending on the hazard. Neither option should be relied on as a primary risk control measure until other options have been exhausted.

Control measures are not mutually exclusive. That is, there may be circumstances where more than one control measure should be used to reduce exposure to hazards.

3.4 Review

Deciding on and implementing a control measure is not the end of the risk management process.

Control measures have to be assessed in order to determine:

- whether the risks have been adequately controlled; and
- that no hazards have been created by the control measures.

This process should continue until the risk is reduced to the lowest practicable level.

The process must be repeated whenever circumstances change. Hazard identification, risk assessment and control is not a 'once-off' task.

For designers, manufacturers and suppliers, risk assessments should be reviewed, particularly when:

- information is obtained about a previously unknown design or manufacturing fault; or about a previously unidentified hazard;
- the design is revised; and
- there is a change to a risk control measure after a review of its effectiveness.

4. Designing Safe Plant

Designers have a responsibility to assess and control the risks associated with the plant they design, and to provide particular kinds of safety information about the plant to manufacturers (and thus, eventually, to users).

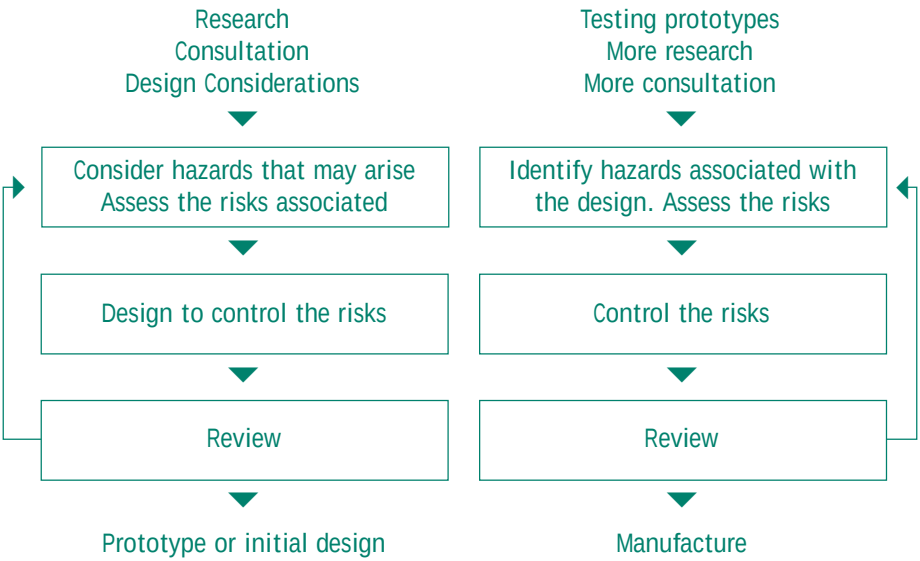
Even though you may not be a professional designer, if you take on that role, you take on the designer's duties.

4.1 Risk management for designers

The design stage of a piece of plant is critically important because it is here that the plant can most easily be altered to eliminate or reduce the risk of a hazard, rather than having to rely on 'lower order' controls that must be implemented in the workplace.

In practice, a professional designer may constantly, and perhaps unconsciously, be moving through the process of recognising hazards, assessing how important they are and introducing control measures.

However, it is necessary to formalise the risk management process at particular stages in the development of the design. A designer needs to be able to demonstrate that all the risks of a plant design have been assessed and controlled before the plant is manufactured and supplied to the workplace.



The risk management process could be used in the development of an initial design or prototype, and then in the production of the finished design.

4.2 Design considerations

This guide is not intended to teach people how to design, but some key safety-related design considerations are described in **Resource 3** in **Section 8**.

Remember: *Standards and guidelines are a good starting point for designing safe plant, but don't assume that designing to a standard, by itself, eliminates risk.*

4.3 Information about the manufacturing process

You should provide the manufacturer with information about the manufacturing methods to be used. If you nominate a specific method or material, you should consider whether there would be any hazards associated with that specification.

4.4 Information for operating manuals

To ensure people understand how to use the plant safely, you should provide the following information for inclusion in the operating manual:

- the uses for which the plant has been designed, manufactured and tested;
- any specific conditions applying to the use of the plant, ways in which experience and testing has shown that the plant should not be used and any specific prohibitions on the use of the plant;
- the results or documentation of tests and examinations carried out on the plant or the design;
- any known residual risks ie, risks that have not been eliminated or sufficiently minimised by design and against which safeguarding is not totally effective;
- control measures, eg., personal protective equipment, that should be used, if any;
- the correct operating procedures for the plant, including systems of work necessary to ensure safe operation;
- the correct way to transport, assemble, erect or install, commission, inspect, test, maintain, repair, dismantle and dispose of the plant;
- the components of the plant which require inspection and testing, as well as the frequency and acceptance criteria for this, and the knowledge, training or skills necessary for people inspecting or testing the plant;

- requirements for any special tools needed to use or maintain the plant;
- instructions about what to do where hot or cold parts or material may create a hazard; and
- information for emergency situations eg., the type of fire-fighting equipment that should be used.

See also ***A note on operating manuals*** in **Section 5.2**.

5. Manufacturing Safe Plant

A manufacturer has a responsibility to follow the designer's specifications precisely in order to ensure the plant is as free from risk as the designer intended.

Under some conditions, for example, if the designer is outside Western Australia, the manufacturer in Western Australia takes on the designer's responsibility to make sure the risks associated with the design are assessed and controlled.

The manufacturer also has a responsibility to provide particular kinds of safety information to users of the plant.

5.1 Risk management for manufacturers

If you are manufacturing plant designed in Western Australia, you only need to go through the risk assessment and control process if you discover a hazardous fault during manufacture. You should not incorporate the fault into the plant. In practice, you should notify the designer of the problem immediately so that it can be corrected.

If you are manufacturing plant designed outside Western Australia, the safety of the plant is your responsibility. In this case you must ensure the full risk management process outlined in **Sections 2, 3 and 5** is carried out, that is, the process of systematically identifying hazards associated with the proposed plant design, assessing risks, controlling them and reviewing the effectiveness of those controls.

Controlling the risks may involve going back to the designer. Remember that if the design is modified, either by you or by the designer, the whole process should be run through again to ensure the modification has been effective and no new hazards have been introduced.

5.2 Providing information to users

You are obliged to provide safety information about the plant to end users, either directly (if supply is direct) or through the supplier.

This will generally be in the form of an operating or instruction manual, either provided by the designer or compiled by you based on information from the designer.

You should review and re-issue safety documentation whenever you become aware of new information about the use of the plant or any associated system of work likely to affect health or safety.

A note on operating manuals

Operating manuals should:

- *be written in clear concise English;*
- *be presented in a logical sequence; and*
- *where appropriate include good illustrations.*

Don't be vague and use misleading expressions - such as 'may be dangerous' or 'safe under most conditions of use'.

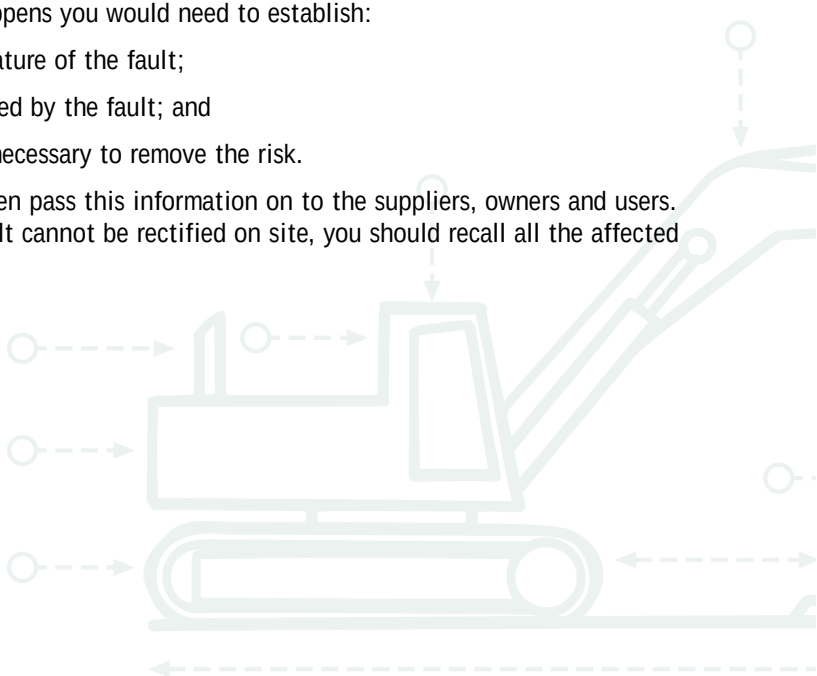
Safety information included in an operating or instruction manual should be integrated with general operating procedures and should be highlighted to clearly identify it.

5.3 Notifying suppliers, owners and users of design or manufacturing faults

Design or manufacturing faults that create a risk to safety and health may become apparent after the plant has been supplied to owners and users. When this happens you would need to establish:

- the exact nature of the fault;
- the risk posed by the fault; and
- the action necessary to remove the risk.

You should then pass this information on to the suppliers, owners and users. Where the fault cannot be rectified on site, you should recall all the affected plant.



6. Importing and Supplying Safe Plant

A person who imports plant from outside Western Australia (an importer) takes on the responsibility of designer and manufacturer to ensure the risks associated with the plant are assessed and controlled, and to provide the required safety and hazard information to users.

Suppliers are responsible for making sure the risks to safety and health from the plant they supply are eliminated or minimised. Suppliers who also import the plant they supply must take on the importer's responsibility thus making sure the whole risk management process is carried out.

The general duties of a supplier apply to hirers and leasors of plant for use at a workplace. In between hirings and leasings, the supplier must ensure the plant is inspected and maintained to reduce as far as is practicable any risk of injury or harm and provide safety and hazard information to persons hiring or leasing the plant.

6.1 Providing information to users

For new plant the supplier must provide the purchaser with the safety and health, and hazard information provided by the designer and manufacturer.

For used plant, the supplier must provide the purchaser with any available safety and health, and hazard information originally provided by the designer and manufacturer, as well as any available records kept by the previous owner.

Some instruction documents accompanying imported plant may need reformatting and revision to ensure they are clear and effective.

6.2 Plant supplied or imported for scrap or spare parts

If an item of plant is supplied or imported as scrap or for spare parts, the supplier must advise the purchaser that the plant in its current condition must not be placed in service.

This can be done either in writing or by marking the plant.

7. Installing or Erecting Plant Safely

Anyone erecting or installing plant has a responsibility to ensure this is done as safely as possible. This involves going through the risk management process to identify any hazards associated with the installation procedures, and assessing and controlling the risks.

If you will be installing several of the same item of plant, you could carry out the risk assessment process using a representative sample. If, however, the risk is going to vary from operator to operator, you will need to assess and control the risk separately for each.

You should pay particular attention to the instructions of the designer and/or manufacturer, and to any relevant standards (eg., Australian standards for electrical installations, particular requirements which apply to erecting scaffolding, etc).

8. Resources

8.1 Resource 1: Sources of information about hazards from plant

All sorts of information can help you identify hazards, and assess and control risks.

Written Material

- Standards covering design, manufacture, testing and use of plant, eg., from Standards Australia;
- Injury, faults, incident and accident reports, and plant failure data kept by manufacturers and users of the same or similar types of plant;
- Statistics, hazard alerts or other reports from relevant statutory authorities, unions and employer associations, specialists, professional bodies representing designers, manufacturers, or engineers;
- Occupational safety and health journals and databases, both Australian and from overseas;
- Research and testing done on previous designs;
- Information and documentation supplied by designers or manufacturers on safety and health issues, such as test reports on previous designs or similar plant;
- Operating and maintenance logs of similar plant that is hired or leased; and
- For importers and/or suppliers, safety information provided with the plant, eg., instruction manuals and/or labels and manufacturer's plates attached to the plant.

Inspections

- Inspect plant that has failed and been returned by users;
- Develop prototypes, and inspect and test their design and manufacture;
- Conduct 'walk-through' surveys of the workplace where the plant will be used before beginning the design process and while the plant is being installed or erected (the latter to look for hazards which may be introduced during installation); and
- Identify and evaluate the tasks which will be associated with the plant that may give rise to hazards.

Consultation

Talk to other designers, specialist practitioners, industry, union or government bodies, owners and users. People actually working with the same or similar plant are often well aware of what can go wrong and why, and how the work environment can change.

8.2 Resource 2: Things to consider when looking for hazards

Possible kinds of hazard

- Could the plant cause injury due to things like entanglement, crushing, trapping, cutting, stabbing, puncturing, shearing, abrasion, tearing or stretching?
- Could the plant create hazardous conditions due to things like pressurised content, electricity, noise, radiation, friction, vibration, fire, explosion, temperature, moisture, vapour, gases, dust, ice, hot or cold parts?
- Could the plant cause injury or ill health due to poor ergonomic design?

Possible sources of hazard

Suitability

- How suitable would the plant be for its intended purpose? What could happen if it was used for a purpose other than the intended purpose?
- How suitable are the materials used to make the plant?
- How suitable are any accessories to the plant? In what condition are they?
- How stable is the plant? Might it roll over?
- If the plant is intended to lift and move people, equipment or materials, how capable is it of doing this? Will there be an effective back-up system to support the load?

Location

- How would the plant affect the safety of the area where it will be located? (Consider its impact on design and layout of the workplace.)
- How would the location affect the safety of the plant? (Consider things like environmental conditions, terrain and work area.)
- Are there likely to be other people or other plant in the vicinity? What effect would this have?

Abnormal situations

- What abnormal situations, misuse or fluctuation in operating conditions can you foresee?
- Would there be potential for falling objects?
- What effects would failure of the plant have? Would it result in loss of contents, loss of load, unintended ejection of workpieces, explosion, fragmentation, collapse of parts?
- Would it be possible for the plant to move or be operated inadvertently?

Systems of work

- What systems of work would be associated with the plant? Could they create any hazards?
- What arrangements are there for access to and egress from the plant, eg., during operation, for maintenance, in an emergency?
- Would the plant's safety depend on the competency of its operators?

8.3 Resource 3: Design considerations

This guide is not intended to teach people how to design, but the following are some key safety-related design considerations:

Consider the plant's life cycle: You should consider all the phases in the life cycle of an item of plant, from manufacture through use, to demolition and disposal. For example, if your design allows easy access to working parts requiring regular maintenance the risk of injury to the maintenance worker may be reduced. However, the design would also have to prevent contact with moving parts while the plant was operating.

Design for safe erection and installation: Ways to control risks related to installing or erecting the plant might be:

- design the plant so it is stable when left freestanding prior to installation;
- make it structurally stable even without 'adjustment' ie, before all the nuts have been tightened; or
- provide special supports that can be used to give stability prior to installation.

Design to facilitate safe use: Consider the following:

- the physical characteristics of users (see also below);
- the maximum number of tasks an operator can be expected to perform at any one time; the complexity of those tasks; and the pace at which they can be performed;
- the need to minimise long periods of physical or repetitive activity;
- the layout of the workstation or environment in which the plant may be used;
- instrumentation and its layout (instrumentation should provide clear, accurate information on how the plant is performing, however, it should not cause 'information overload' which can cause operator error);
- consistency and 'naturalness' of controls, eg., 'up' is always 'off';
- designing controls and operating procedures to make correct actions easier for operators to perform than incorrect actions; and
- the need for emergency stop buttons.

Physical characteristics of users: The plant should accommodate the range of physical characteristics in the user population. You should take into account the range of human dimensions and capabilities such as height, reach and weight, to provide an optimum match between plant and user.

The principles of ergonomics should be applied to minimise the operator's discomfort, fatigue and psychological stress under the intended conditions of use.

Consider intended use and reasonably foreseeable misuse: Misuse is the intentional use of plant for a task for which it was not designed and originally intended.

For example, it would be reasonably foreseeable that a forklift intended to operate on a slope no greater than 1:5 might sometimes be used on a steeper grade. The designer might incorporate a tilt alarm to control this risk.

Design for safe maintenance: Consider the difficulties workers may face when maintaining or repairing the plant. For example, you could:

- reduce the need for maintenance - the less frequently maintenance is required the less the worker is exposed to the risks; or
- locate adjustment, lubrication, and other maintenance points outside danger zones eg., by extending lubrication points away from moving parts.

Design so the plant 'fails to safety': If plant fails, it should be in a safe condition and not create safety and health risks. For example, if moving parts of the plant break up, fragments should not be ejected.

Other considerations: Specific advice about such things as access and egress, operating controls, emergency stop devices and guards is covered in the Occupational Safety and Health Regulations and relevant Australian Standards.

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