

# *Foundry Code of Practice 2004*

Workplace Health and Safety Queensland

Department of Justice and Attorney-General



# Foundry Code of Practice 2004

## Important information about the code

1. The code was made on 24 June 2004.
2. The code commences on 1 July 2004.
3. The code was amended on 28 April 2006 and 5 December 2008.
4. The code expires 10 years after it commenced.

## What is this code of practice about?

The purpose of the Foundry Code of Practice 2004 is to give practical advice about ways to manage exposure to risks identified as typical in foundry work.

## Workplace health and safety obligations and the *Workplace Health and Safety Act 1995*

The *Workplace Health and Safety Act 1995* imposes obligations on people at workplaces to ensure workplace health and safety. Workplace health and safety is ensured when persons are free from death, injury or illness created by workplaces, relevant workplace areas, work activities or plant or substances for use at a workplace. Ensuring workplace health and safety involves identifying and managing exposure to the risks at your workplace.

## Obligations of a person who conducts a business or undertaking (a 'relevant person')

The *Workplace Health and Safety Act 1995* places obligations on a person who conducts a business or undertaking. The Act refers to a person who conducts a business or undertaking as a 'relevant person'. The obligations apply whether or not:

- the relevant person conducts the business or undertaking as an employer, self-employed person or otherwise
- the business or undertaking is conducted for gain or reward, and
- a person works on a voluntary basis.

'Relevant persons' have an obligation to ensure:

- the workplace health and safety of their workers and any other persons is not affected by the conduct of the relevant person's business or undertaking, and
- their own workplace health and safety.

The term 'relevant person' is also used in the *Workplace Health and Safety Regulation 2008*.

Where this code of practice provides advice to employers and self-employed persons on managing exposure to risks, other persons who conduct a business or undertaking may also find this advice applicable depending on their circumstances.

## How can I meet my obligations?

Under the Act, there are three types of instruments made to help you meet your workplace health and safety obligations - regulations, ministerial notices and codes of practice.

If there is a regulation about a risk, you **must** do what the regulation or notice says.

If there is a code of practice about a risk - you **must** either:

- (a) do what the code says, or
- (b) do all of the following:
  - adopt and follow another way that gives the same level of protection against the risk,
  - take reasonable precautions, and
  - exercise proper diligence.

If there is no regulation, ministerial notice or code of practice about a risk, you must choose an appropriate way to manage exposure to the risk and take reasonable precautions and exercise proper diligence to ensure that your obligations are met.

**NOTE:** There may be additional risks at your workplace that have not been specifically addressed in this code of practice. You are still required under the Act to identify and assess these risks and ensure that control measures are implemented and reviewed to eliminate or minimise exposure to these risks.

The *Risk Management Code of Practice* provides a process to help you meet your workplace health and safety obligation by identifying and managing exposure to the risks at your workplace.

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# Introduction

If you work in the foundry industry, this code of practice will help you meet your workplace health and safety obligations as required under the *Workplace Health and Safety Act 1995*.

This code of practice provides information on:

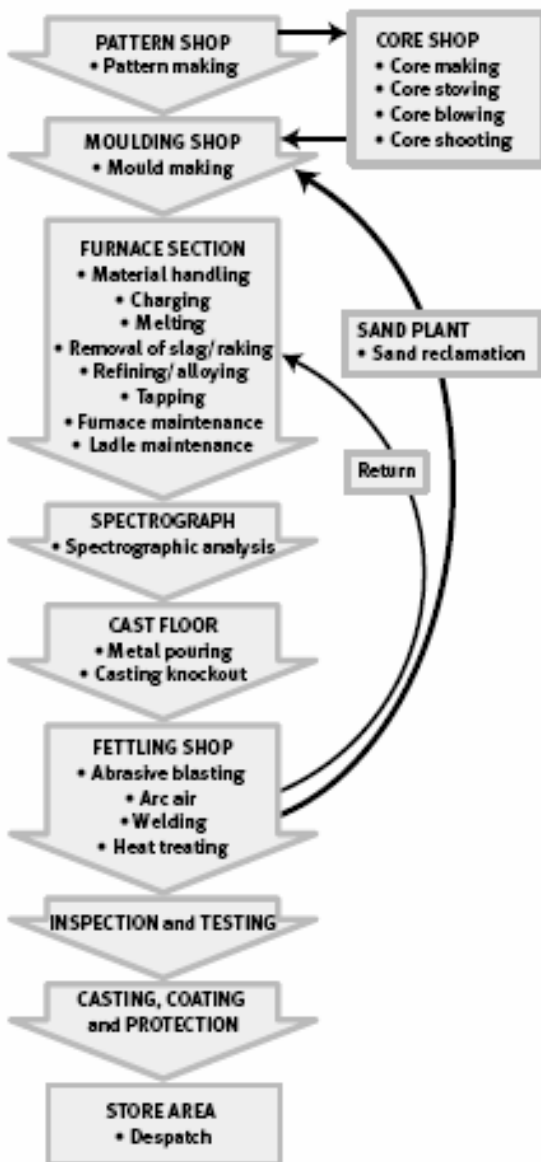
- hazards in foundry work
- control options for dealing with the risks associated with these hazards
- a list of useful references.

## **What is foundry work?**

Foundry work is the process of making a metal casting of an object by pouring molten metal into a mould. The mould is made using a pattern of the article required. In some cases, the mould contains a core that determines the dimensions of any internal cavities.

There are two types of foundries. Ferrous foundries produce iron and steel castings. Non-ferrous foundries produce castings of copper-based alloys (brass, bronze and copper), aluminium-based alloys (lead, zinc, nickel, magnesium) and other alloys.

Foundry work involves all or some of the processes illustrated in the following flowchart:



## Foundry operation and associated hazards

### Pattern shop

The pattern shop area involves the making, assembly and storage of patterns for use in moulding and core-making foundry processes.

Pattern making is the process of forming a likeness of the final casting so that a mould can be made.

The major hazards associated with the pattern shop are:

- reinforced plastic resins, epoxy resins and adhesives (skin and respiratory problems)
- catalysts used in urethane systems e.g. formaldehyde and mould release paints (respiratory sensitisation)
- wood dust (sensitisation of the nasal passages)
- noise from woodworking and metal machining
- fire/explosion from patterns and dust – controlled and uncontrolled
- falling objects from storage and movement of patterns

- manual handling of heavy and awkward items
- cranes and forklift plant
- machinery e.g. rotating and cutting parts
- electric shock
- falls from heights during pattern retrieval and storage.

## Core shop

The core shop is primarily concerned with processing and curing cores. Tasks include core moulding, blowing/shooting, painting and stoving.

### Core moulding

Core moulding is the process of mixing sand and binders to give the necessary strength to the core.

### Shell coremaking

This process uses specially manufactured shell sand, which is pre-coated with a thermal setting resin. Shell core machines can be semi automatic or fully automatic.

### Core blowing/core shooting

Core blowing/shooting is the manual or machine manufacture of cores using various types of sand and binding resins.

### Core painting

Once the core has been moulded the core is sprayed, brushed or dipped with water or solvent based refractory mould paint (usually zircon and graphite based).

Hazards associated with the core shop area include:

- direct skin exposure to hazardous substances used in the core preparation, curing and painting e.g. amines and formaldehyde and sand binder system ingredients include toluene, phenol, furfuryl alcohol and isocyanates
- atmospheric contaminants from the sand crystalline (silica), binders systems and baking fumes from core making process e.g. carbon monoxide, ammonia and hydrogen cyanide
- compressed air during the core preparation
- noise
- manual handling of heavy and awkward items, such as cores/boxes
- slips, trips and falls from sand and poor housekeeping
- radiation from zircon sand
- fire and explosion from flammable gases and liquids
- uncontrolled emission of compressed gas
- sand under pressure.

## Moulding shop

Mould making involves the use of a sand mixer and dispenser. The mould box and pattern are placed underneath the dispenser or hopper where they are filled with the sand/binder mix. The other alternative is pit moulding, where the pattern is formed in an excavated area and kibbled sand is dispensed into the mould.

Hazards associated with the moulding shop include:

- direct skin exposure to hazardous substances used in the mould preparation e.g. esters, solvents, isocyanates, phenol, formaldehyde, furfuryl alcohol
- inhalation exposure to atmospheric contaminants from the volatile mould binders, catalysts (sulphur dioxide, amines, acids) and dust (crystalline silica)
- misuse of compressed air
- noise
- manual handling of heavy and awkward items e.g. cores and mould boxes
- awkward postures and repeated vibrations associated with ramming moulds
- slips, trips and falls
- fire and explosion from flammable gases and liquids.

## Furnace section

### Types of furnaces

#### **Electric arc furnace**

This type of furnace draws an electric arc that rapidly heats and melts the charge material. When the melt is ready to pour, the electrodes are raised and the furnace is tilted to pour the molten metal into a receiving ladle.

Electric arc furnaces produce tremendous quantities of metal fume, however, the furnace is normally equipped with a fume capture system to reduce both workplace and air pollution.

Noise is also a serious problem with these furnaces, due to the intermittent make-and-break of the arc. These furnaces are common in large ferrous foundries.

#### **Ladle furnace**

In some foundries, a ladle furnace is used for metallurgical refining and holding of molten metal in a ladle. The principal operation is very similar to an electric arc furnace and would have similar hazards.

#### **Induction furnace**

Induction furnaces are cylindrical or cup shaped refractory lined vessels surrounded by water-cooled copper coils. The coils are energised by an alternating frequency current, which produces a fluctuating electromagnetic field. This induces a current in the metal and causes it to melt.

Electrically powered induction furnaces are used to process higher grades of cast iron, steel and non-ferrous metals. These furnaces generate the least noise and nuisance heat. Induction furnaces are used widely in both nonferrous and ferrous foundries.

#### **Crucible furnace**

This furnace is widely used for non-ferrous alloys. The crucible is filled with the metal charge and is heated directly by electricity, gas or oil burner, or coke. Scrap metal is cleansed and heated before introducing it into the furnace as any oil or moisture could cause an explosion.

The principal hazards in using this type of furnace include:

- carbon monoxide
- metal fumes
- noise
- heat.

In non-ferrous foundries, significant amounts of lead and zinc fumes are produced from the melting of alloys containing these elements. Also, the fluxing of these alloys results in copious amounts of metal fume being produced.

### **Cupola furnace**

Some ferrous foundries use cupola furnaces. The cupola is a vertical shaft-like furnace, consisting of a cylindrical steel shell lined with refractory materials and equipped with a wind box and tuyeres (nozzles which direct the air into the bed of coke).

Removal of molten metal for intermittent tapping cupolas is controlled by a process called 'botting'. The major hazard with this process is that the incorrect botting of the discharge hole may allow molten metal to continually flow.

Major hazards from cupola furnace operation are:

- carbon monoxide fumes
- oxygen deficiency
- heat, especially on or around the charge platform.

## **Furnace processes**

### **Charging**

Charging is the process of actually getting the raw materials such as coke, pig iron, limestone and scrap iron or steel into the furnace. Moist charge material introduced to molten metal is extremely dangerous and may lead to violent splattering or eruption of the molten metal. Enclosed pieces of pipe or other material that may contain trapped air or oil pockets may also cause a violent explosion of the molten metal.

The main hazards associated with furnace charging include:

- exposure to toxic metal fumes
- carbon monoxide
- other toxic gases
- heat stress
- noise
- manual handling
- contact with molten metal.

### **Melting**

Melting is the actual liquefying of the charge material. A variety of furnace types are used for melting metals.

### **Removal of slag**

The removal of slag is the process of removing unwanted debris from the melt either manually or with the aid of limestone additives.

### **Refining**

Refining is the process of bringing the molten metal to a predetermined chemical specification by removing unwanted contaminants.

## **Tapping**

Tapping is the process of pouring the molten metal from the furnace into a ladle.

## **Furnace maintenance**

The refractory linings of the furnace need to be patched or renewed to prevent metal runout and contamination. This is a two-step process:

- Knocking out of furnace and ladle linings
  - This process requires the removal of the residual solid metal and slag stuck to the furnace or ladle wall, then the removal of the refractory materials.
  - The main hazards include working in confined and awkward spaces and the potential to be exposed to atmospheric contaminants, such as silica dusts.
- Relining the furnace or ladles
  - Refractory bricks, mortar, cement and mouldibles are used to reline furnaces and ladles. These are layered or installed inside the furnace or ladle in predetermined positions.

Other hazards common to the furnace area include:

- noise
- falling equipment and objects
- material handling
- slip, trips and falls
- electric shock
- molten metal
- thermal conditions
- falls from heights (e.g. cupola platform)
- radiation (e.g. ultraviolet, infra-red, electromagnetic)
- ejection/explosion due to bridging and contaminated charge material
- oxy-boiling of carbon
- liquid sintering (e.g. a process for hardening of the lining with molten metal).

## **Spectrograph section**

A spectrograph is used to check the chemical analysis of small samples of molten metal for refining purposes.

Hazards associated with the spectrograph section include:

- gases from ionising processes (e.g. ozone)
- heat
- molten metal
- electric shock
- getting caught in rotating parts (e.g. finishing wheels)
- flying objects.

## **Cast floor**

### **Pouring and cooling**

In automated foundries, moulds are conveyed to the pouring ladle using a 'mould fill' control device. In other foundries, the ladle is transported to the moulds mostly by overhead cranes.

Hazards associated with pouring and after cast include:

- combustion gases from decomposing binders e.g. carbon monoxide, and particulate smoke
- other atmospheric contaminants e.g. sulphur dioxide from breakdown of catalysts such as benzene sulphonic acid.

### **Shakeout or knockout**

The casting is removed from the mould at the shakeout or knockout area. In some cases, the mould is placed on a vibrating screen or grid and the moulding sand falls through the screen into a hopper or sand collector and returned by conveyor for reconditioning. The hot castings are mechanically removed for cleaning in the after-cast area.

Hazards associated with the shakeout and knockout include:

- vibration from knockout process or machinery
- atmospheric contaminants (e.g. respirable silica, phenolic resins)
- noise
- slips, trips and falls
- manual handling of materials or tools (e.g. sledge hammers)
- trapped by moving machinery
- contact with hot castings
- falling objects (e.g. castings)
- low level radiation from zircon sand.

## **Fettling shop**

This is the process of stripping away unwanted metal to produce the finished cast product and can include the processes of abrasive blasting, arc air, oxy-cutting, dressing, welding and heat-treating.

### **Abrasive blasting**

The two most common forms of abrasive blasting techniques used in the foundry industry are abrasive grit and shot blasting.

#### **Abrasive grit**

This process uses high-pressure air to propel abrasive grit at the surface of the casting to remove sand. For large castings, this is generally undertaken in a blast chamber by an operator dressed in appropriate personal protective equipment. For small castings, an abrasive blasting cabinet is often used.

#### **Shot blasting**

In this process, steel shot is projected by a 'slinger' (a spinning wheel containing blades) in a predetermined pattern. Castings placed within this shot blast pattern area are cleaned by the abrasive action of the steel shot.

The *Abrasive Blasting Code of Practice* provides practical advice about ways to manage exposure to risks identified in abrasive blasting and associated work.

#### **Arc-air process**

This process involves arc heating of the casting using electrical equipment similar to an arc-welder.

## **Oxy-cutting**

Oxy-cutting is used to remove metal projections that are unable to be knocked off by other means, or where breakage of the casting may occur, for example, carbon steel castings.

## **Dressing**

This process involves the removal of unwanted metal protrusions from the casting by mechanical means.

## **Welding**

In the foundry industry, welding techniques are mainly used for repair or reworking of castings that are not acceptable in their condition as produced from the casting process.

## **Heat treatment**

Heat treatment involves the improvement in the properties of materials used in the casting by bringing about certain permanent structural changes. This involves further heating of the casting in a heat treatment furnace or oven by closely controlled heating application rates and temperatures. Cooling involves either a controlled cool down in the oven or furnace, air cooling, or quenching in water or special oils.

Hazards associated with the fettling shop include:

- flying objects (e.g. metal dust and fragments)
- respirable crystalline silica and inhalable metal dusts
- toxic dust
- falling objects (e.g. castings and pieces of metal waste)
- noise
- vibration
- manual handling
- heat
- metal fumes (e.g. iron oxide, manganese oxide)
- gaseous contaminants (e.g. ozone produced in electric arcs)
- radiation from welding
- electrical
- slips, trips and falls
- fire
- compressed air
- arc flash
- working in confined spaces
- working at heights
- plant and equipment.

## **Sand plant**

### **Sand reclamation**

This involves the collection, channelling and reconditioning of spent sand for reuse in the foundry process.

Hazards that may be encountered include:

- atmospheric contaminants including respirable silica
- working in confined spaces (e.g. sand sampling)
- conveyors

- moving machinery
- noise
- falls from heights
- pressure build-up during sand transportation
- working with hot sand and foreign objects.

## Major foundry hazards

This section provides information about some of the potential hazards that have been identified in the foundry industry and provides guidance in managing exposure to the risks associated with these hazards.

Major hazards in the foundry industry are:

- working in heat
- hazardous substances
- dangerous goods
- airborne contaminants
- manual tasks
- noise
- vibration
- molten metal
- plant and machinery
- electricity.

In this code of practice, the control measures for managing exposure to risk are presented by priority. This is an order that tells you which of the control measures provides a better level of risk control. You should use control measures that are presented first, wherever possible.

You must manage exposure to the risks associated with **all** hazards at your workplace, and there may be additional risks at your workplace that have not been specifically addressed in this code of practice.

You are still required under the Act to identify and assess these risks and ensure that control measures are implemented and reviewed to eliminate or minimise exposure to these risks.

The *Risk Management Code of Practice* provides a five step process for managing exposure to the risks arising from workplace hazards.

## Working in heat

The furnaces and molten metal in a foundry create a hot working environment. The heating of moulds and cores, the preheating of ladles and the heat treatment of metal castings create additional sources of heat.

Workers engaged in furnace or ladle slagging and those working closest to molten metal, including furnace workers, metal pourers, welders, arc-air operators, oxy-cutters and crane operators, experience the most severe exposures to heat.

The human body is able to function normally within 1°C to 1.5°C of a 37°C core body temperature. The body maintains this temperature by balancing heat generated within the body and heat loss with the environment.

Working in hot environments causes strength to decline, and fatigue occurs sooner than it would otherwise. Alertness and mental capacity may be affected also.

### **Health effects of heat exposure**

Where the body is unable to lose heat fast enough through the evaporative cooling process to maintain a steady core body temperature, it begins to experience physiological heat strain with different illnesses depending on the degree of heat stress.

Potential health effects for persons under increasing levels of heat stress include:

- discomfort
- heat fainting
- heat stroke
- prickly heat
- irritability
- dehydration
- reduced concentration or attention
- heat rash
- reduced tolerance to chemicals and noise exposure
- heat cramps
- heat exhaustion
- heat stroke.

Heat cramps, heat exhaustion and heat stroke are the most serious forms of heat illnesses. Heat stroke is a life threatening condition and may result in permanent damage to the heart, kidneys and brain. The effects of heat stress are most likely to increase during the summer months.

### **Acclimatisation**

Persons who work regularly in a hot environment become acclimatised to a certain level of heat. Acclimatisation reduces heat discomfort, increases the effectiveness of sweating, reduces salt loss and returns recovery rate to normal. Persons differ in their ability to acclimatise to heat.

Acclimatisation provides only partial protection from extreme heat and adverse health effects to exposed workers may still occur. Once exposure to heat has ceased, the protection from acclimatisation is progressively lost. A worker who has been absent from a hot work environment for an extended period, such as a week, should be re-acclimatised to the hot environment to avoid heat related effects.

### **Factors governing heat stress**

The main factors that must be considered as contributing to heat problems are:

- Job factors:
  - work of a strenuous nature
  - work that is sustained for extended periods
  - awkward or uncomfortable body posture
  - inadequate cooling off or rest periods.
- Environmental and seasonal factors:
  - high air temperatures
  - radiant heat from hot objects such as machinery

- radiant heat from working outdoors in the sun
- higher relative humidity levels
- low air movement.
- Worker factors:
  - excessive or inappropriate clothing, protective or otherwise
  - level of acclimatisation
  - degree of proper hydration
  - accessibility to water and cool recovery areas
  - medical fitness e.g. heart, circulatory or skin disorders
  - medication that impairs temperature regulation or perspiration (check with doctor)
  - age
  - weight
  - extent of physical fitness
  - inadequate salt in the diet
  - tiredness or being run down.

## Control measures for limiting heat stress

### **Elimination controls**

Eliminating situations that could lead to heat related illnesses is the best form of control strategy.

This can be done by:

- eliminating unnecessary sources of radiant heat
- eliminating sources of water vapour in the workplace (ie. leaks from steam valves, evaporation of water from wet floors, etc).

### **Altering the work environment**

Various control measures that are effective in preventing or minimising exposure to risk by reducing heat in the workplace include:

- reducing radiant heat emissions from hot surfaces and plant e.g. by insulation and shielding
- modifying the air temperature, relative humidity and air movement using general or local ventilation, spot coolers, blowers, fans, air conditioning
- reducing the body's metabolic heat production using automation and mechanisation of tasks
- using ventilation e.g. installing flues extending from a foundry to the open air to ventilate cooling racks and fixed heat sources
- humidity reducing methods (e.g. install a dehumidifier — seek engineering advice).

### **Administrative controls**

Administrative controls largely involve the development of safe working practices and procedures.

These controls may include:

- rescheduling hot work to cooler parts of the day and maintenance to cooler seasons
- encouraging workers to take short breaks
- allowing new workers or workers returning from holidays to acclimatise to the heat
- decreasing heat exposure duration e.g. by rotation of workers
- scheduling regular work/rest breaks in cool, shady areas with protective clothing removed
- isolate hot work practices to times/locations distant from other workers
- consider job sharing/rotation or using extra workers
- screen workers for heat intolerance (e.g. those with heart and blood pressure problems or previous heat illness)

- training of workers in the hazards associated with working in heat and recognising heat related illnesses, safe work practices, control measures and the use and maintenance of personal protective equipment
- introduction of a ‘buddy system’ where workers and supervisors in hot work environments look out for early signs of heat illness in fellow workers
- limit consumption of diuretics e.g. caffeinated drinks and alcohol
- workers to seek medical advice - if on medication that may interfere with heat tolerance (e.g. blood pressure medication, sedatives, and antidepressants)
- provision of reasonable access to an adequate supply of clean and cool drinking water. (e.g. as a rule of thumb, workers doing hot work should drink a cup of water every 15 to 20 minutes.)
- develop a contingency plan for the treatment of affected workers.

### **Personal protective equipment (PPE)**

Where exposure to heat cannot be prevented or reduced by any other form of control, all exposed persons must be provided with PPE<sup>1</sup>. PPE may be used in addition to other control measures.

PPE designed to protect persons in hot environments may include:

- eye wear, such as ultra-violet glasses
- non-flammable and heat reflective clothing and equipment
- water cooled bodysuits/vests and other equipment
- protective gloves and footwear.

## **Hazardous substances**

Hazardous substances are widely used in the foundry industry. For a relevant person who is an employer or self-employed person at a workplace a “hazardous substance” means a substance for which its supplier must (under the provisions of the *Workplace Health and Safety Regulation 2008*) give an employer or self-employed person its current Material Safety Data Sheet (MSDS).

Workers are likely to come into frequent contact with hazardous substances in the areas of pattern making, mould making, core making, casting and protective coating.

Hazardous substances common to the foundry industry include:

- amines
- benzene
- hexachloroethane
- ammonia
- epoxy resins
- formaldehyde
- furfuryl alcohol
- isocyanates
- mould release paints
- protective coatings
- phenol.

There will also be a number of substances generated directly by processes in a foundry for which no MSDSs have been supplied. They are usually present as air contaminants and should be treated with equal concern as hazardous substances. (See section on airborne contaminants)

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<sup>1</sup> PPE may be used in addition to other control measures.

## **Health effects of hazardous substances**

Hazardous substances can enter the body through inhalation, skin contact or by accidental ingestion. Different hazardous substances have different effects, including fire, explosion, and short and long term effects on specific organs of the body.

Prolonged exposure to hazardous substances may result in the following health effects:

- headaches
- nausea
- fatigue
- irritant or allergic dermatitis
- asthma
- bronchitis
- chemical burns
- irritation of the nose, eyes and respiratory tract
- adverse effects on the central nervous system and other bodily systems, including the lungs, kidneys and liver.

## **Managing the risk**

*Part 16 (Hazardous Substances) of the Workplace Health and Safety Regulation 2008* sets out the requirement of a relevant person to assess the risks to health from a hazardous substance that is used at the workplace.

The following issues should be considered when hazardous substances are used in the workplace:

- how hazardous substances should be used
- how persons are exposed to hazardous substances
- whether the risk from the hazardous substance is significant
- how exposure to hazardous substances in the workplace should be controlled.

A 10-step plan outlined in the *Hazardous Substances Code of Practice* should be followed to assist in managing the risks associated with hazardous substances in the workplace.

## **Assessing risk**

An assessment is the examination of ways in which a hazardous substance is used at work and the health risks involved.

The purpose of the assessment is to enable decisions to be made about appropriate control measures, training, monitoring and health surveillance.

These decisions will depend on the risk that arises from the use of a hazardous substance under particular working conditions.

All the factors in a risk assessment are interconnected. For the purposes of performing an assessment, the following factors should be considered in isolation and then considered in their combined effect:

- the risk associated with the hazard (e.g. substances are inhaled, get on skin or in eyes)
- the probability that an event or an exposure will occur
- the period of exposure a person has to the hazard (ranging from occasional to continuous contact with the hazard)
- the possible consequences that may result (e.g. causing liver disease, cancer and burns).

Assessment reports should reflect the detail of the assessment and provide sufficient information to show how the decisions about risk and controls were made. Records must be kept about the risk assessments conducted.

### **Material safety data sheets (MSDSs) and registers**

Material safety data sheets (MSDSs) provide information on hazards associated with a hazardous substance and the minimum safety requirements for its safe use. MSDSs should be referred to as part of the risk assessment and can assist in determining the most appropriate control measures.

Each hazardous substance has its own MSDS that must be provided by the supplier. If the supplier does not provide an MSDS, you have an obligation to ask for a copy of the current MSDS.

A readily accessible hazardous substances register must be kept at the workplace. This should contain a list of all the hazardous substances used and the MSDSs for these substances.

Where workers are exposed to a hazardous substance, the level of exposure must not be more than the Workplace Exposure Standard (WES) for the period stated in the document *Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment* [NOHSC:1003(1995)]. Appendix 1 contains information on the uses, health effects and exposure standards for hazardous substances commonly encountered in foundries.

The WES for a particular substance should also be stated in the MSDS; however this should be checked to ensure it is current during the risk assessment process.

### **Control measures**

Control or prevention of exposure is undertaken by implementing appropriate control measures. Control measures are not mutually exclusive and in some circumstances two or more control measures may be required to reduce exposure to as low a level as is practical.

### **Elimination**

Where a work activity involves the use of a hazardous substance that is not essential to the work activity the hazardous substance should be eliminated, wherever practical.

Examples of elimination include:

- using a physical process rather than a chemical process to clean an object, (e.g. use of ultrasound)
- using clips, clamps or bolts instead of adhesive
- purchasing supplies of a material in a ready-cut and sized form rather than carrying out a dust producing cutting process on site.

### **Substitution**

This can be accomplished by substituting:

- a substance with a less hazardous one
- a substance with a less hazardous form (e.g. granular instead of powder)
- the same substance in a less hazardous process.

Examples of substitution include:

- substituting toluene for benzene
- substituting tablets which produce nitrogen gas or rotary degassing with argon or nitrogen gas for hexachloroethane tablets or chlorine gas
- substituting solvent-based coatings with water-based coatings

- substituting spray painting processes (when coating cores) with brushing or dipping processes.

### **Isolation**

Isolation involves separation of the process from people by distance or the use of barriers or time to prevent exposure.

Examples of isolation include:

- using a separate room for the mixing and use of epoxy resins in the pattern making section, with access to the room restricted to authorised persons wearing appropriate protective equipment
- using an exclusion zone around work areas where hazardous substances are being used to prevent the access of unprotected persons.

### **Engineering controls**

The risks from hazardous substances may be managed using engineering controls.

These may involve the use of plant or processes which:

- minimise the generation of a hazardous substance
- suppress or contain a hazardous substance
- limit the area of contamination in the event of spills or leaks.

For example, an effective measure to minimise exposure to fumes from hazardous substances is to remove the contaminated air directly from the source.

This can be achieved by using local exhaust ventilation that usually consists of:

- a hood which captures the fumes at its point of generation
- a ducted system with an appropriate airflow
- an air cleaning system to prevent pollution of the general atmosphere
- an exhaust fan
- a stack or other means of dispersion of the cleaned air to the atmosphere.

These exhaust systems should be carefully placed so the draft of contaminated air being drawn into the extractor does not pass through the worker's breathing zone. Fresh air should also be directed into the work area to replace the air being removed.

### **Administrative controls**

Administrative controls are work practices that require people to work in safer ways and are intended to limit the extent of exposure to a hazardous substance. Some issues for consideration include:

- excluding non essential persons from a work area
- shift or work rotation to reduce the period of exposure for workers
- regular cleaning of contamination from walls and surfaces
- providing means for safe storage and disposal of a hazardous substance
- prohibiting eating, drinking and smoking in contaminated areas
- prohibiting the use of compressed air for personal cleaning purposes
- vacuuming dust from areas where cutting processes take place
- keeping lids on containers when not in use
- providing and using facilities for effective decontamination
- providing first aid, safety showers and eye wash facilities, evacuation procedures and emergency procedures

- ongoing training about the substance and the safe use and maintenance of personal protective equipment
- regular application of barrier creams (two hourly and after washing hands) to the face, neck, forearms and hands - may also assist removal of a chemical after accidental splashes
- using disposable containers for mixing and pouring - under no circumstances should food containers be used for this purpose
- cleaning chemical spills immediately
- regularly maintaining ventilation and exhaust systems
- providing hand cleaning facilities and educating workers about personal hygiene prior to eating, drinking and smoking.

### **Personal protective equipment**

Where exposure to hazardous substances cannot be prevented or reduced by any other form of control, all exposed persons must be provided with personal protective equipment (PPE).

The basic personal protective equipment available to guard against risks from hazardous substances includes respirators, goggles, face shields, gloves, footwear and aprons. Self contained breathing apparatus or hazardous chemical suits may be required if the risk of exposure is significant because a hazardous substance is present in an uncontrolled environment.

Issues that need to be considered include:

- nature of the substance, the degree of exposure and the nature of the work in selecting PPE
- using overalls, gloves, mittens and safety boots where there is a risk of absorption through the skin: gloves should not be made of cotton and should be impervious, chemical resistant and washable
- use of respiratory protection where there is a risk of inhalation of vapours or particulates - air purifying respirators (with dust filters and/or gas absorbers) and supplied air devices (demand breathing or positive pressure airline respirators, powered air purifying respirators [PAPR], self contained breathing apparatus with half or full-face respirator or hoods).

### **Review of control measures**

All measures for the control of exposure should be thoroughly examined and tested at regular intervals to ensure effective performance. Controls should be reviewed if work - related ill health is reported.

The *Hazardous Substances Code of Practice* provides advice on ways to identify and manage specific risks that arise when hazardous substances are used at the workplace.

## **Dangerous goods**

This section provides some simple advice to foundry occupiers about their obligations for storage and handling of dangerous goods and combustible liquids. Dangerous goods are materials that are classified on the basis of their ability to cause immediate harm to people, property and the environment. Dangerous goods properties may include an ability to cause or contribute to fire, explosion, corrosion, radioactivity, toxicity, asphyxiation, or environmental harm.

These materials may be dangerous because of one or more of the following properties:

- an ability to cause or accelerate combustion
- acute toxic effects
- an ability to cause corrosion of skin and other materials

- capacity to harm the environment
- potential to cause asphyxiation by displacement of oxygen
- temperature or pressure hazards
- ability to react with other materials adversely.

Table 2 in Appendix 2 shows examples of stated dangerous goods or combustible liquids used in foundry operations.

### **Identifying dangerous goods**

Dangerous goods are assigned to one of nine primary risk classification categories, based on series of chemical tests and criteria established by the United Nations. The primary risk can be recognised by Class diamonds present on the product label. These are shown in Figure 1 in Appendix 2.

Dangerous goods will also be assigned with a Proper Shipping Name, a 4 digit United Nations number (U.N. number) and may be assigned with a subsidiary risk. In most instances dangerous goods will be assigned to a packing group (PG) of either I, II, or III that denotes the level of hazard for the primary risk the material has been assigned to. Goods assigned with PG I are the most dangerous with PG III the least dangerous. Not all dangerous goods are allocated with a packing group.

Combustible liquids (e.g. diesel fuel) are designated as either C1 or C2 combustible liquids. A C2 combustible liquid has a flashpoint between 61°C to 150°C. A C1 combustible liquid has flashpoint exceeding 150°C. This information can be obtained by reviewing the “Chemical and Physical Properties of a material safety data sheet, (MSDS).

The objective of dangerous goods safety management is to protect people, property and the environment by establishing systems for the prevention, preparedness and mitigation of emergencies involving dangerous goods or combustible liquids (e.g. fire, explosion, toxic release, spill, etc).

### **Legislation**

The safe storage and handling of dangerous goods, goods too dangerous to be transported and combustible liquids is covered by the following legislation in Queensland:

- *The Dangerous Goods Safety Management Act 2001 (DGSM Act)*
- *The Dangerous Goods Safety Management Regulation 2001 (DGSM Regulation).*

The DGSM Regulation provides a comprehensive array of storage and handling requirements based on the quantities of stated dangerous goods, goods too dangerous to be transported and combustible liquids present on site. Stated dangerous goods include dangerous goods of Class 2, 3, 4, 5, 6.1, 8, 9 and goods too dangerous to be transported.

Occupiers of a site have obligations based on the site classification which is based on the quantities of stated dangerous goods or combustible liquids stored or handled on site. A place may be classified as one of the following:

- a workplace using dangerous goods in minor quantities (MSW),
- a dangerous goods location (DGL), or
- a large dangerous goods location (LDGL).

A summary of the requirements under the DGSM Act and Regulation is provided in Table 1 in Appendix 2, “Overview of DGSM Requirements”.

If dangerous goods are stored or handled in the foundry, the site must be classified, to comply with requirements relating to the classification.

Further information regarding this legislation can be obtained from the Department of Emergency Services website at [www.emergency.qld.gov.au](http://www.emergency.qld.gov.au).

### **Information about dangerous goods**

The first stages in managing dangerous goods safety are to identify the dangerous goods or combustible liquids, ascertain the hazardous properties and safe handling precautions that may be required.

The following actions will ensure that workers and others in the foundry can obtain sufficient information about dangerous goods or combustible liquids so that they can identify hazards, assess the risks from their storage and handling, and implement effective control measures.

- Review the package markings and label to identify each of the goods as dangerous goods.
- Review the MSDS to determine the identity, appearance, physical and chemical properties, health effects, precautions for use, and safe handling practices.
- A copy of each MSDS must be obtained for each dangerous goods or combustible liquids on site. These must be kept in your register along with the name of each stated dangerous goods and combustible liquids.
- The register may be shared with your hazardous substances register, as there is no need to duplicate this requirement.
- A copy of each MSDS must be made available close to where workers who may be exposed can refer to it easily.

### **Carry out and record a hazard identification and assessment of risk**

After reviewing the packaging information and MSDS you are required to identify and record the hazards for each of the dangerous goods and combustible liquids and assess the risk from the way you store, handle or use the goods or liquids.

Once you have identified the hazards you must assess the risk and determine appropriate control measures if you have not ensured that risk has been minimised as far as reasonably practicable.

This assessment must be recorded and made available to workers.

### **Induction, information, training and supervision**

All workers who may be effected by the storage or handling of the dangerous goods or combustible liquids must be provided induction, training, information, and effective supervision.

The nature of the training and information must be relevant to the tasks being informed and the risks to each person.

### **Controlling ignition sources where flammable atmospheres may exist**

In areas where flammable liquids or gases (e.g. methyl formate, toluene, xylene) are being stored or handled and may give rise to potentially flammable atmospheres (hazardous areas), the following controls are required.

- Areas must be classified in accordance with AS 2430 Series *Classification of hazardous areas*.
- Hazardous areas must be clearly marked and sign-posted.
- Ignition sources (e.g. naked lights, electrical equipment, mobile phones) must be removed or controlled in those areas.

- Electrical equipment operated in the area must be appropriately designed for use in the hazardous area.
- Hot work permit systems may need to be considered.

### **Segregation of incompatible goods and other materials**

Segregation relates to the practice of separating materials that are incompatible. Two or more goods are incompatible if they may react or combine in a manner that may present a hazard (e.g. explode, emit toxic flammable or corrosive gases) or cause deterioration of the containers or their contents.

Where two goods are incompatible they should be stored at least 3m apart. Where the goods may react violently a distance of at least five metres apart is recommended. Alternatively impervious, fire rated, vapour proof, physical barriers may be used.

### **Separation from protected works**

Separation is the practice whereby dangerous goods stores are separated from 'protected places' where members of the public may be at risk in an emergency situation.

Protected places may include each of the following as examples.

- dwellings, places of worship, public buildings, schools, colleges, hospitals, theatres, within or outside of the installation
- a factory, office, workshop store, building outside of the boundary of the installation
- a vessel lying at permanent berthing facilities
- the property boundary.

Dangerous goods stores should be located at appropriate distances from protected places in order to protect people and property during a hazardous materials emergency. This can be done using appropriate distances or physical barriers. The distances required will depend on the nature and quantity of goods stored or handled on-site.

### **Spills management**

The principal means of spills management is by containing spills and by cleaning them up promptly. Spills are usually contained by providing storage areas with a bund of sufficient capacity to retain a rupture of a container or tank of combustible liquids or liquid dangerous goods. In some minor storage areas, a drip tray may be adequate.

Provision must be made to ensure appropriate systems and materials are provided on-site to promptly and safely clean up spills that could occur during storage and handling operations.

### **Provision of safety equipment and personal protective equipment (PPE)**

Occupiers of places need to ensure that appropriate personal protective equipment (e.g. gloves, respirators, chemical splash suits, breathing apparatus) is provided to protect workers and others on-site from exposure to the dangerous goods.

The PPE required will vary on the task. PPE required for routine operations such as decanting may differ from the kind of PPE required in an emergency situation (e.g. cleaning up a spill). The MSDS will provide information on what PPE should be provided.

Safety equipment also is required to be provided and well maintained. This may include but not be limited to the following:

- toxic or flammable gas detection and alarm systems
- eye wash/safety showers for toxic, flammable or corrosive liquids

- escape respirators
- confined spaces rescue equipment
- emergency equipment (e.g. radios, pumps for spills, gases detection equipment)
- audible and visible alarms
- alarm call points.

### **Safety management systems**

All dangerous goods locations are required to have a documented safety management system. The safety management system is an integrated approach to the overall management of risks from storage and handling of hazardous materials. These should be integrated into any existing safety, health and environmental management systems.

A safety management system should provide a systematic framework consisting of policies, systems, and procedures to ensure that the risk to people, property and the environment is minimised.

## **Airborne contaminants**

Significant concentrations of airborne contaminants (e.g. gases, vapours, fumes and dusts) may be encountered in all facets of foundry operations. These contaminants may be encountered in many areas including pattern making, core making, mould making, furnace, fettling and sand plant sections.

In foundries, airborne contaminants may be released by, or generated from:

- the handling of scrap - receiving, unloading, storage and conveying
- scrap preparation using heat and solvent degreasers - carbon monoxide
- the melting process - carbon monoxide, sulphur dioxide, nitrogen oxide, chloride and fluoride compounds
- the treatment and inoculation of molten metal before pouring
- core and mould making processes during sand reclamation, sand preparation and sand mixing
- mould and core forming processes including core baking and mould drying from additives, binders and catalysts,
- cooling of casts causing decomposition of organic binders
- casting knockout and shake-out
- fettling.

Airborne contaminants may also be generated by other foundry processes.

High concentrations of airborne contaminants are produced during furnace operations such as melting and pouring. During melting, carbon monoxide is produced by the combustion of graphite lost from the electrodes and the carbon added to the charge. The amount of carbon monoxide generated is affected by the dust and particulate material on the scrap, the combustion of coke in the furnace and the furnace temperature.

Cupola furnaces characteristically produce sulphur dioxide due to the presence of sulphur in the coke. Chloride and fluoride compounds are also generated from flux additives, salts and scale from the scrap charge and carbon additives, depending on the extent of combustion.

In electric arc furnaces, airborne contaminants may be generated by the vaporisation of molten metal and the transformation of additives.

Prior to pouring, dust may be generated during the treatment and inoculation of the molten metal. The addition of magnesium to molten metal to produce ductile iron results in a reaction that is accompanied by the emission of magnesium oxides and metallic fumes.

Contaminants released during pouring include hot metal fumes. When the mould and core materials contact with molten metal, carbon monoxide, organic vapours, acid gases, smoke and dusts may also be released.

### **Gases and vapours**

Gases are formless fluids that expand to occupy the space or enclosure in which they are confined. Consult the section on dangerous goods for hazards arising from stored gases.

True gases exist in the vapour phase at normal temperature and pressure. Many gases may be stored under pressure as liquids until vaporised for use. If these pressurised gases are not controlled, the workplace breathing air may become contaminated.

Other gaseous contaminants may arise as by-products of foundry processes. In this situation, gases are produced as a result of a chemical reaction or in the breakdown of a complex chemical.

Gases typically to be encountered in a foundry include:

- acrolein
- ammonia
- carbon dioxide
- carbon monoxide
- chlorine
- formaldehyde
- hydrogen chloride
- hydrogen sulphide
- methane
- nitrogen
- sulphur dioxide
- ozone.

Vapours are the gaseous form of a substance that is normally in the solid or liquid state at room temperature and pressure.

Organic chemicals used as solvents, paints, binders and catalysts in foundry processes produce vapours through natural evaporation, heating or spraying.

Vapours likely to be encountered in a foundry include:

- benzene
- dimethylamine
- dimethyl ethylamine
- methyl formate
- isocyanates
- furfuryl alcohol
- formaldehyde
- naphthalene
- toluene
- xylene

- methyl alcohol.

Gases and vapours are mostly invisible; however some may have strong and characteristic odours that may give warning of their presence in a foundry. Alternatively, some gases may have no warning odour and may cause harmful health effects at extremely low concentrations.

Other gases may indicate their presence by various irritating effects such as respiratory irritation, coughing, asthma, acidic taste and watering of the eyes. For example:

- hydrogen sulphide can be detected at low concentrations although it cannot be smelt at higher concentrations due to olfactory fatigue (smell fatigue)
- carbon monoxide does not have any warning odour
- chlorine gas may cause respiratory irritation
- formaldehyde may cause eye irritation.

### **Dust and fumes**

Dust is particulate generated from solids and dispersed into the air by movement, loading, cleaning and handling of organic or inorganic materials such as metal, wood and sand.

Fumes are airborne solid particles that are formed when the material from a volatilised solid, usually molten metal, condenses in cool air. A number of polycyclic aromatic hydrocarbons (PAHs) have been identified in foundry dusts associated with coke, carbon and organic substance pyrolysis.

Foundry operations create dusty conditions exposing workers to various health risks. Foundry workers may be exposed to various types of dust, including nuisance dust, wood dust, metal dust and silica dust. Specific illnesses have been linked with exposure to certain types of dust.

### **Wood dust**

Foundry workers may be exposed to wood dusts during pattern making operations.

The inhalation of wood dusts causes a slowing of dust clearance and alteration to the structure of the mucous membrane lining of the nasal cavity. This may be accompanied by the risk of cancer of the nasal cavity and sinuses. Some wood dusts also act as sensitisers that may manifest itself as a skin rash, inflammation or as an asthmatic condition.

The presence of wood dusts in high airborne concentrations in the workplace also presents a risk of explosion.

### **Metal dust**

Metal dusts and fumes may be released into the foundry environment during the charging of the furnaces and cleaning of castings.

The inhalation of metal dusts may produce diverse health effects depending on the specific metal dust involved. For example:

- iron dust may accumulate in the lungs and cause siderosis
- aluminium dust irritates the respiratory system and may result in chronic non-specific lung disease
- beryllium dust irritates the lungs and may result in tracheobronchitis, pneumonitis and berylliosis, and may also be a possible carcinogen
- lead dust results in systemic poison effects
- manganese dust irritates the lungs and may have a chronic effect on the nervous system

- nickel dust irritates the respiratory tract and some nickel exposures may result in lung or nasal cancer.

### **Silica dust**

Silica dust presents one of the greatest risks to the health of foundry workers. Fine silica dust is produced in foundries by the rubbing, abrading or mechanical action on quartz and which is primarily composed of crystalline silica.

The major foundry operations which produce fine silica dust are mould and core making, shakeout, cleaning of castings, sand reclamation and sand preparation.

The principal health effect associated with silica dust is silicosis, which is stiffening and scarring of the lungs. Silicosis is a chronic disease, and usually takes a number of years for the symptoms to appear. It results in increasing shortness of breath, coughing and chest pain. The effects are irreversible, and lead to degeneration in the person's health, invariably resulting in the premature death of the worker.

Silica is also now classed by the International Agency for Research on Cancer as an occupational carcinogen, where excessive exposures can lead to irreversible lung cancer.

## **Control measures for airborne contaminants**

There are a number of control options that can be used alone, or in combination, to prevent or minimise exposure to the risk.

### **Substitution**

The risks from airborne contaminants may be controlled by substituting a hazardous process or material for a safer one. For example:

- use wet (with caution for recycled sands) or vacuum methods or brushes to remove loose dust or sand in the mould making process rather than compressed air to minimise dust creation
- use chromite sand instead of silica sand.

### **Isolation**

Isolation involves the separation of the process from persons by the use of barriers to prevent exposure. For example, major emission points such as conveyor belt transfer areas can be enclosed. The contaminated air from the enclosure can be passed through a fabric filter into a dust collector.

### **Engineering controls**

Engineering controls may involve the use of plant or processes which:

- minimise the generation of a contaminant
- suppress or contain a contaminant
- limit the area of contamination.

For example:

- High-energy scrubbers and bag houses (fabric filters) should be installed to control contaminants arising from cupola and electric arc furnaces.
- Canopy hoods or other special hoods near the furnace doors and tapping outlets can be used to capture contaminants and reroute them into and through an emission control system.
- Cupola furnaces may be provided with catalytic incinerators or an after burner system located in the furnace stack to oxidise carbon monoxide and to burn organic fumes, tars and oils.

- A collection and venting system should be installed to capture airborne contaminants and vent to the outside atmosphere. The contaminated air being drawn into the system should not go through the breathing zone of the worker. Fresh air intake should be made available to the work area to replace the air being removed.

### **Administrative controls**

Administrative controls largely involve the development and training of workers in safe work practices and procedures that should be used in combination with other control measures for airborne contaminants.

For example:

- use of continuous monitoring devices to monitor the levels of carbon monoxide in the work area
- systematic monitoring to ensure airborne contaminants are within the Workplace Exposure Standard (WES). (See appendix 1 for more information on exposure standards)
- training in safe work practices and use and maintenance of personal protective equipment.

### **Personal protective equipment**

Personal protective equipment that can be used in the control of airborne contaminants includes:

- face and eye protection
- respiratory protection appropriate to the contaminant (where the contaminant level cannot be reduced to below the workplace Exposure Standard)
- respirators with organic vapour filters for organic vapours.

## **Manual tasks**

‘Manual tasks’ are part of nearly all work done by workers. They include any activity where workers grasp, manipulate, carry, move (lift, lower, push, pull), hold or restrain a load.

Workers in most areas within a foundry would perform manual tasks. The areas that involve frequent performance of manual tasks include pattern and core making, moulding, fettling shops, stores and dispatch, inspection and surface coating area.

The *Manual Tasks Code of Practice* provides information regarding risks associated with musculoskeletal disorders and manual tasks and provides guidance when identifying and controlling these risks.

### **What are the risks of injury when performing manual tasks?**

Over a period of time, damage to the low back, upper back or shoulder can gradually build up through:

- handling of loads – frequent lifting with the back bent or twisted, or pushing/pulling loads
- working in a fixed position with the back bent, continuous sitting or standing, or driving vehicles for long periods
- repetitive work with the hand or arm, and having to grip tools or loads tightly
- working with the neck, shoulders and arms in a fixed position (e.g. using tools and handling heavy loads).

### **Control measures for manual tasks**

Control measures for manual tasks fall into two major categories – design and administrative controls as demonstrated below:

## Design controls

These controls involve the arrangement, or alteration of the work process or physical aspects of the workplace such as equipment or work stations.

- **Job design and redesign** - where there is a high degree of risk associated with performing a manual task, job redesign should be the initial consideration. Manual handling risks may be removed by redesigning equipment or work practices.

The aim is to take into account all the factors that affect the task so the whole job is without likely risk to the health and safety of the worker. Wherever practical, jobs should be redesigned to reduce the amount of force required to carry out the tasks and include a mixture of repetitive and non-repetitive work.

Examples include:

- core stacking and storage - move cores from conveyor belt to a trolley and where practical, utilise hoists, cranes or scissor lifts
  - position tasks at comfortable working height using hoists and cranes where possible (i.e. welding and cleaning of castings).
- **Provide mechanical aids** - if redesign is not practical, mechanical devices, which assist workers to carry out their tasks without risk of injury, should be provided and maintained. The aim of mechanical devices is to remove or reduce the need for workers to use physical force or repetition to move a load.

Some devices that may reduce the burden of manual handling include:

- conveyor systems
- cranes
- hoists
- forklift trucks
- roller systems.

## Administrative controls

Administrative controls involve designing policies, procedures and work practices to reduce exposure to the risk of a musculoskeletal injury due to the performance of manual tasks. This extends to the provision of specific training and supervisory practices.

- **Task-specific training** - education and training in relation to the performance of manual tasks is part of the requirements of the *Manual Tasks Code of Practice*. This includes training in the correct use of mechanical devices, such as hoists and trolleys, as well as safe performance of the specific manual tasks.
- **Work organisation** - consideration should also be given to the amount of time a worker is required to perform any one task. Methods such as job rotation may be used to vary the tasks a worker performs to allow the worker to adopt a number of different working postures and reduce fatigue on isolated muscle groups.
- **Preventative maintenance programs** - service and maintain tools on a regular basis. This will ensure the effort needed to operate them is not increased.
- **Personal protective equipment (PPE)<sup>2</sup>** - PPE and clothing either because it is lacking or unsuitable, can increase the potential for injury. For instance, incorrectly sized gloves interfere

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<sup>2</sup> Abdominal belts are not considered effective PPE as they have not been shown to offer protection against the risk of back injury.

with a worker's gripping ability and manual dexterity and so contribute to increased muscular effort and fatigue.

To prevent a decrease in work efficiency or an increase in injury potential, consider the following:

- Clothing which restricts the ability to move freely should not be worn.
- When gloves have to be worn:
  - provide different sizes so the right size can be selected
  - cover only the area of the hand necessary to protect the worker (vibration).
- Provide knee protectors for work involving kneeling to reduce stress on the knee.

## Noise

Noise is unwanted sound that may damage a person's hearing. The amount of damage caused by noise depends on the total amount of energy received over time. This means as noise becomes louder, it causes damage in less time.

### Noise in the foundry industry

In the foundry industry, hazardous noise levels are produced in many operations. The noise created by foundry machinery is complex due to the wide variety of noise sources and whether it is constant or intermittent. These noise sources include:

- machinery used in pattern making - bandsaws, circular saws
- moulding machinery - machinery used in jolt and squeeze operations, pattern vibrators, compressed air blow-off, air circulation fans
- core-making machinery - fans, air nozzles, air exhaust fans, pneumatic equipment, gas jets, pattern/mould vibrators
- furnaces - arc furnaces
- shake-out and knockout of castings
- machinery used in tumbling, grinding and cleaning of castings
- fettling and dressing of castings.

Noise levels can be expected to range between about 80 and 116dB(A). For example:

### Typical noise sources

*At operator ear level:*

<b><i>Mould vibrators</i></b>		
	L	85 – 114 dB(A)
<b><i>Inverter</i></b>		
	L	83 – 116 dB(A)
<b><i>Arc/air gauging</i></b>		
	L	82 – 107 dB(A)
<b><i>9 inch Angle grinder</i></b>		
	L	97 – 110 dB(A)
<b><i>Shot blasting</i></b>		
	L	86 – 101 dB(A)
<b><i>Shake out</i></b>		
	L	84 – 95 dB(A)

Other significant sources of noise could consist of the dropping of mould boxes onto machines, poorly maintained electric motors or loose panels.

## **Effects of noise exposure**

Noise exposure exceeding 85 dB(A) over an eight hour day (84 dB(A) over 10 hours or 83 dB(A) over 12 hours) presents a high risk of damage to a person's hearing ability. All persons working with or near noisy machinery or equipment may be affected by high direct or ambient noise and may develop noise-induced hearing loss in situations where no control measures have been put in place.

Regular exposure to high noise levels causes hearing loss through the destruction of the delicate hair cells (cilia hairs) in the inner ear's cochlea. This is often accompanied by tinnitus, or ringing in the ears. Damage to our ears is cumulative depending on the degree and length of exposure. There is no cure for hearing loss.

Effects of noise exposure include:

- temporary threshold shift - occurs immediately after exposure to high noise levels, condition may last for minutes to hours
- noise induced hearing loss - occurs from long term exposure to high noise levels, irreversible
- tinnitus - ringing in the ears which sometimes accompanies noise induced hearing loss
- acoustic trauma - results from explosions or extremely loud impulsive noise which may destroy the cilia hair cells and ear structure.

In addition to the risk of temporary or permanent hearing loss, high noise levels may cause difficulties in verbal communication and in hearing warning signals or emergency commands.

## **Managing the risk of exposure to noise**

The *Noise Code of Practice* provides practical advice about identifying sources and levels of noise, assessing exposure to noise and eliminating or minimising noise exposure as a risk to health and safety at the workplace.

If a risk assessment shows noise exposure is a risk to workplace health and safety, a relevant person who is an employer must develop a noise control policy and hearing conservation program to implement control measures and manage risks from noise exposure at the workplace.

A full explanation of the noise control policy and hearing conservation program is provided in the *Noise Code of Practice*.

## **Noise control measures**

Noise control measures are ways to manage the risks from exposure to noise.

The following control measures are listed in order of the most effective way of managing risks from noise:

- elimination
- engineering controls
- administrative controls
- personal hearing protectors.

One control measure may prevent the risks from exposure to excessive noise; however, usually a combination of control measures has to be used.

Elimination, engineering and administrative control measures are the preferred options as they actually reduce a person's exposure, whereas personal hearing protectors do not.

## **Elimination**

Plant and equipment, which expose persons to excessive noise, should be considered for replacement and should form part of a foundry's future planning strategy. The replacement plant and equipment should be designed to prevent or minimise exposure to excessive noise.

For example:

- eliminating or replacing the machine or its operation with a quieter alternative with equal or better efficiency
- replacing noisy machinery with newer equipment designed to operate at lower noise levels
- correcting the specific noise source by design changes (e.g. replacing metal components with plastic).

New workplaces and installation sites for new plant in existing workplaces should be designed and constructed to ensure exposure to noise is as low as possible. If new plant is likely to expose persons to excessive noise, design features should include engineering noise control measures. These measures can reduce noise to as low a level as possible.

## **Engineering controls**

Once a noise assessment has been carried out and the need to reduce the noise exposure is established, the task of controlling the noise can be addressed. Priority should be given to those noise sources that contribute the highest noise exposure levels to the largest number of persons.

There are three basic engineering noise control measures for managing noise levels:

1. engineering treatment of the source
2. engineering treatment of the noise transmission path
3. engineering treatment at the receiver.

Examples of engineering controls in the foundry industry include:

- Separating noisy equipment such as automatic moulding machines and vibrating equipment by positioning them away from other work areas or by providing soundproof enclosures for operators.
- Using mobile enclosures, lined internally with sound absorbent - can reduce operator exposures by about 5 to 20 dB(A) and will also reduce the exposures of nearby workers.
- Improving mould design so as to reduce the amount of excess metal which is to be removed after casting.
- Using noise-reduced grinding discs or equipment – may reduce noise output by up to 5 dB(A).
- Substituting piston-type vibrators used in the moulding and core making shop for turbine and rotary vibrators.
- Maintaining a high standard of plant and equipment.
- Adding noise barriers, noise enclosures, dampening devices.
- Separating noisy machine elements from the basic machine e.g. pumps, fans, air compressors.
- Isolating machinery or equipment in an enclosure or sound proof room.
- Placing machinery or equipment in a room or area away from the largest number of workers.
- Acoustically redesigning the area using noise attenuation materials within the work space.

For example:

- The exposure of workers to noise emitted from an electric arc furnace can be reduced by locating all operating controls inside an isolated control room.
- The exposure of workers to noise emitted from tumbling machines can be reduced by enclosing the tumbling machinery.

## **Administrative controls**

Administrative control measures should be used when it is not possible to reduce noise exposure through elimination or engineering control measures.

Administrative control measures include:

- Organising schedules so that noisy work is done when as few people as possible are present.
- Notifying people in advance when noisy work is to be carried out so they can limit their exposure to it.
- Keeping people out of noisy areas if their job does not require them to be there.
- Sign posting noisy areas.
- Providing quiet rest areas for food and rest breaks.
- Limiting the time workers spend in noisy areas by moving them to quiet work areas before their daily noise exposure levels are exceeded.
- Job rotation - changing the variety and length of tasks performed by workers so they are not constantly exposed to excessive noise.
- Equipment maintenance programs - in most cases maintaining machines and equipment in good condition will reduce noise by up to 8dB(A).
- 'Buy quiet' program - consider buying quieter plant or equipment when replacing old equipment or buying new equipment. Prospective suppliers should specify the expected sound pressure levels from the plant in operation as well as possible associated costs, and
- Training workers in safe work practices and use and maintenance of personal protective equipment.

## **Personal hearing protection**

A personal hearing protector is a device, or pair of devices, designed to be worn over or inserted in the ears of a person to protect hearing.

Personal hearing protectors should not be used as a substitute for engineering or administrative noise control measures. Hearing protectors should be used where excessive noise cannot be reduced, and should normally be regarded as an interim measure while reduction of noise exposure is being achieved by other control measures.

Workers should be:

- supplied with personal hearing protectors
- instructed in the correct use of their personal hearing protectors
- instructed to wear personal hearing protectors when exposed to noise as a condition of employment
- trained in the maintenance and care of hearing protection devices.

Areas where persons may be exposed to excessive noise should be sign-posted as 'hearing protection areas'. No one should enter a hearing protection area during normal operation, unless appropriate personal hearing protectors are worn. This is regardless of how long the person spends in the 'hearing protection area'.

## **Vibration**

Exposure to noise in industry is often accompanied by exposure to vibration.

Vibration is usually classified as:

- whole body vibration (1 to 80 Hz), or
- hand-arm or segmental vibration (8 Hz to 1 kHz).

Foundry workers may be subject to whole-body vibration during shake out processes, sand-slinging and from forklift truck, conveyor, overhead crane, pneumatic ramming operations and jolt-squeeze machines. Hand-arm vibrations occur when using hand-held power grinders, chippers and other pneumatic tools.

### **Health effects of vibration**

Vibration disease may develop after several years of exposure and result from either *whole body* vibration or *segmental* (hand arm) vibration.

The main effects of **whole-body** vibration include:

- blood pressure and heart problems
- nervous disorders
- stomach problems
- joint and spine damage.

The main effects of *hand-arm* vibration are a narrowing of the arteries and damage to nerve endings in the fingers and hands, known as vibration white finger. Hand-arm vibration is a more localised stress that may result in Raynaud's phenomenon. It usually results from using hand tools that vibrate in the low frequency range up to 300 Hz, although higher frequencies up to 5000 Hz may also be involved.

Factors that influence the effect of vibration on the hand and wrist include:

- vibration frequency
- level of insulation
- duration of exposure
- hardness of the material being worked on
- grip force applied
- cold conditions and whether the worker smokes (because of effects on the circulation)
- state of tool maintenance.

Symptoms include:

- blanching and numbness in the fingers (white finger disease)
- decreased sensitivity to touch, temperature and pain
- loss of muscular control
- discomfort and/or pain in the joints, such as the wrists, elbows and shoulders.

Chronic exposure may result in gangrenous and necrotic changes in the finger.

## **Control measures for vibration**

### **Elimination**

Vibration reduced equipment should be considered when purchasing or replacing equipment.

### **Engineering controls**

Only tools with vibration dampers should be used. They should weigh as little as possible to reduce muscular effort and have handgrips that do not involve twisting the hand away from a normal position while using the tool.

The use of tool suspended balancers to reduce muscle load can be helpful. Alternatively it may be possible to apply vibration-dampening material to handles, (e.g. lagging with soft resilient rubber).

### **Administrative controls**

Administrative controls involve the development of safe work practices and procedures.

Examples of administrative controls to reduce exposure to vibration include:

- Labelling equipment to warn workers of potential hazards.
- Avoiding prolonged use of vibrating equipment. Allow for frequent micro breaks and a variety of hand movements and variations in task components.
- Ensuring that the manufacturer's recommended disk type or other replaceable items are used to reduce vibration when grinding.
- Frequent servicing and maintenance of machinery to eliminate vibration due to bent shafts, and worn bearings, and
- Providing training on the correct operation of vibrating tools to ensure low vibration levels are achieved and maintained consistent with safe operation, and hazards and risks associated with the operation of vibrating equipment.

### **Personal protective equipment**

Where exposure to vibration cannot be prevented or reduced by any other form of control, personal protective equipment should be provided. For example:

- protective gloves (limited assistance) - will dampen approximately 10% of vibration above 500 Hz e.g. rigger gloves
- provision of vibration absorbing material, such as matting and inner soles for boots

Section 10.4 of the *Manual Tasks Code of Practice* provides further information on the control measures to eliminate or minimise exposure to vibration.

## **Molten metal**

Molten metal is a major hazard in foundry melting and pouring areas. Workers, who perform tasks with or near molten metal, may come into contact with metal splashes and be exposed to electromagnetic radiation.

The following situations may increase the risk of hot metal splashes:

- charging a furnace with contaminated or moist scrap metal and alloys
- using moist tools, moulds or other material when contacting molten metal
- tapping or pouring the molten metal into a holding furnace, tundish or ladle
- slagging or raking operations
- pouring molten metal from ladles into moulds.

Extreme caution must be taken to prevent metal and metal slag from coming into contact with water or moisture, as this may result in an explosive reaction or ejection of molten metal with catastrophic consequences.

Electromagnetic radiation is emitted from molten metal in the furnaces and pouring areas. Foundry workers are mainly exposed to infrared and ultraviolet radiation.

Visitors and workers with medical implants, joints, plates or similar objects should enter the vicinity of the induction furnaces with caution as the magnetic fields involved in the melting process can

induce a charge in the metallic implant. Personnel with cardiac pace makers are particularly at risk and should be restricted from approaching the induction equipment.

### **Health effects of molten metal**

Serious burns may result from splashes of molten metal and radiant heat at any time in the melting and pouring areas. Sparks from molten metal may also damage the eyes. Exposure to infrared and ultraviolet radiation may result in eye damage including cataracts.

### **Molten metal control measures**

There are a number of control options that can be used alone, or in combination, to prevent or minimise exposure to the risk.

### **Engineering controls**

The risks from molten metal may be managed by implementing engineering controls. Barriers and other suitable shields, including mobile shields should be used or installed to protect workers against molten metal splashes and electromagnetic radiation.

### **Administrative controls**

Administrative controls involve the development of safe working practices and procedures.

Examples of administrative controls for molten metal include:

- Avoiding contact between molten metal and water or other contaminants at all times. All charge material, ladles and other equipment that may come in contact with molten metal must be completely dry.
- Restricting unauthorised access by barriers and signage (exclusion zone) to the furnace and pouring section.
- Restricting visitors and workers from wearing synthetic clothing, including undergarments when entering the furnace and pouring areas.
- Keeping melting and pouring areas free of combustible material and volatile liquids.
- Providing training in safe work practices and the use and maintenance of personal protective equipment.

### **Personal protective equipment**

Where the risk of exposure to molten metal cannot be prevented or sufficiently reduced by any other form of control, all exposed persons should be provided with personal protective equipment.

This may include:

- heat resistant protective clothing - footwear, headgear, face shields, fire retardant spats, aprons, coats and gaiters
- eye protection with side shields
- special UV and infra-red glasses.

## **Plant and machinery**

A wide range of plant and machinery is used in foundry work. This includes:

- wood cutting and finishing machines in the pattern shop
- automatic and semi-automatic machinery in moulding and core-making
- mechanical handling devices - cranes, hoists, monorails, conveyors, forklifts, trucks, electromagnets
- grinders.

Special care should be taken with plant and machinery used in foundry environments. For example, the elevated temperature in a foundry creates greater stress on crane components and may dramatically reduce a crane's working life.

Continuous vibration of some equipment results in increased mechanical stress on nuts, bolts, chains and cables, which may eventually lead to equipment failure. This in turn may result in major explosions, fires, spills and burns.

Atmospheric particulate matter also increases wear through contamination of lubricants and ingress to bearings.

The *Plant Code of Practice* provides practical advice on ways to manage exposure to risks related to the use of plant, including its safe design, manufacture and installation. It outlines the obligations of persons involved with plant and provides information on risks and their control.

### **Injuries from plant and machinery**

Improper maintenance, repair, guarding and use of plant and machinery in foundries may result in significant increases in the risk of injury to operators and nearby workers.

These injuries may include:

- cuts and lacerations
- amputations
- foreign bodies in eyes
- crush injuries
- fractures
- burns
- manual handling injuries.

### **Identify the hazards**

There are a number of methods that can be used to identify hazards associated with plant. The type of plant and work processes involved will determine the method selected. A combination of methods may give the most complete results.

Methods of identifying hazards associated with plant at a workplace include:

- **Walk through survey** of the workplace, preferably using a hazard checklist.
- **Work process evaluation** - procedures devised for evaluating work processes and identifying associated hazards can be used to evaluate the plant related tasks that give rise to hazards.
- **Consulting with workers** is one of the easiest and most effective means of identifying hazards at the workplace.
- **Near miss, incident, accident, injury disease data** relating to plant at a workplace can be reviewed to help identify problem areas.
- **Manufacturer's instructions** are an important source of information regarding the hazards associated with plant.
- **Specialist practitioners and representatives** of industry association, unions and government bodies may be of assistance in gathering health and safety information relevant to hazards associated with plant.

## **Assess the risks**

Once a hazard has been identified, the associated risks should be assessed. A risk assessment should consider the risks to all people potentially affected by the hazard, including non-workers such as subcontractors and members of the public.

A risk assessment should determine the following:

- the occupations and tasks at risk
- the number of persons at risk
- the likelihood of an incident occurring because of the hazard
- the duration of exposure a person has to the hazard
- the possible consequences (death, injury or illness) that may result.

## **Control measures for plant**

There are a number of control options that can be used alone, or in combination, to prevent or minimise exposure to the risk.

### **Substitution**

Substitution involves replacing the hazard with one that presents a lower (and more manageable) risk e.g. replacing an existing machine with one that has better guarding to make the same product.

### **Redesign**

Redesign involves changing the design of the workplace, equipment or work process. It involves thinking about ways the work could be done differently to make the plant safer such as modifying equipment, combining tasks, changing procedures, changing the sequence of tasks.

### **Isolation**

Isolating or separating the hazard from the person, or the person from the hazard enclosing or guarding dangerous equipment, or installing screens or barriers around hazardous areas. Guarding may be used on dangerous moving parts, such as flywheels, gearing equipment, belt and pulley drives, chain and sprocket drives, electric generators, motors, feed-in rollers, exposed electrical conductors, rotating or reciprocating machine elements.

All potential energy sources should also be neutralised (lock-out and tag-out) during maintenance and repairs.

This can involve:

- lockout devices and tagging systems
- isolating electrical energy - remove fuses
- ensuring energy from pneumatic and hydraulic fluid lines are locked-out
- ensuring valves are locked open or shut depending on function and position in lines
- ensuring that energy from mechanisms under spring tension, gravity or compression is blocked, clamped or chained in position.

### **Administrative controls**

Administrative controls involve minimising exposure to a risk through the use of procedures or instruction. It is often necessary to use these controls in conjunction with other measures in the development of safe working practices and procedures.

Examples of administrative controls to protect workers from injury from plant and machinery include:

- ensuring that purchasing specifications for new equipment incorporate all required safety features, for example, safety devices and guards and “fail safe” design
- carrying out routine and preventive maintenance programs at regular intervals
- maintaining records of equipment installation, maintenance schedules, failures and repairs to assist in setting up inspection and preventive maintenance schedules
- providing training in the safe operation and maintenance of plant and equipment, including lockout and tag-out systems
- considering workload and fatigue factors when developing rosters.

### **Personal protective equipment**

Where exposure to risks from plant and machinery cannot be prevented or reduced by any other form of control, all persons must be provided with personal protective equipment.

This may include:

- eye protection - against flying or ejected materials
- hearing protection
- safety helmets, and
- skin protection - gloves, barrier creams.

## **Electricity**

Electricity is a form of energy that can cause death or serious injury if poorly controlled. Foundry workers who may be exposed to the risk of injury from electricity include those who work with electrical equipment in areas such as the pattern shop, fettling shop, and the furnace section.

### **Legislation**

The *Electrical Safety Act 2002* imposes obligations on persons who may affect the electrical safety of others by their acts or omissions. It is supported by the *Electrical Safety Regulation 2002* and three codes of practice.

The following two codes of practice are relevant to the Foundry Industry and should be referenced when seeking guidance on managing electrical risk.

- **Working near exposed live parts** - provides guidance on ways to manage electrical risk when working near exposed live parts.
- **Electrical work** - provides benchmarks for performing electrical work in ways that are electrically safe.

### **Electrical licence**

The *Electrical Safety Act 2002* and *Electrical Safety Regulation 2002* provide the circumstances when an electrical licence is required when undertaking electrical work.

The Electrical Safety legislation and other information regarding electrical safety in the workplace are available from the Electrical Safety Office website at [www.eso.qld.gov.au](http://www.eso.qld.gov.au).

## **Common electrical hazards**

The common electrical hazards and causes of injury can be broken into three broad categories:

## **Electric shock**

Causing injury or death. The electric shock may be received by direct contact, tracking through or across a medium, or by arcing.

Wet skin is generally more conductive than dry skin and can affect the severity or likelihood of receiving an electric shock. The chances of workers receiving an electric shock may be increased due to excessive sweating when working in a hot environment such as a foundry.

## **Arcing, explosion or fire**

Causing burns. The injuries are often suffered because arcing or explosion or both occur when high fault currents are present.

## **Toxic gases**

Causing illness or death. Burning and arcing associated with electrical equipment causes a range of gases and contaminants to be present. Compounds ranging from ozone to cyanide and sulphuric acids can be present as well as the hazards such as low oxygen content in the air.

The three common electrical hazards may be present individually or combined.

## **Control measures**

There are a number of control options that can be used alone, or in combination, to prevent or minimise exposure to the risk of injury from electricity.

## **Elimination**

Do not work on live equipment or installations unless proper safeguards are in place.

## **Engineering controls**

Under the *Electrical Safety Regulation 2002* requirements for workplace electrical installations are classified by the type of work being performed. Most of the work performed in foundries would fall into the Class 2 work definition, that is assembly, fabrication, installation, maintenance, manufacturing, refurbishment or repair work.

Safety switches are designed to provide increased protection from electrical shock resulting from a fault in electrical appliances, circuit wiring or misuse of electrical equipment.

*Section 90 of the Electrical Safety Regulation 2002* provides that employers must ensure that specified electrical equipment used in class 2 work is inspected and tested by a competent person at least once every year (twice a year if not double insulated equipment), AND connected to a type 1 safety switch or a type 2 safety switch.

If a safety switch is installed, *Section 91 of the Electrical Safety Regulation 2002* provides that you must ensure that each safety switch at the workplace is tested by a competent person immediately after it is connected, and tested at regular intervals.

Whilst this is a way for employers to discharge their obligation, the regulation regarding class 2 work does not provide all that must be done to meet your electrical safety obligation.

Employers have an obligation to ensure their business is conducted in a way that is electrically safe, including that all electrical equipment is safe. Safety switches and regular maintenance of electrical equipment are good ways of controlling electrical safety risk.

### **Administrative controls**

Inspection, testing and tagging of electrical equipment must be carried out by a competent person on a regular basis in accordance with the *Electrical Safety Regulation 2002*.

Other controls include:

- prohibiting the use of double adaptors or piggyback plug
- cleaning up liquid spills quickly
- immediately removing and replacing damaged plugs and cords
- ensuring lock-out and tagging procedures are used for all maintenance, servicing and repairs of equipment
- not using electrical equipment while standing on a metal ladder unless the tools are cordless
- not working with electrical equipment in metal enclosures or in damp places unless the tools are cordless.

### **Personal protective equipment (PPE)**

PPE should be fit for purpose. The correct application, use, maintenance and testing of PPE should be explained to users.

Prevention or reduction of the effects of electric shock and burns may be controlled by:

- using clothing that covers the arms, legs and body, and has flame resistant and retardant properties
- using non conductive footwear
- using insulating gloves
- rubber insulating mats.

Additional information is available in the relevant *Electrical Safety Code of Practice* at [www.eso.qld.gov.au](http://www.eso.qld.gov.au).

# Appendix 1: Main hazardous substances encountered in foundries

The information given in this table is provided as a guide only. It does not represent all substances that may be encountered in a foundry environment. As the exposure standards are subject to change, reference should be made to the current national exposure standard for that substance.

Substance	Process/use	Health effects	Exposure standard
Acids	Used as amine neutralisers in effluent gas washers	Skin, eye and respiratory irritation	Various e.g. HCl Peak limitation: 5 ppm or 7.5 mg/m <sup>3</sup>
Acrolein	Decomposition product from core ovens. Emitted during pouring and shakeout where oil sand cores are used.	Eye, nose and throat irritation, lacrimation, pulmonary oedema	TWA: 0.1 ppm or 0.23 mg/m <sup>3</sup> STEL: 0.3 ppm or 0.69 mg/m <sup>3</sup>
Aluminium oxide	Melting and pouring of aluminium alloys. Deoxidant for steel alloys.	Respiratory irritation. May possibly result in pulmonary fibrosis	TWA: 10 mg/m <sup>3</sup>
Ammonia	Core-making decomposition product of nitrogen containing binding materials.	Eyes and respiratory tract irritation, high concentrations may result in chronic lung disease and eye damage	TWA: 25 ppm or 17 mg/m <sup>3</sup> STEL: 35 ppm or 24 mg/m <sup>3</sup>
Benzene	Solvent used in core-washing	Leukaemia-established human carcinogen. Chronic exposures may result in convulsions, ventricular fibrillation, and leukaemia. Acute exposures may result in CNS depressions and dermatitis.	TWA: 1 ppm or 3.2 mg/m <sup>3</sup>
Beryllium	Copper alloy, emitted during melting and pouring.	Probable human carcinogen. Lung cancer, dermatitis.	TWA: 0.002 mg/m <sup>3</sup>
Carbon dioxide	Emitted from core ovens and during melting and pouring processes and welding.	Asphyxiant, may contribute to oxygen deficiency if in excessive concentrations.	TWA: 5,000 ppm or 9,000 mg/m <sup>3</sup> STEL: 30,000 ppm or 54,000 mg/m <sup>3</sup>
Carbon monoxide	Emitted during melting and pouring processes, or any process pyrolysing carboniferous compounds. Decomposition	A chemical asphyxiant that interferes with oxygen carrying capacity of blood that may lead to anoxia. Headaches, dizziness, drowsiness,	TWA: 30 ppm or 34 mg/m <sup>3</sup> STEL: 60 ppm for 60 min 100 ppm for 30 mins 200 ppm for 15 mins

	product of core-making.	nausea, vomiting, loss of co-ordination or death.	
Chlorine	Degassing agent used with non-ferrous alloys.	Eye, nose and throat irritation, pulmonary oedema and congestion. Acute exposures may cause asphyxia.	Peak limitation: 1 ppm or 3 mg/m <sup>3</sup>
Chromium VI	Melting, pouring and grinding of low alloy and stainless steel and chrome alloys. Chromate sand constituent.	Established carcinogen.	TWA: 0.05 mg/m <sup>3</sup>
Copper (fume)	Melting, pouring and grinding of copper alloys.	Acute respiratory irritation, metal fume fever.	TWA: 0.2 mg/m <sup>3</sup>
Dimethylamine (DMEA)	Catalyst for cold-box binder systems.	Skin irritation, corneal oedema, "halovision", contact dermatitis.	TWA: 10 ppm or 18 mg/m <sup>3</sup>
Diphenylmethane diisocyanate (MDI)	Binder component used in urethane binders.	Eye, respiratory tract and skin irritation, bronchitis, nausea, vomiting, abdominal pain, occupational asthma.	TWA: 0.02 mg/m <sup>3</sup> as - NCO group STEL: 0.07 mg/m <sup>3</sup> as - NCO group
Formaldehyde	Constituent of various resinous binders. Vapours emitted in moulding, pouring and shakeout areas from the decomposition of binder materials.	Strong irritant and sensitiser to skin, eyes and respiratory tract, pulmonary oedema, bronchitis, contact dermatitis. Probable human carcinogen.	TWA: 1 ppm or 1.2 mg/m <sup>3</sup> STEL: 2 ppm or 2.5 mg/m <sup>3</sup>
Furfuryl alcohol	Added to urea-formaldehyde resins. Component in furan resin systems.	Lacrimation of eyes, bronchitis, allergic contact dermatitis	TWA: 10 ppm or 40 mg/m <sup>3</sup> STEL: 15 ppm or 60 mg/m <sup>3</sup>
Hydrogen chloride	Mist produced during the degassing and fluxing of non-ferrous metals.	Respiratory irritation, burns	Peak limitation: 5 ppm or 7.5 mg/m <sup>3</sup>
Hydrogen cyanide	Decomposition product of nitrogen-containing binding agents.	Dermatitis, asphyxia, death, neurological changes	Peak limitation: 10 ppm or 11 mg/m <sup>3</sup>
Hydrogen sulphide	Emitted during water quenching of slag. Decomposition product of some binders and catalysts during pouring.	Eye and respiratory irritation, nervous system changes, respiratory paralysis	TWA: 10 ppm or 14 mg/m <sup>3</sup> STEL: 15 ppm or 21 mg/m <sup>3</sup>
Iron oxide (fume)	Melting, pouring and grinding of iron and	Pulmonary irritation	TWA: 5 mg/m <sup>3</sup>

	steel.		
Lead (fume)	Alloying agent for copper-based alloys. Emitted during melting, pouring and grinding of lead, iron and steel.	Kidney, blood, gastrointestinal and nervous system changes	TWA: 0.15 mg/m <sup>3</sup>
Magnesium oxide (fume)	Melting and pouring of ductile (nodular) iron and magnesium. Corewash refractory.	Metal fume fever - fever, fatigue, aches, metallic taste in mouth	TWA: 10 mg/m <sup>3</sup>
Manganese	Welding, arc air gouging of manganese steel castings.	Neurological disorders involving the central nervous systems including apathy, anorexia, mental excitement, speech disturbance, muscular rigidity	TWA: 1 mg/m <sup>3</sup> STEL: 3 mg/m <sup>3</sup>
Methane	Emitted from ovens, furnaces and cupolas, and during pouring and shakeout.	Asphyxiant, unconsciousness and death.	Maintain minimum oxygen content in air 18% by volume under normal atmospheric
pressure Methyl formate	Chemical bonding systems.	Inhalation may cause irritation to nasal passages and conjunctiva, optic neuritis, narcosis, retching and death from pulmonary irritation.	TWA: 100 ppm or 246 mg/m <sup>3</sup> STEL: 150 ppm or 368 mg/m <sup>3</sup>
Nickel	Melting, pouring and grinding of nickel and stainless steel.	Dermatitis, lung and nasal cancer.	TWA: 1 mg/m <sup>3</sup>
Nitrogen	Emitted from furnaces.	Oxygen deficiency, asphyxiant.	Maintain minimum oxygen content in air 18% by volume under normal atmospheric pressure
Nitrogen dioxide	Produced in electric welding and arc air gouging.	Respiratory effects, lung oedema.	TWA: 3 ppm or 5.6 mg/m <sup>3</sup> STEL: 5 ppm or 9.4 mg/m <sup>3</sup>
Ozone	Produced in electric welding and arc air gouging.	Respiratory effects, lung oedema.	Peak limitation: 0.1 ppm or 0.2 mg/m <sup>3</sup>
Phenol	Binder constituent. Decomposition product of binding system.	Liver, kidney and CNS changes, pigmentary changes in skin, skin cancer	TWA: 1 ppm or 4 mg/m <sup>3</sup>
Phosphoric acid	Furan resin catalyst.	Eye, skin and respiratory tract irritation, dermatitis	TWA: 1 mg/m <sup>3</sup> STEL: 3 mg/m <sup>3</sup>

Polycyclic aromatic hydrocarbons (PAH's)	Produced in pyrolysis of organic compounds. Pouring decomposition product of sand moulds, cupola melting.	Associated with lung cancer, skin erythema and sensitisation to ultra violet radiation	Examples: Cresol TWA: 5 ppm or 22 mg/m <sup>3</sup> Naphthalene TWA: 10 ppm or 52 mg/m <sup>3</sup> STEL: 15 ppm or 79 mg/m <sup>3</sup>
Silica (quartz)	Dusts emitted during moulding, core-making, shakeout, fettling and sand reclamation processes. Abrasive blasting of metal castings. Some mould release agents.	Chronic lung disease, silicosis	TWA: 0.1 mg/m <sup>3</sup>
Sulphur dioxide	Catalyst for cold-box binder system. Emitted from furnaces and during magnesium casting. Breakdown product of toluene sulphonic acid or benzene sulphonic acid used as catalysts.	Eye and respiratory irritation, chronic bronchitis, asphyxia.	TWA: 2 ppm or 5.2 mg/m <sup>3</sup> STEL: 5 ppm or 13 mg/m <sup>3</sup>
Toluene	Solvent used in corewashing. Mould decomposition product. Solvent in polyurethane resins.	Dermatitis, CNS depression, respiratory tract and mucous membrane irritation	TWA: 50 ppm or 191 mg/m <sup>3</sup> STEL: 150 ppm or 574 mg/m <sup>3</sup>
Triethylamine	Catalyst used in coldbox binder system.	Irritation, oedema, chemical sensitisation	TWA: 3 ppm or 12 mg/m <sup>3</sup> STEL: 5 ppm or 20 mg/m <sup>3</sup>
Wood dusts (hardwoods)	Pattern making	Alteration to structure of mucous membrane linings. Nasal cancer. Respiratory sensitisation and asthma.	TWA: 1 mg/m <sup>3</sup>
Wood dusts (softwoods)	Pattern making	Allergic reactions, skin sensitisation, occupational asthma.	TWA: 5 mg/m <sup>3</sup> STEL: 10 mg/m <sup>3</sup>
Xylene	Solvent used in corewashing. Mould decomposition product.	Irritation, CNS depression, liver and kidney damage pulmonary oedema	TWA: 80 ppm or 350 mg/m <sup>3</sup> STEL: 150 ppm or 655 mg/m <sup>3</sup>
Zinc oxide (fume)	Melting, pouring and grinding of zinc, galvanised metal and brass.	Dermatitis, metal fume fever	TWA: 5 mg/m <sup>3</sup> STEL: 10 mg/m <sup>3</sup>

# Appendix 2: Dangerous goods

Figure 1: Stated dangerous goods class diamonds

Dangerous goods class diamonds



Class 2.1  
Flammable gases



Class 2.2  
Non-flammable,  
non-toxic gases



Non-toxic Gases  
Class 2.3,  
Oxidizing gas, Subclass 2.3.1



Class 2.4  
Toxic gas



Class 3  
Flammable liquids



Class 4.1  
Flammable solids



Class 4.2  
Substances liable to  
spontaneous combustion



Class 4.3  
Substances that in water  
with flammable gases



Class 5.1  
Oxidizing substances



Class 5.2  
Organic peroxides



Class 6.1  
Toxic substances



Class 8  
Corrosive substances



Class 9  
Miscellaneous dangerous  
goods and articles

Table 1: Overview of DGSM legislation requirements

DGSM requirement	Reference	MSW	DGL	LDGL
<b>General safety obligations</b>	Act, Part 2, S.16	✓	✓	✓
<b>Management systems</b>	Regulation, Part 3, Division 4	✓		
• Hazard identification and risk assessment	Regulation, Part 3, Division 1		✓	✓
• Induction, information, supervision, education and training	Regulation, Part 3, Division 4	✓		
	Act, Part 2, Division 2, S.23(1)		✓	✓
• Safety Management System	Regulation, Part 3, Division 1		✓	✓
	Act, Part 2, Division 2, S.23(1)		✓	✓
<b>Provision of information</b>	Regulation, Part 3, Division 4	✓		
• MSDS, Labels, Marking, DG register	Regulation, Part 3, Division 1		✓	✓
• Placarding	Regulation, Part 3, Division 1		✓	✓
• Manifest	Regulation, Part 3, Division 2			✓
<b>Protective measures</b>	Regulation, Part 3, Division 4	✓		
	Regulation, Part 3, Division 1		✓	✓
<b>Emergency planning</b>	Act, Part 2, Division. 2 S.23(2)			
	Regulation, Part 3, Division 2			✓
<b>Notification of LDGL</b> (to chief executive of emergency services regarding possible existence)	Act, Part 5, Division 2			✓
	Regulation, Part 3, Division 3			

Table 2: Shows examples of stated dangerous goods or combustible liquids used in foundry operations

<b>Dangerous goods in foundry operations</b>				
<b>Substance</b>	<b>Foundry use</b>	<b>Class</b>	<b>Sub-risk</b>	<b>Acute hazards</b>
Carbon dioxide	Silicate binder in core making	2.2	nil	Asphyxiant Stored under pressure in cylinders
Chlorine	Degassing agent for use with non ferrous alloys	2.3	8	Heavier than air, toxic, corrosive gas, stored under pressure in cylinders
Dimethylene Amine (DMEA)	Catalyst for cold box binder systems	2.1	2.3	Fire, explosion risk, shock/friction sensitive, flammable, toxic gas
Formaldehyde	Resinous binders in moulding	3	nil	Flammable liquid
Furfuryl alcohol	Added to urea-formaldehyde systems in moulding	6.1	nil	Toxic, also C1 Combustible liquid
Methyl formate	Core/mould making binder	3	nil	Highly flammable, low boiling point, drums may rupture if stored above boiling point
Oxygen	Injected into furnace	2.2	5.1	Oxidising gas, Accelerates combustion
Phosphoric acid	Furan resin catalyst	8	nil	Corrosive
Sulphur dioxide	Catalyst in cold box binder system	2.3	8	Heavier than air toxic gas, corrosive
Toluene	Solvent used in core washing	3	nil	Flammable liquid
Triethylamine	Catalyst	3	8	Highly flammable, corrosive liquid
Xylene	Solvent in core washing	3	nil	Flammable liquid

## Further information

Further information regarding workplace health and safety legislation, Workplace Health and Safety Codes of Practice and guidance materials produced by Workplace Health and Safety Queensland can be obtained from Workplace Health and Safety Queensland website at [www.worksafe.qld.gov.au](http://www.worksafe.qld.gov.au).

### Legislation

1. *Workplace Health and Safety Act 1995*.
2. *Workplace Health and Safety Regulation 2008*.
3. WHSQ Brochure – *A Quick Start to the Workplace Health and Safety Act 1995*.

### Working in heat

1. Workplace Health and Safety, 'Heat stress' at <http://www.deir.qld.gov.au/workplace/subjects/sunsafety/heatstress/>.
2. Australian Standard AS 1336 – *Recommended practices for occupational eye protection*.
3. Australian Standard AS 1337 – *Eye protectors for industrial applications*.
4. Australian Standard AS 1338 – *Filters for eye protection*.
5. Australian Standard AS 2210 – *Occupational Protective Footwear*.
6. Australian Standard AS 2375 – *Guide to the selection, care and use of clothing for protection against heat and fire*.

### Hazardous substances

1. *Workplace Health and Safety Act 1995* – for obligations, offences and penalties.
2. *Workplace Health and Safety Regulation 2008* - Part 16 (Hazardous Substances), Part 17 (Lead), Part 18 (Confined Spaces), Schedule 8 (Hazardous substances for which health surveillance must be supplied).
3. *Abrasive Blasting Code of Practice*.
4. *Hazardous Substances Code of Practice*.
5. *Risk Management Code of Practice*.
6. *Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment* [NOHSC:1003(1995)].
7. Australian Standard AS 1940 – *The storage and handling of flammable and combustible liquids*.
8. Australian Standard AS 3780 – *The storage and handling of corrosive substances*.
9. *National Code of Practice for the Preparation of Material Safety Data Sheets 2<sup>nd</sup> Ed* [NOHSC 2011:2003].

### Dangerous goods

1. *Dangerous Goods Safety Management Act 2001*.
2. *Dangerous Goods Safety Management Regulation 2001*.
3. Australian Standard AS 1020 – *The control of undesirable static electricity*.
4. Australian Standard AS 1216 – *Class labels for dangerous goods*.
5. Australian Standard AS 1319 – *Safety signs for the occupational environment*.
6. Australian Standard AS 1345 – *Identification of pipes, conduits and ducts*.
7. Australian Standard AS 1596 – *The storage and handling of LP gas*.
8. Australian Standard AS 1674.1 – *Safety in Welding and Allied Process-Fire Precautions*.
9. Australian Standard AS 1692 – *Steel tanks for flammable and combustible liquids*.
10. Australian Standard AS 1894 – *Storage and Handling of Non-flammable cryogenic and refrigerated liquids*.
11. Australian Standard AS 1940 – *The storage and handling of flammable and combustible liquids*.
12. Australian Standard AS 2022 – *Anhydrous ammonia – storage and handling*.

13. Australian Standard AS 2030.1 – *The verification, filling, inspection, testing and maintenance of cylinders used for storage and transport of compressed gases. Part 1: Cylinders for compressed gases other than acetylene.*
14. Australian Standard AS 2030.2 – *The Verification, filling, inspection, testing and maintenance of cylinders used for storage and transport of compressed gases. Part 2: Cylinders for dissolved acetylene.*
15. Australian Standard AS 2243.1 – *Safety in laboratories – Planning and operational aspects.*
16. Australian Standard AS 2243.2 – *Safety in laboratories – Chemical aspects.*
17. Australian Standard AS 2243.10 – *Safety in laboratories – Storage of chemicals.*
18. Australian Standard AS 2359.12 – *Powered Industrial /Trucks – Hazardous areas.*
19. Australian and New Zealand Standard AS/NZS 60079.10 – *Electrical apparatus for explosive gas atmospheres – Classification of hazardous areas.*
20. Australian Standard AS 2430.3.1 – *Classification of hazardous areas – Examples of area classification – General.*
21. Australian Standard AS 2430.3.2 – *Classification of hazardous areas – Examples of area classification – vehicle workshops, vehicle parking, fuel dispensing stations and aircraft hangers.*
22. Australian Standard AS 2430.3.3 – *Classification of hazardous areas – Examples of area classification – Flammable liquids.*
23. Australian Standard AS 2430.3.4 – *Classification of hazardous areas – Examples of area classification – Flammable gases.*
24. Australian Standard AS 2430.3.5 – *Classification of hazardous areas – Examples of area classification – Refineries and major processing plants.*
25. Australian Standard AS 2430.3.6 – *Classification of hazardous areas – Examples of area classification – Laboratories including fume cupboards and flammable medical agents.*
26. Australian Standard AS 2430.3.7 – *Classification of hazardous areas – Examples of area classification – Landfill gas, sewage treatment and sewage pumping plants.*

### **Airborne contaminants**

1. *Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:1003(1995)].*
2. *Risk Management Code of Practice.*
3. Australian Standard AS 1319 – *Safety Signs for the Occupational Environment.*
4. Australian Standard AS 1336 – *Recommended Practices for occupational eye protection.*
5. Australian Standard AS 1337 – *Eye Protectors for Industrial Application.*
6. Australian Standard AS 1715 – *Selection, Use and Maintenance of Respiratory Protective Devices.*
7. Australian and New Zealand Standard AS/NZS 1716 – *Respiratory Protective Devices.*

### **Manual tasks**

1. *Manual Tasks Code of Practice.*
2. *Risk Management Code of Practice.*

### **Noise**

1. *Noise Code of Practice.*
2. *Workplace Health and Safety Regulation 2008 Part 12 – Noise.*
3. Australian Standard AS 1269 Set – *Occupational Noise Management Set.*
4. Australian Standard AS 1270:2002 – *Acoustics – Hearing Protectors.*
5. Australian Standard AS 1319 – *Safety Signs for the Occupational Environment.*

## **Vibration**

1. *Plant Code of Practice.*
2. *Manual Tasks Code of Practice 2000 – Section 10.4 Vibration.*
3. Australian Standard AS 2670.1 – *Evaluation of Human Exposure to Whole Body Vibration – General Requirements.*
4. Australian Standard AS 2763 – *Vibration and shock - Hand-transmitted vibration - Guidelines for measurement and assessment of human exposure.*
5. Australian Standard AS 2972 – *Vibration and shock - Isolators - Procedure for specifying characteristics.*

## **Plant and machinery**

1. *Plant Code of Practice.*
2. Risk Management Code of Practice.
3. WHSQ Brochure – *Guide to safeguarding common machinery and plant.*
4. Australian Standard AS 4024.1 Series – *Safety of Machinery.*

## **Electricity**

1. *Electrical Safety Act 2002*<sup>3</sup>.
2. *Electrical Safety Regulation 2002.*
3. *Code of Practice – Electrical Work.*
4. *Code of Practice – Working near exposed live parts.*
5. *Risk Management Code of Practice.*
6. Australian Standard AS 2670 – *Evaluation of Human Exposure to Whole-Body Vibration – General Requirements.*
7. Australian Standard [AS 1674.2 - Safety in Welding and Allied Processes - Electrical.](#)

## **Risk management**

1. *Risk Management Code of Practice*
2. WHSQ Business Management Tool *Tri Safe Management Systems Audit*
3. Australian and New Zealand Standard AS/NZS 4360 *Risk Management Set*

## **How to get copies of this code of practice**

Hard copies of this code of practice can be obtained through:

SDS Publications

371 Vulture Street

Woolloongabba Qld 4102.

Telephone: (07) 3118 6900

The *Foundry Code of Practice* is available on the Department of Employment and Industrial Relations website at [www.worksafe.qld.gov.au](http://www.worksafe.qld.gov.au).

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<sup>3</sup> This legislation can be accessed via the [Electrical Safety Office](http://www.eso.qld.gov.au) website: [www.eso.qld.gov.au](http://www.eso.qld.gov.au).