Office of Industrial Relations
Workplace Health and Safety Queensland

Foundry

Code of Practice 2004

Queensland Government

This Queensland code of practice was preserved as a code of practice under section 284 of the *Work Health and Safety Act 2011*.

This code was varied by the Minister for Education and Industrial Relations on 27 November 2011 and published in the Queensland Government Gazette on 2 December 2011.

This preserved code commenced on 1 January 2012.

This code was varied on 30 May 2014 following a review of the work health and safety laws in Queensland.

This code was varied by the Minister for Education and Industrial Relations on 1 July 2018.

PN11176

Contents

1. Introduction

This *Foundry Code of Practice* is an approved code of practice under section 274 of the *Work Health and Safety Act 2011* (the WHS Act).

An approved code of practice is a practical guide to achieving the standards of health, safety and welfare required under the WHS Act and the *Work Health and Safety Regulation 2011* (the WHS Regulation).

From 1 July 2018 duty holders are required to comply with an approved code of practice under the WHS Act. Duty holders may, for the subject matter in the code, follow another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety to the standard required in the code.

A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the health and safety duties in the WHS Act, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks which may arise. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS Act and WHS Regulation. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

An inspector may refer to an approved code of practice when issuing an improvement or prohibition notice. This may include issuing an improvement notice for failure to comply with a code of practice where equivalent or higher standards of work health and safety have not been demonstrated.

How is the code organised

In providing guidance, the word ‘should’ is used in this code to indicate a recommended course of action, while ‘may’ is used to indicate an optional course of action.

This code also includes various references to provisions of the WHS Act and WHS Regulation which set out the legal requirements. These references are not exhaustive. The words ‘must’, ‘requires’ or ‘mandatory’ indicate that a legal requirement exists and must be complied with.

Who has duties?

A **person conducting a business or undertaking** (PCBU) has the primary duty under the WHS Act to ensure, as far as reasonably practicable, that workers and other persons are not exposed to health and safety risks arising from the business or undertaking.

Officers, such as company directors, have a duty to exercise due diligence to ensure that the business or undertaking complies with the WHS Act and WHS Regulation. This includes taking reasonable steps to ensure that the business or undertaking has and uses appropriate resources and processes to provide and maintain a safe work environment.

Workers have a duty to take reasonable care for their own health and safety and that they do not adversely affect the health and safety of other persons. Workers must comply with any reasonable instruction and cooperate with any reasonable policy or procedure relating to health and safety at the workplace.

Consulting workers

Consultation involves sharing of information, giving workers a reasonable opportunity to express views and taking those views into account before making decisions on health and safety matters.

The WHS Act requires that you consult, so far as is reasonably practicable, with workers who carry out work for you who are (or are likely to be) directly affected by a work health and safety matter.

If the workers are represented by a health and safety representative, the consultation must involve that representative.

You must consult your workers when proposing any changes to the work that may affect their health and safety.

Consulting, cooperating and coordinating activities with other duty holders

The WHS Act requires that you consult, cooperate and coordinate activities with all other persons who have a work health or safety duty in relation to the same matter, so far as is reasonably practicable.

Sometimes you may share responsibility for a health and safety matter with other business operators who are involved in the same activities or who share the same workplace. In these situations, you should exchange information to find out who is doing what and work together in a cooperative and coordinated way so that all risks are eliminated or minimised as far as reasonably practicable.

Further guidance on consultation is available in the *Work health and safety consultation, coordination and cooperation Code of Practice.*

If you work in the foundry industry, this code of practice will help you meet your workplace health and safety duties as required under the *Work Health and Safety Act 2011* (WHS Act).

This code of practice provides information on:

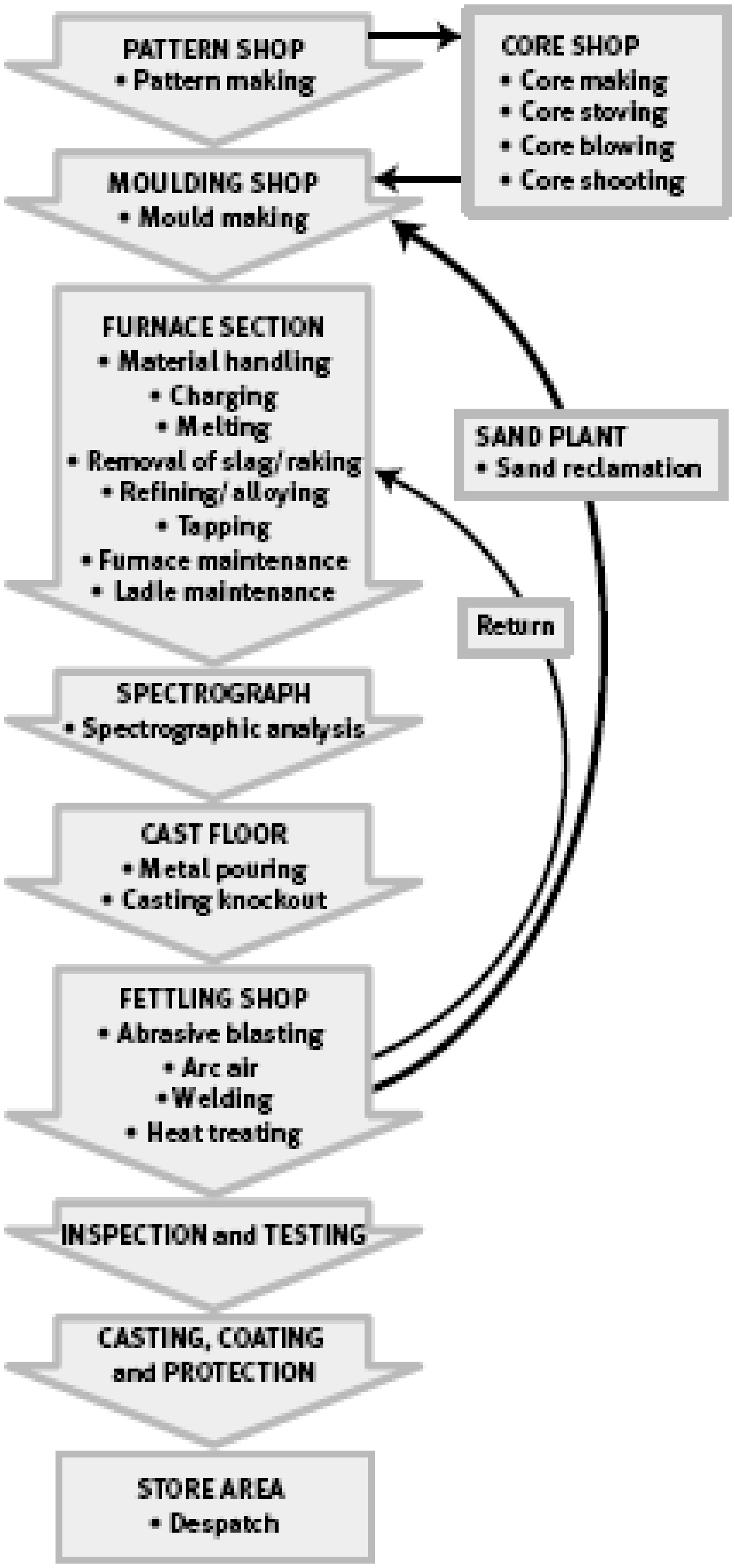
- hazards in foundry work
- control options for dealing with the risks associated with these hazards
- a list of useful references.

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:



2. Foundry operation and associated hazards

2.1 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.

2.2 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 chemicals 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.

2.3 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 chemicals 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.

2.4 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).

2.5 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.

2.6 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, pneumatic wedges)
- trapped by moving machinery
- contact with hot castings and radiant heat
- falling objects (e.g. castings)
- low level radiation from zircon sand.

2.7 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, disintegrating discs)
- 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.

2.8 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.

3. Managing risks to health and safety

The WHS Act and the *Work Health and Safety Regulation 2011* (the WHS Regulation) set out the laws about workplace health and safety for all workplaces and aim to prevent a person's death, injury or illness being caused by a workplace or by work activities. The WHS Act places the responsibility for workplace health and safety upon persons conducting a business or undertaking. This responsibility applies to the person conducting a business or undertaking whether the business or undertaking is conducted alone or with others, and regardless of whether or not the business or undertaking is conducted for profit. The Act also places responsibility on others responsible for work activities such as persons conducting a business or undertaking with management or control of the workplace, or persons conducting a business or undertaking with management or control of fixtures, fittings or plant at the workplace.

The WHS Act defines a workplace as a place where work is carried out for a business or undertaking and includes any place a worker goes, or is likely to be, while at work. This definition includes places commonly recognised as workplaces, such as factories, construction sites, hospitals, farms and rural properties. It also includes many other types of less obvious workplaces, such as a vehicle supplied by the person conducting the business or undertaking for use by a worker in the performance of work.

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 chemicals (incorporating hazardous substances and 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 from highest level of protection and reliability to lowest. This ranking of priority is known as the hierarchy of risk control. You must always aim to eliminate a hazard, which is the most effective control. If elimination is not possible, you should minimise the risk by working through other alternatives in the hierarchy.

The WHS Act and the WHS Regulation require persons who have health and safety duties to ‘manage risks’ by eliminating health and safety risks so far as is reasonably practicable. If it is not reasonably practicable to eliminate the risks, persons with health and safety duties are required to minimise those risks so far as is reasonably practicable.

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 *How to manage work health and safety risks Code of Practice* describes the risk management process and provides information on how this process should be undertaken. The information on hazards provided by this code of practice should be considered when undertaking the risk management process.

3.1 Working in heat

The WHS Regulation requires a person conducting a business or undertaking to ensure, so far as reasonably practicable, that workers carrying out work in extremes of heat or cold are able to carry out work without risk to health and safety.

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 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 should 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 (i.e. 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. 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 and radiant energy reflective face shields
- non-flammable and heat reflective clothing and equipment
- water cooled bodysuits/vests and other equipment
- protective gloves and footwear.

3.2 Hazardous chemicals

Hazardous chemicals (which incorporate hazardous substances, dangerous goods and combustible liquids) are widely used in the foundry industry. The WHS Regulation applies to the handling, storage or generation of hazardous chemicals at a workplace. The WHS Regulation also requires manufacturers or importers of a hazardous chemical to prepare a Safety Data Sheet (SDS) for each hazardous chemical they deal with and for suppliers to provide a current SDS to any person that is likely to use or be affected by the hazardous chemical.

Hazardous chemicals common to the foundry industry include:
- amines
- benzene
- hexachloroethane
- ammonia
- epoxy resins
- formaldehyde
- furfuryl alcohol
- isocyanates
- mould release paints
- protective coatings
- phenol
- crystalline silica.

Also refer to Appendix 1 which contains a list of the main hazardous chemicals that are encountered in foundries.

Health effects of hazardous chemicals
Hazardous chemicals can enter the body through inhalation, skin contact or by accidental ingestion. Different hazardous chemicals can create different hazards including fires or explosions as well as short and long term effects on specific organs of the body.

Prolonged exposure to hazardous chemicals 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.

Information about hazardous chemicals including safety data sheets (SDSs)
One of the first stages in managing hazardous chemicals safety is to identify all hazardous chemicals used at the workplace and ascertain the hazardous properties and safe handling precautions that may be required.

To do this, review the package markings and labels that identify each hazardous chemical. Each chemical which is recognised as a hazardous chemical will also have its own safety data sheet (SDS). The WHS Regulation requires the supplier of any hazardous chemical to provide a copy of the current SDS with the hazardous chemical. If the supplier does not provide an SDS, the person conducting the business or undertaking has a duty to ask for a copy of the current SDS.

All relevant SDSs should be referred to as part of the risk assessment process and can assist in determining the most appropriate control measures. The person conducting the business or undertaking should review the relevant SDS to determine the identity, appearance, physical and chemical properties, health effects, precautions regarding use, and safe handling practices associated with each hazardous chemical.

The WHS Regulation also requires a register of hazardous chemicals used, handled or stored at the workplace to be prepared and kept up to date. The register must be readily accessible to workers involved in using, handling or storing hazardous chemicals, and to anyone else who is likely to be affected by a hazardous chemical at the workplace. The register must contain the current SDS for each hazardous chemical listed.

Where workers are exposed to a chemical for which there is an exposure standard under the *Workplace Exposure Standard for Airborne Contaminants* (WES) as published by Safe Work Australia, the exposure standard for the chemical must not be exceeded. For a chemical for which no WES has been produced, efforts should be made to minimise exposure. The WES for a particular chemical should also be stated in the SDS; however this should be checked during the risk assessment process to ensure it is current.

It is also important for the person conducting the business or undertaking to check the hazardous chemicals and major hazard facilities sections of the WHS Regulation to ensure that he or she does not have a duty to notify the regulator of the quantities of hazardous chemicals they have on site. This duty will arise if the manifest quantity or 10% of the major hazard facility threshold has been exceeded. The WHS Regulation provides further details regarding this issue and the associated need for a manifest, a site plan and the provision of an emergency plan to the primary emergency service organisation.

Managing the risk of hazardous chemicals

As mentioned above, persons conducting a business or undertaking have a duty to manage the risks to health and safety associated with hazards at the workplace. The *How to manage work health and safety risks Code of Practice* provides practical advice on the risk management process including the conducting of a risk assessment for the workplace. The *Managing risks of hazardous chemicals Code of Practice* should also be referred to as it provides detailed information on how to manage the risks associated with hazardous chemicals in the workplace.

All control measures implemented to control the risk of hazardous chemicals should be examined and tested at regular intervals to ensure effective performance. Control measures should also be reviewed if work-related ill health is reported.

Some examples of control measures to consider while working through the *How to manage work health and safety risks Code of Practice* and the *Managing risks of hazardous chemicals Code of Practice* are included below.

<u>Elimination</u>

Work activities that are not essential should be eliminated wherever practical. For example:

- Use a physical process to clean an object (e.g. ultra-sound) instead of using a chemical process
- Use clips, clamps or bolt instead of adhesives
- Purchase supplies of a material in a ready-cut and sized form rather than carrying out a dust producing cutting process on site

<u>Substitution, isolation or engineering controls</u>

Substitution can be accomplished in a number of different ways. For example, a less hazardous chemical can be used during a chemical process, or the same chemical can be used in a less hazardous form (i.e. granular form instead of power), or the same chemical can be substituted into a less hazardous process. Other substitutions include:

- The use of toluene instead of benzene,
- water-based coatings instead of solvent-based coatings, and
- brushing or dipping processes instead of spray painting when coating cores.

Isolation involves the separation of the process from people. This can be done using distance, barriers or time to prevent exposure. Examples of isolation include:

- Use of a separate room for mixing epoxy resins in the pattern making process. Access to this room should be restricted to authorised persons who wear appropriate protective equipment.
- Use of an exclusion zone around work areas where hazardous chemicals are being used. This will prevent unprotected persons from entering or having access to the area.

Engineering controls may involve the use of plant or processes which minimise the generation of hazardous chemicals, suppress or contain a hazardous chemical, or limit the area of contamination in the event of spills or leaks. For example, an effective measure to minimise exposure to fumes from hazardous chemicals 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 workers' 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 hazardous chemicals. Administrative controls to consider 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 chemical
- 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 chemical 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 chemicals cannot be prevented or reduced by any other form of control, all exposed persons must be provided with personal protective equipment (PPE).

The basic PPE available to guard against risks from hazardous chemicals 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 chemical is present in an uncontrolled environment.

Issues that need to be considered include:

- nature of the chemical, the degree of exposure and the nature of the work; this will help in selecting the appropriate PPE
- use of 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 (this

includes demand breathing or positive pressure airline respirators, powered air purifying respirators [PAPR], self contained breathing apparatus with half or full-face respirator or hoods).

The WHS Regulation requires the person conducting a business or undertaking to provide PPE for workers at the workplace and to ensure that the selected PPE is suitable to the nature of the work and hazards associated with the work. The person conducting the business or undertaking must also ensure that the PPE is of a suitable size and fit and reasonable comfortable for the worker who is to wear it. The PPE must be maintained, repaired or replaced so that it continues to provide protection to the worker and must be kept clean and hygienic and in good working order. Workers must be provided with training and instruction on the proper use and wear of PPE and how to store and maintain it properly.

Controlling ignition sources where flammable atmospheres may exist
Flammable hazardous chemicals (e.g. methyl formate, toluene, xylene) may give rise to potentially hazardous (e.g. flammable) atmospheres and hazardous areas.[1] The WHS Regulation requires the person conducting the business or undertaking to manage the risks to health and safety associated with an ignition source in a hazardous atmosphere and a hazardous area. Areas where these hazardous chemicals are being used, stored or handled will require the following controls:

- Hazardous areas should be clearly defined or 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.
- Appropriate fire protection and fire-fighting equipment.
- Prevent accumulation of flammable and combustible materials by keeping these chemicals at the lowest practical quantity.
- 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 chemicals are incompatible if they can 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.

[1] Note that in the WHS Regulation, an atmosphere is considered to be hazardous if:

(a) the atmosphere does not have a safe oxygen level; or

(b) the concentration of oxygen in the atmosphere increases the fire risk; or

(c) the concentration of flammable gas, vapour, mist, or fumes exceeds 5 per cent of the LEL for the gas, vapour, mist or fumes; or

(d) a hazardous chemical in the form of a combustible dust is present in a quantity and form that would result in a hazardous area.

A hazardous area means a hazardous area under:

(a) AS/NZS 60079.10 (Electrical apparatus for explosive gas atmospheres—Classification of hazardous areas); or

(b) AS/NZS 61241.10 (Electrical apparatus for use in the presence of combustible dusts—Classification of areas where combustible dusts may be present).

Separation from protected works

Separation is the practice whereby stores of hazardous chemicals are separated from 'protected places'.

Protected places may include each of the following as examples.

- dwellings, places of worship, public buildings, schools, colleges, hospitals, theatres, assembly areas 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.

Stores of hazardous chemicals 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 and/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 hazardous chemicals. 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.

3.3 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 oxides, 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. For example, 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 influenced 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.

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 chemical 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 beryllosis, 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, furnace and ladle repair, 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

The person conducting a business or undertaking must manage risks to health and safety associated with hazardous atmospheres at the workplace. Exposure standards apply to certain airborne contaminants; the persons conducting the business or undertaking must ensure that no person at a workplace is exposed to a chemical in an airborne concentration that exceeds the exposure standard. The person must also ensure that air monitoring is carried out if the person is not certain on reasonable grounds whether or not the airborne concentration of a chemical exceeds the relevant exposure standard. Information on exposure standards can be found in the *Workplace Exposure Standard for Airborne Contaminants* (WES) as published by Safe Work Australia.

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

Substitution, isolation or engineering controls
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 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 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 do not exceed the exposure standard provided by the *Workplace Exposure Standard for Airborne Contaminants* (WES) as published by Safe Work Australia.
- 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.

3.4 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 *Hazardous manual tasks Code of Practice* provides detailed information regarding risks associated with musculoskeletal disorders and manual tasks and guidance on 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
While working through the *Hazardous manual task Code of Practice*, consider the following information and examples.

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** - 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)**[1] - PPE and clothing either because it is lacking or unsuitable, can increase the potential for injury. For instance, incorrectly sized gloves interfere 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.

3.5 Noise

Hazardous 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.

[1] Abdominal belts are not considered effective PPE as they have not been shown to offer protection against the risk of back injury.

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

Typical noise sources

At operator ear level:

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

The noise exposure standard is:

$L_{Aeq,8h}$ of 85 dB(A) or (b)$L_{C,peak}$

of 140 dB(C).

$L_{Aeq,8h}$ means the eight-hour equivalent continuous A-weighted sound pressure level in decibels (dB(A)) referenced to 20 micropascals, determined in accordance with AS/NZS 1269.1:2005 (Occupational noise management—Measurement and assessment of noise imission and exposure).

$L_{C,peak}$ means the C-weighted peak sound pressure level in decibels (dB(C)) referenced to 20 micropascals, determined in accordance with AS/NZS 1269.1:2005 (Occupational noise management—Measurement and assessment of noise imission and 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 *Managing noise and preventing hearing loss at work Code of Practice* provides detailed 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.

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'.

The hearing of workers exposed to noise can be monitored through regular audiometric examinations. Audiometric testing is an important part of managing the risks from noise exposure at the workplace. Starting the audiometric testing before people are exposed to hazardous noise (such as new starters or those changing jobs) provides a baseline as a reference for future audiometric test results. To be effective, initial audiometric testing should be provided within three months of the worker commencing work with regular follow-up tests at least every two years. These should be undertaken well into the work shift so that any temporary hearing loss can be picked up.

Please refer to the *Managing noise and preventing hearing loss at work Code of Practice* for further information and advice on audiometric testing.

3.6 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.

Both the *Hazardous manual tasks Code of Practice* and the *Managing noise and preventing hearing loss at work Code of Practice* provide further information and advice regarding vibration.

3.7 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.

3.8 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 *Managing risks of plant in the workplace Code of Practice* for plant 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 duties 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.

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. Consider the following information and examples while working through the Plant Code of Practice.

Substitution, redesign or isolation
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 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.

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.

3.9 Electricity

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

The *Electrical Safety Act 2002* (ES Act) imposes duties on persons conducting a business or undertaking to ensure the workplace and any electrical equipment under their control is electrically safe.

The *Electrical safety code of practice - Managing Electrical Risks in the Workplace* provides guidance to ensure your workplace is electrically safe.

Electrical work
Electrical work, as defined by the ES Act must only be performed by a suitably licensed person; either a licensed electrical contractor or a licensed electrical worker employed by the person conducting a business or undertaking

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 measures that can be used alone, or in combination, to reduce the level of risk of injury from electricity.

Elimination
Turn off the power. Do not work on electrical equipment where there may be a risk of exposed live parts. Removing covers on equipment to access mechanical parts may also expose live electrical parts. A risk assessment must be done to identify these risks and control measures must be implemented to reduce the risk to as low as is reasonably practicable. If there is still a high risk even with control measures in place, work must not proceed.

Engineering controls
Under the *Electrical Safety Regulation 2013* (ES Regulation), requirements for workplace electrical installations are classified by the type of work being performed. Most of the work performed in foundries would fall within the definition of Manufacturing 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.

The ES Regulation provides that employers must ensure that specified electrical equipment used in manufacturing 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, the ES Regulation 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.

While this is a way for PCBUs to discharge their duty, the ES Regulation regarding manufacturing work does not provide all that must be done to meet your electrical safety duty.

PCBUs have a duty 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.

Appendix 1: Main hazardous chemicals encountered in foundries

The information given in this table is provided as a guide only. It does not represent all chemicals that may be encountered in a foundry environment. As exposure standards are subject to change, reference should be made to the *Workplace Exposure Standard for Airborne Contaminants* (WES) as published by Safe Work Australia to ensure that the exposure standard is correct.

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Substance	Process/use	Health effects	Exposure standard
Acids	Used as amine neutralisers in effluent gas	Skin, eye and respiratory irritation	Various e.g. HCl Peak limitation: 5 ppm or
Acrolein	Decomposition product from core ovens. Emitted during pouring and shakeout where oil sand cores are	Eye, nose and throat irritation, lacrimation, pulmonary oedema	TWA: 0.1 ppm or 0.23 mg/m^3 STEL: 0.3 ppm or 0.69 mg/m^3
Aluminium oxide	Melting and pouring of aluminium alloys. Deoxidant for steel alloys.	Respiratory irritation. May possibly result in pulmonary fibrosis	TWA: 10 mg/m^3
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^3 STEL: 35 ppm or 24 mg/m^3
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	TWA: 1ppm or 3.2 mg/m^3
Beryllium	Copper alloy, emitted during melting and pouring.	Probable human carcinogen. Lung cancer, dermatitis.	TWA: 0.002 mg/m^3
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^3 STEL: 30,000 ppm or 54,000 mg/m^3

Carbon monoxide	Emitted during melting and pouring processes, or any process pyrolysing carboniferous compounds. Decomposition product of core-making.	A chemical asphyxiant that interferes with oxygen carrying capacity of blood that may lead to anoxia. Headaches, dizziness, drowsiness, nausea, vomiting, loss of co-	TWA: 30 ppm or 34 mg/m^3 STEL: 60 ppm for 60 min 100 ppm for 30 mins 200 ppm for 15 mins
Chlorine	Degassing agent used with non-ferrous alloys.	Eye, nose and throat irritation, pulmonary oedema and congestion. Acute exposures may cause	Peak limitation: 1 ppm or 3 mg/m^3
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^3
Copper (fume)	Melting, pouring and grinding of copper alloys.	Acute respiratory irritation, metal fume fever.	TWA: 0.2 mg/m^3
Dimethylamine (DMEA)	Catalyst for cold-box binder systems.	Skin irritation, corneal oedema, “halovision”, contact	TWA: 10 ppm or 18 mg/m^3
Diphenylmethane diisocyanate (MDI)	Binder component used in urethane binders.	Eye, respiratory tract and skin irritation, bronchitis, nausea, vomiting, abdominal pain, occupational	TWA: 0.02 mg/m^3 as - NCO group STEL: 0.07 mg/m^3 as - NCO group
Formaldehyde	Constituent of resinous binders. Vapours emitted in moulding, pouring and shakeout areas from the decomposition of binder materials.	Strong irritant and sensitiser to skin, and respiratory tract, pulmonary oedema, bronchitis, contact dermatitis. Probable human carcinogen.	TWA: 1 ppm or 1.2 mg/m^3 STEL: 2 ppm or 2.5 mg/m^3
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^3 STEL: 15 ppm or 60 mg/m^3
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^3
Hydrogen cyanide	Decomposition product of nitrogen-containing binding agents.	Dermatitis, asphyxia, death, neurological changes	Peak limitation: 10 ppm or 11 mg/m^3

Hydrogen sulphide	Emitted during water quenching of slag. Decomposition product of some binders and catalysts during	Eye and respiratory irritation, nervous system changes, respiratory paralysis	TWA: 10 ppm or 14 mg/m^3 STEL: 15 ppm or 21 mg/m^3
Iron oxide (fume)	Melting, pouring and grinding of iron and steel.	Pulmonary irritation	TWA: 5 mg/m^3
Lead (fume)	Alloying agent for copper-based alloys. Emitted during melting, pouring and grinding of lead, iron	Kidney, blood, gastrointestinal and nervous system changes	TWA: 0.15 mg/m^3
Magnesium oxide (fume)	Melting and pouring of ductile (nodular) iron and magnesium.	Metal fume fever - fever, fatigue, aches, metallic taste in mouth	TWA: 10 mg/m^3
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^3 STEL: 3 mg/m^3
Methane	Emitted from ovens, furnaces and cupolas, and during pouring and	Asphyxiant, unconsciousness and death.	Maintain minimum oxygen content in air 18% by volume under normal
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^3 STEL: 150 ppm or 368 mg/m^3
Nickel	Melting, pouring and grinding of nickel and stainless steel.	Dermatitis, lung and nasal cancer.	TWA: 1 mg/m^3
Nitrogen	Emitted from furnaces.	Oxygen deficiency, asphyxiant.	Maintain minimum oxygen content in air 18% by volume under normal atmospheric
Nitrogen dioxide	Produced in electric welding and arc air gouging.	Respiratory effects, lung oedema.	TWA: 3 ppm or 5.6 mg/m^3 STEL: 5 ppm or 9.4 mg/m^3
Ozone	Produced in electric welding and arc air gouging.	Respiratory effects, lung oedema.	Peak limitation: 0.1 ppm or 0.2 mg/m^3

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^3
Phosphoric acid	Furan resin catalyst.	Eye, skin and respiratory tract irritation, dermatitis	TWA: 1 mg/m^3 STEL: 3 mg/m^3
Polycyclic aromatic hydrocarbons (PAHs)	Produced in pyrolysis of organic compounds. Pouring decompositio n product of sand moulds, cupola	Associated with lung cancer, skin erthyema and sensitisation to ultra violet radiation	Examples: Cresol TWA: 5 ppm or 22 mg/m^3 Naphthalene TWA: 10 ppm or 52 mg/m^3
Silica (quartz)	Dusts emitted during moulding, core- making, shakeout, fettling and sand reclamation processes. Abrasive blasting of metal castings.	Chronic lung disease, silicosis	TWA: 0.1 mg/m^3
Sulphur dioxide	Catalyst for cold-box binder system. Emitted from furnaces and during magnesium casting. Breakdown product of toluene sulphonic acid or benzene	Eye and respiratory irritation, chronic bronchitis, asphyxia.	TWA: 2 ppm or 5.2 mg/m^3 STEL: 5 ppm or 13 mg/m^3
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^3 STEL: 150 ppm or 574 mg/m^3
Triethylamine	Catalyst used in coldbox binder system.	Irritation, oedema, chemical sensitisation	TWA: 3 ppm or 12 mg/m^3 STEL: 5 ppm or 20 mg/m^3
Wood dusts (hardwoods)	Pattern making	Alteration to structure of mucous membrane linings. Nasal cancer. Respiratory sensitisation and	TWA: 1 mg/m^3
Wood dusts (softwoods)	Pattern making	Allergic reactions, skin sensitisation, occupational	TWA: 5 mg/m^3 STEL: 10 mg/m^3

Xylene	Solvent used in corewashing. Mould decomposition product.	Irritation, CNS depression, liver and kidney damage pulmonary oedema	TWA: 80 ppm or 350 mg/m^3 STEL: 150 ppm or 655 mg/m^3
Zinc oxide (fume)	Melting, pouring and grinding or zinc, galvanised metal and brass.	Dermatitis, metal fume fever	TWA: 5 mg/m^3 STEL: 10 mg/m^3