HEALTH AND SAFETY IN THE STEEL INDUSTRY

A Workers' Handbook

International Metalworkers' Federation
Geneva, 1999

Foreword by Marcello Malentacchi, General Secretary, International Metalworkers' Federation

Occupational health and safety is undoubtedly the single most important issue for working people, irrespective of which region of the world or country they happen to live in, or in which industry or sector they are employed.

In the past, and sadly today in many developing countries, many workers have been forced to make a choice between having work and their health and general well-being. And they have not been helped by the lack of reliable and independent sources of easily available information, knowledge which is essential in order to recognise the dangers posed by, and how to avoid exposure to, harmful substances or other hazards associated with industrial production processes.

The iron and steel industry is accepted as being one of the most dangerous in which to work, but most if not all of these hazards can either be eliminated by substitution or technical solutions, or else controlled to prevent harmful exposure, either for the workers themselves, or the wider environment.

With the knowledge and technologies we have today, workers do not have to choose between having a job and risking their life and limb. It is not only possible to have both - a job and a healthy life, but the failure by employers to ensure this, is both morally and economically indefensible.

Many studies have identified the huge costs arising from occupational illnesses and accidents, both to the employer, as well as to society at large. Furthermore, it has been shown that expenditure on improving health and safety is cost-effective. Yet far too many employers still see money spent on health and safety provisions as a cost to be avoided or at best minimised, rather than an investment that will reap significant rewards, both for themselves as well as their employees, who for far too long have been forced to pay for their employers neglect, through ill-health, disablement or premature death.

This hand-book on occupational health and safety, which has been produced for the IMF by the Sheffield Occupational Health Project, is designed to help to overcome the lack of information, and help steelworkers recognise the sources of the many different hazards they are likely to be exposed to in the course of their employment. Armed with this knowledge, they will be able to demand improvements in their health and safety provisions and conditions of work, that will ensure they are able to enjoy the fruits of their endeavours.

Contents

CONTENTS

The book is divided into three main sections:

- The **first section** describes the health and safety problems associated with **different parts of the production process** in steelmaking and the manufacture of steel products.

- In the **diseases section**, the **main health problems** of steel and foundry workers are described, along with information on how to recognise them, and the jobs which have most often been associated with them.

- The **hazards section** describes the **physical, chemical and psychological causes** of steelworkers' health problems and methods of prevention. Internationally accepted exposure standards are described.

Health and safety in the steel and foundry industry

In 1998, seven million workers are employed worldwide in the steel industry alone. Numbers of steelworkers are falling in the long-industrialised countries but continue to rise in the transitional economies in Latin America, South and East Asia.

World trade

The health and safety of steel and foundryworkers all over the world is linked. Production technologies are exported whether as designs or as hardware. The time lag between innovation and adoption of a new technology as standard all over the world can be as little as ten years. Second hand equipment is traded as well.

Two-thirds of raw materials and steel products are involved in world trade - i.e. manufactured for external markets; so that the resources available to firms to invest in health and safety are affected by changes in the world economy and in the prices for raw materials and finished products.

Import of labour

Of the millions employed worldwide in the steel and foundry industries hundreds of thousands are migrant workers often with no permanent residing rights in the countries where they work.

Multinationals

The primary metal industries have strategic importance to national governments. However steel companies are becoming increasingly multinational. The largest companies now have production subsidiaries in ten or more countries. The health and safety standards employed in these subsidiaries are not always consistent.

The same problems worldwide

In many ways steel and foundry-workers all over the world face the same health and safety problems: the same technologies, and economic pressures. Governments have come under pressure to weaken health and safety regulations, and to reduce the level of enforcement. Sub-contracting and casual work have become more common in many countries. As manning levels have been reduced the individual workload has increased - with longer working hours and additional responsibilities being introduced. The introduction of new technologies and management structures has not always been matched by the training required to prevent new problems from arising.

But in certain respects problems differ. There has been a tendency for new technologies to be adopted first in the long-industrialised countries and for these technologies to require fewer workers for a given level of production. The same countries have concentrated their production on the most expensive products often introducing new alloys. New technologies and new management techniques may introduce new threats to workers' health.

At the same time much older and more labour intensive technologies continue to be used in countries where wages are low, investment capital is short or traditional materials are cheap.

The health of the workforce

Workforces in newly set-up industries tend to be relatively young. Inevitably exposure to hazards has been short so that there is less evidence of ill-health and often less experience of controlling hazards. In older industries with declining workforces employers tend to recruit fewer workers and offer older workers incentives to leave the workforce. These offers are often accepted by those in the workforce who are most sick, with the result that the health effects of work in the steel industry are borne by society. Consequently the steel industry appears a relatively healthy place to work.

What is being done

Training provided at plant level is frequently inadequate. The International Metalworkers' Federation (IMF) is the main organisation which brings together steelworkers from different countries in joint training programmes. The best methods by which workers can improve working conditions can be then be spread widely.

The IMF

The aim of the IMF is to improve working conditions and to fight for the rights of metalworkers all over the world.
The IMF works with international bodies, such as the International Labour Organisation and the OECD to make sure that the best standards are introduced across the world, and that the results of research are passed on to steel and foundry-workers everywhere.

Conclusions

Working in the steel and foundry industries is dangerous. Yet the health risks of their jobs have received less attention than those in many other work sectors.
Partly this is because work in the industries is extremely varied; it is harder to research and more difficult to draw general conclusions. There is a reluctance sometimes to admit to health effects which are seen as inevitable - just part of the job.
The level of fitness required for many of the heavy manual jobs in the steel and foundry industries means that surveys have often shown that after only a few years of work steel and foundry workers are still fitter than those in other jobs.
However the most careful studies have shown that steel and foundry workers are at increased risk of many of the major causes of death; lung cancer, chronic lung diseases, and even heart disease.
Other illnesses of steel and foundry occupations affect quality of life and may result in workers having to leave their jobs or finish work altogether; vibration syndrome, eye problems, upper limb disorders, back problems and dermatitis are examples.

Risk Map from the SICARTSA steelworks in Mexico. The map was based on the results of a workers' questionnaire organised by the trade union (Laurell AC, Noriega M,

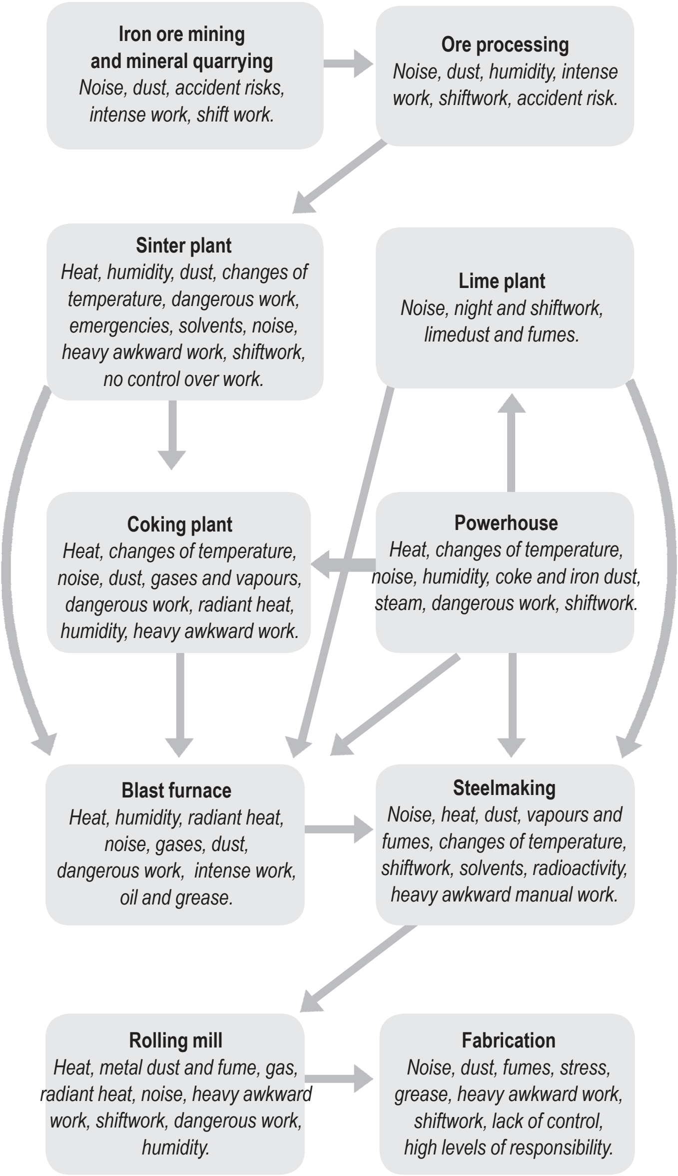
Machine shop
Heat, dust, fumes, noise, shiftwork, dangerous work, heavy awkward work, monotony.

Joiners shop
Heat, noise, lighting, solvents (paints, thinners) accidents, dust (wood).

Internal transport
Dust, fumes, heat, noise, changes of temperature, dangerous work, boring work, awkward work, shiftwork, isolation, doubleshifts.

These impact all areas

Maintenance
Noise, heat, dust, fumes, heavy, awkward work, dangerous work,molten metal, unsupportive supervision.


Iron ore mining and mineral quarrying
Noise, dust, accident risks, intense work, shift work.
Ore processing
Noise, dust, humidity, intense work, shiftwork, accident risk.
Sinter plant
Heat, humidity, dust, changes of temperature, dangerous work, emergencies, solvents, noise, heavy awkward work, shiftwork, no control over work.
Lime plant
Noise, night and shiftwork, limedust and fumes.
Coking plant
Heat, changes of temperature, noise, dust, gases and vapours, dangerous work, radiant heat, humidity, heavy awkward work.
Powerhouse
Heat, changes of temperature, noise, humidity, coke and iron dust, steam, dangerous work, shiftwork.
Blast furnace
Heat, humidity, radiant heat, noise, gases, dust, dangerous work, intense work, oil and grease.
Steelmaking
Noise, heat, dust, vapours and fumes, changes of temperature, shiftwork, solvents, radioactivity, heavy awkward manual work.
Rolling mill
Heat, metal dust and fume, gas, radiant heat, noise, heavy awkward work, shiftwork, dangerous work, humidity.
Fabrication
Noise, dust, fumes, stress, grease, heavy awkward work, shiftwork, lack of control, high levels of responsibility.

1.1 WORK AREAS: COKING PLANTS

In the coking process the carbon content of coal is increased by driving off or burning the volatile constituents of coal. The purity of coke and its high burning temperature make it suitable for production of iron.

Cleaning, grading and loading of coal

The main hazards in this area are dust, manual handling, noise and vibration.

Coke production

Temperatures between 700 and 1,200°C are reached in the coke ovens themselves. This exposes workers to heat and to volatile substances including benzene, xylene, naphthalene, hydrogen cyanide, ammonia, hydrogen sulphide, carbon monoxide, and polycyclic aromatic hydrocarbons (PAHs) (including 3,4 Benz-a-pyrene). The highest levels of benzene, xylene, toluene and PAH's are reached on the oven top. Emissions are greatest soon after charging the coke oven.

When the conversion of coal to coke is complete the coke is quenched with water or gas. Quenching releases more volatile substances. Wet quenching produces steam, gases and emissions of coke dust.

Recycling of gases, use of by-products

The volatile substances are cooled and separated. Some fractions are recycled to be burnt as a source of heat within the steelworks. Others are separated out and used as raw materials for chemical manufacturing. Further exposures to organic chemicals occur at this stage with storage tanks as the source of the highest levels of benzene, toluene and xylene.

In a steelworks in Sao Paulo, Brazil, benzene from coke production was burnt as a fuel in the steelworks itself. As a result 2,000 workers suffered blood abnormalities.

Loading

The coke is loaded into trucks or transported by conveyor to the blast furnace.

Health problems

- The combination of heat and acute as well as chronic exposures to chemicals may produce combined effects more serious than those of individual exposures on their own.
- Acute irritation from ammonia and other gases.
- Chronic obstructive lung disease
- Lung, kidney and bladder cancer (the highest level of carcinogens is found at the coke oven top).
- Leukaemia.
- Occupational deafness.
- Poisoning from carbon monoxide, hydrogen sulphide, hydrogen cyanide and benzene.
- Musculoskeletal injuries.
- Burns.

BLAST FURNACES AND DIRECT REDUCTION

Iron ore is reduced to iron in the blast furnace using coke (or coal) and limestone in the reduction. Heated air, sometimes supplemented with oxygen, is blown into the base of the blast furnace to burn the coke. In some blast furnaces a fuel is added to the heated air and oxygen, usually oil or powdered coal.

Ore preparation and sintering

Preparation of iron ore, coal, coke and limestone (or dolomite) is carried out prior to charging the blast furnace. Ore is crushed and graded for size and may be either sintered or pelletised. Coke, limestone, and other fluxes are graded to the required size. Ore preparation and sintering are extremely dusty processes. Ore may contain significant quantities of manganese, arsenic, sulphur and other elements.

Blast furnace

The process of reducing the ore to iron produces large amounts of gas rich in carbon monoxide (up to 40%) which is collected for use as a fuel, often to heat the air used in the blast furnace. The molten impure iron is tapped off from the bottom of the blast furnace, together with the slag formed from limestone and the impurities in the iron and coke.

Direct reduction

Extensive research has been carried out to find an alternative to the coke oven/blast furnace route for the production of metallic iron. The improved energy efficiency of eliminating the need for coke production, and the potentially more flexible output levels of direct reduction are amongst the attractions.

In the Corex technology coke is gasified directly by reaction with oxygen and then supplied to a reduction shaft in which it reacts with iron ore to form metallic sponge iron. The reaction of coal and oxygen generates a temperature of 1,000°C which breaks down hazardous tar and phenol compounds.

A number of other direct reduction technologies are in development. It is too early to say whether they will eliminate hazards associated with blast furnaces and coking or will introduce them in a different form.

Hazards and health problems

The principal hazards and health problems encountered in hot metal production arise from inhalation of dust, (from raw materials, blast furnace linings and slag), and from gases (carbon monoxide, sulphur dioxide). Dusts may include silica, and compounds of iron, manganese, phosphorus, magnesium and calcium. Blast furnace linings include carbon blocks, silicon carbide (for tuyeres for example) and high alumina bricks.

Other problems arise from exposure to heat, particularly in front of the blast furnace, and infrared radiation from the iron itself especially affecting casters. Low levels of volatile organic chemicals from coke or coal may occur.

All areas associated with ore and raw material preparation and the blast furnace itself are noisy. Noise levels are highest around the tuyeres through which gas is introduced into the base of the furnace and at the offtakes from which gases are vented at the top of the furnace. Operators are exposed to whole body vibration.

Manual tasks are increasingly being replaced by automation, reducing risk of injury and strain. However there are still many heavy jobs involving work in high temperatures and exposure to heat radiation. Specific accident risks exist from dust explosions in coal and coke bunkers, and during tapping.

Diseases:

- Chronic obstructive lung disease and bronchitis.
- Silicosis.
- Skin and lung cancer.
- Heat stress.
- Heat cataract.
- Carbon monoxide poisoning.
- Cardiovascular disease.
- Dermatitis.
- Occupational deafness.
- Back injuries and other musculo-skeletal disorders.
- Burns.

The main types of melting furnace currently in use are:

1) Basic oxygen furnace
2) Electric arc furnace
3) Cupola furnace
4) Induction furnace

Basic oxygen and electric arc furnaces are responsible for most steel production. Cupola and induction furnaces are largely restricted to the foundry industry. A few open hearth furnaces are still used for steelmaking. The common problems of all melting processes are heat, noise, metal fumes, toxic gases, slag and refractory dust.

There are differences between the melting methods which depend on:

1) Types of steel or iron which are produced
2) Nature of raw materials used (pig iron or scrap).

Basic oxygen steelmaking (BOS)

In basic oxygen steelmaking the main raw material used is molten iron with scrap and pig iron contributing a smaller percentage. BOS plants are sited close to blast furnaces so that molten iron is supplied directly to the convertor. The distinguishing characteristic of BOS is that the heat required by the furnace is produced by reaction of oxygen (usually supplied via a lance) with carbon and other impurities (including silicon and manganese) in the hot metal. Large quantities of dust are generated during the transfer of molten iron to the convertor and by oxygen lancing.

Electric arc furnace (EAF)

In electric arc furnaces steel is made by melting scrap and alloy additions with the heat of an electric discharge between electrode and the scrap.

Secondary steelmaking

The raw steel is tapped from the BOS or from an EAF into a ladle and can be further treated to achieve the correct chemical specification. This may involve one or more of the following ‘secondary steelmaking’ processes:

- Addition of alloying elements during tapping,
- Alloy trimming and stirring, including treatment in specialist units such as CAS, CAS-OB, wire feeding or desulphurisation,
- Further heating in a ladle furnace or by oxidation of aluminium,
- Vacuum treatment to remove carbon or hydrogen.

The steel is then cast into solid shapes either in ingot moulds or increasingly via continuous casting machines. Continous casting machines can produce slab and sheet steel as well as billets.

Induction furnace

Electrical currents induced in steel scrap heat the steel to melting point. The induction furnace is mainly used in melting small quantities of steel for manufacturing castings or for pre-heating in other areas of steel production.

Other types of furnace

The cupola furnace shares many of the risks associated with blast furnace work though scrap rather than iron ore is normally used as raw material. The cupola furnace is charged with coke and scrap or pig iron. Molten iron is removed for casting. Carbon monoxide levels in the vicinity of cupola furnaces are frequently high. The Bessemer or Thomas convertor was the forerunner of the BOS process, but with bottom blown air rather than an oxygen lance used to speed the reduction process.

Open hearth (Siemens) furnace

This is a slower and older method of steelmaking using hot, metal pig iron or scrap, in a bath-shaped furnace. Linings were acidic or basic (Thomas). In the 1950s oxygen blowing was introduced to speed up the process. A few open hearth furnaces are still in use, particularly where low labour costs make a slower and more labour intensive steelmaking method economical. Plants making gas from coal were frequently built close to open hearth furnaces to supply them with coal gas. Coal gasification produces coal tar derivatives known to increase risk of a number of cancers.

The principle hazards in melting come from:

■ Heat

All workers particularly those involved in charging, tapping, casting, and lancing. Because of pressure to maintain production, maintenance is often carried out while the furnace is still hot. Open hearth furnaces take longer to make steel and expose workers for longer periods and to higher levels of heat radiation than other methods.

■ Noise

Noise sources include scrap-handling, the electric arc in the electric arc furnace during melting, the addition of alloys, and from gas blowers and oxygen supply in open hearth and BOS. Extraction equipment is another source of noise. Noise levels in working areas frequently exceed 100 dBA.

■ Fumes

The main sources of fume are the metals being melted; scrap, alloy additions, impurities in the scrap (e.g. plastics, oil, paint) which burn off to produced complex mixtures of organic chemicals and soot. Electric arc furnaces generate nitrogen oxides and ozone from the ultraviolet-induced breakdown of air around the furnace. Fume and dust levels are frequently worst in the atmosphere around the overhead cranes.

Breakdown of oil films used in ingot moulds is a further source of fumes.

■ Dust

The dust evolved by steelmaking includes metals, fluxes, slag dust and dust from furnace linings.

Metals: Very large quantities of metal fume and dust (sometimes as much as 1% or more of steel melted) can be generated, most of which will be iron or an oxide of iron. However any metallic element present in the final product (see table in the Hazards Guide) as well as impurities in the scrap; cadmium, lead, arsenic, beryllium, or zinc may be present. Lead, zinc and arsenic are frequently present where cheap scrap or leaded steel has been used. Radioactive scrap (e.g. from medical sources or from the nuclear industry) is occasionally used, with consequences at all stages in steel production.

Slagging agents or fluxes: Other sources of dust include slag and "top powders"; which include aluminium oxide, calcium oxide, magnesium oxide, fluorides, calcium cyanamide. The slag itself will contain phosphorus, calcium, aluminium, manganese and sulphur compounds derived from impurities in the steel and the flux itself. Grinding of wet slag releases hydrogen sulphide.

Breakdown products: Benz-a-pyrene and other polycyclic aromatic hydrocarbons. Coal tar pitch volatiles, chlorinated hydrocarbons (including dioxins).

Refractory materials include magnesite, aluminium oxide, tar-impregnated bricks, silicates and silica flair. Asbestos has traditionally been used to insulate pipes and cables and to fill joints. Man-made mineral fibres are currently used in some of the same applications, as well as in furnace linings. Silicate linings were originally widely used but have been replaced by basic linings since the 1960s. However silica brick is still used where costs of importing or transporting basic linings would be high. Basic linings (calcium or magnesium carbonate) help to remove phophorus which allows the use of high phosphorus ores in ironmaking. Ladle linings include magnesium oxide, magnesium-chromium compounds and alumina based bricks.

■ *Gases*

Raised levels of a number of gases have been observed in electric arc processes; ozone and nitrogen oxides produced by the UV breakdown of nitrogen and oxygen in the air, and carbon monoxide from incomplete combustion of impurities in scrap or from the carbon content in the steel. Sulphur dioxide has also been found at damaging levels.

■ *UV light*

The electric arc produces intense UV light.

■ *Electromagnetic radiation/ Ionising radiation*

High levels of electromagnetic radiation may occur around transformers and other electrical plant. Monitors should be in place to prevent contamination arising from use of radioactive scrap.

Occupational diseases in melting shop workers

- Chronic obstructive lung disease, bronchitis, lung fibrosis (rarely silicosis): all areas.
- Dermatitis: particularly furnace bricklayers and labourers.
- Whole body vibration (digestive and musculoskeletal effects): overhead crane drivers and charger drivers.
- Back problems and musculo-skeletal disorders: manual handling of ladles (foundry melting shops), continuous casting, maint-enance operations, ladle and furnace wrecking and relining.
- Accidents: explosion risk, burns, flying metal particles.
- Heat stress: all areas.

- Occupational deafness: all areas.
- Stress: all areas.
- Eye problems: heat cataract: melters.
- Poisoning: carbon monoxide poisoning near cupola furnaces and BOS extraction systems.
- Metal fume fever: melters, casters.
- Coronary heart disease, angina (foundry melting shops).

ROLLING

The principal risks in rolling mills come from noise, dust and fumes, and manual handling.

Noise

The main sources of noise are from metal passing through the rolls themselves, associated gears and from other activities; pre-heating furnace, bar-straightening, shears and saws as well as handling and stacking of finished products.

Dust and fumes

There are several different sources of airborne dust and fumes in the rolling mills.

- Metal dust and fumes: iron and other metals and their oxides (rolling, cutting, scarfing, grinding).
- Oil: from lubrication, causing a fine mist, paraffin to 'brighten' steel.
- Water: from coolants, which may be unpurified.
- Gas fumes: from pre-heating furnaces.
- Gases released by the metal itself, including sulphur dioxide.
- Acids and solvents: for cleaning and pickling steel and for roll cleaning.

Airborne material is generally a mixture of these substances. Research has shown that rolling mill workers have an increased risk of chest diseases including bronchitis, chronic obstructive lung disease, lung fibrosis and lipoid pneumonia (from inhalation of mineral oils).

Manual handling and accidents

Modern automated rolling mills employ fewer workers, most of whom work away from the rolling millfloor in a sound-proofed, air-conditioned cabin or carrying out maintenance operations. Older rolling mills involve manipulation of steel from one set of rolls to another. This involves heavy loads moved at awkward heights. Back injuries and cumulative traumas from use of tools for holding steel are common.

Radiant heat

Individual exposure levels to heat radiation may be higher in rolling mills than at melting furnaces, because of longer periods of exposure. Heat stress is the main effect reported.

Diseases

- Chronic obstructive lung disease.
- Lipoid pneumonia.
- Asthma, and lung fibrosis.
- Occupational deafness.
- Occupational skin problems.
- Musculoskeletal disorders.
- Heat stress.
- Injuries.

FORGING, STAMPING, BLACKSMITHING

Steel is heated and shaped on a die under the impact of a hammer or die. Once stamped or forged, workpieces may be cooled in quenching liquids. Parting materials are often placed between die and workpiece and over the workpiece before it is forged.

Noise

The main hazards in this process are noise from the impact of the hammer, from explosive destruction of parting materials, and from gears, power sources and pre-heating furnaces. Much of the noise is impact noise or noise with a considerable low frequency component. In addition to typical "sensorineural" deafness due to noise, there is evidence that hearing loss may occur at low frequencies more than usual and that damage to the ear drum may occur with an increased risk of middle ear infection.
Other non-auditory effects of noise are also likely to occur.

Radiant heat

Radiant heat from pre-heating furnaces and the workpiece can expose workers to high levels of infrared radiation because of the long periods of exposure.

Electromagnetic fields

Induction furnaces used for heating steel can produce fields of 12 mTesla at a distance of one metre from the coil.

Manual handling

Depending on the size of the workpieces, forging and stamping is often heavy work involving use of tongs or manipulators to place and manoeuvre the workpiece. Back injuries, upper limb disorders and work related hand injuries are common. The effect of repeated vibration and recoil in the hands is that a number of hand syndromes occur: vibration induced white finger, carpal tunnel syndrome and Dupuytren's contracture.

Chemicals

The principal chemical exposures are

- Dust from the steel being forged (i.e. any steel alloy metal and its oxide), dust from the die.
- Parting compounds: oils, sawdusts etc, graphite in dropstamping.
- Quenching fumes: oil breakdown products.
- Fumes from pre-heating furnaces: carbon monoxide, soot etc.

Forgeworkers and stampers are more susceptible to chronic obstructive lung disease including asthma than non-exposed workers. While few surveys of forges have been carried out it seems likely that fumes and dust will give rise to an increased risk of cancer of the lungs and possibly other sites.

Injuries

The large forces and heavy unit weights involved in many forges mean that there is a high risk of injury. Flying steel from the workpiece can cause severe cuts and burns. Crushing injuries also occur.

Illnesses

- Occupational deafness.
- Hand-arm vibratrion syndrome.
- Chronic obstructive lung disease.

WIREDRAWING

1.6

Metal is drawn through a die lubricated with soap (generally an aluminium, calcium or sodium stearate). Further treatment of the wire includes pickling, degreasing, plating, coating and heat treatment.

Hazards associated with wiredrawing include dust from the wire itself, soap dust and combustion products from the soap (polycyclic aromatic hydrocarbons and soot). The dies through which the wire is drawn are made of hardened steel or tungsten carbide. Diegrinding may expose workers to tungsten carbide dust. Skin contact with soap powders and other die lubricants can result in dermatitis. Patenting; a process involving cooling of newly drawn wire in a bath of molten lead to improve its ductility, carries a risk of exposure to lead fume.

New chemicals are constantly being tried out to allow faster wiredrawing speeds and to obtain particular surface properties.

Wiredrawing is noisy. Grinding and shaping the bar before drawing exposes workers to high levels of hand-arm vibration.

The main accident risks come from unguarded wiredrawing machines and from wirecoiling operations.

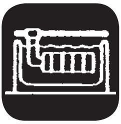
Other hazards are those described elsewhere for pickling, degreasing, heat treatment and coating.

Diseases

- Chronic obstructive lung disease.
- Dermatitis.
- Lead and solvent poisoning.
- Occupational deafness.
- Hand-arm vibration syndrome.

PICKLING

1.7



Pickling of steel as a method of removing scale involves use of one or more of the following acids; sulphuric acid, hydrochloric acid, hydrofluoric acid, nitric acid and phosphoric acid.

The principle health effects result from breathing in acid mists. Strong acid mists are known to cause cancer of the throat and lung, chronic obstructive lung disease and bronchitis. Contact of acid vapours with nose and eyes results in nose bleeds and irritation. Damage and discolouration of the teeth is a common effect of work close to pickling vats.

The pickling process is noisy and can cause occupational deafness. Injuries from splashes, and explosions resulting from the evolution of hydrogen gas can occur.

Some research suggests an increased risk of heart disease amongst workers involved in pickling.

Diseases

- Lung and laryngeal cancer.
- Chronic obstructive lung disease.
- Occupational deafness.
- Dental erosion.

FINISHING

Many processes are used to ensure that steel products have the desired surface properties. These processes include scarfing, grinding and chipping to remove scale and imperfections in rolled products. Shotblasting, chipping, grinding and scarfing are all used to clean castings of adhering mould materials. Strip or tube may be welded.

The principle hazards are dust and fume from the steel itself, the electrode used in welding, and, in foundries, from mould or core materials. The composition of the dust will depend on the composition of the iron or steel being produced and the nature of foundry materials used (sand or resin type) The steel finishing operations are noisy and involve high levels of hand-arm vibration.

Manual handling is frequently used to shift the steel product or casting into a new position.

Eye hazards come from dust and fume generated by cleaning operations.

Principle accident risks include trapping injuries, burns (frequently castings are worked on while still hot). Floors are often covered with material which has been removed from the steel product giving rise to risks of tripping and falling.

Illnesses

- Chronic obstructive lung disease, 'welder's lung'.
- Silicosis.
- Hand-arm vibration syndrome.
- Welder's flash or "arc-eye".
- Occupational deafness.

Molten metal is poured into a mould in which it solidifies. The cast metal is then separated from the mould, cleaned and any defects repaired. The shape of the mould which is generally made of sand mixed with other substances, is produced by making a pattern the same size and shape as the finished article. The pattern itself is fabricated out of wood, metal or plastic (or wax in the "lost wax" method). More complex shapes with voids or hollows require a "core" to be made from sand bonded with synthetic chemicals and precisely positioned during casting. In centrifugal casting, metal is cast into a spinning mould to produce castings in which steel composition may vary from the outer to the inner part.

Dust and fumes

The main sources of dust and fumes in the foundry are:-

- Moulding and coremaking: sand and resin breakdown products. (See table).
- Pattern-making: wood and plastic dust, adhesives.
- Melting, teeming and casting: metal fumes and fumes.
  from the breakdown of mould and core-making chemicals.
- Knock-out, sand reclamation: sand and resin breakdown products. (See Steelmaking).
- Fettling: sand, resin breakdown products and metal dust. (See Finishing).
- Arc-air gouging: metal fumes. (See Finishing).
- Burning off the mould paint.

The health problems connected with metal fumes are dealt with in the section on Steelmaking. Particular problems in foundries arise from the silica content of moulding sands before and after use and the chemistry of resins (see table on resins). Dust levels are highest in fettling (where metal dust is also present) at knockout and around sand reclamation areas. The levels of resin chemicals are highest in the coremaking area.

Silica exposure gives rise to silicosis, chronic obstructive lung disease and possibly lung cancer. Many resin reagents are lung irritants and sensitisers giving rise to asthma and other obstructive lung problems.

The combination of fumes and dust present in the foundry are responsible for a special rsk of lung cancer amongst foundry workers. It is thought that the breakdown products of coremaking chemicals, which include known carcinogens are one possible cause. Other cancers are also more common amongst foundryworkers according to some research studies; these include stomach cancer.

Noise

Noise levels in moulding, melting, knockout, fettling and sand-reclamation areas are frequently above 90 dBA.

Vibration

The principle sources of vibration in foundries are the hand-held tools used to clean castings, particularly pneumatic chippers and high speed grinding wheels. Vibration syndrome, carpal tunnel syndrome,

Chemical emissions from various foundry processes

Chemical name \ Process	Clay-bound mold materials with carbon carriers	Waterglass binder with carbohydrate containing additives	Phenolic resin, cold-hardening	Furanic resin, cold-hardening	Urethane reactants (eg. cold-box process)	Shell mold process	Hot-box process, phenolic resin	Hot-box process, furanic resin	SO_2 process	Greensand
Ammonia						✓	✓	✓		
Benzene			✓		✓				✓	✓
Carbon dioxide	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbon monoxide	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cresol				✓						
Dimethylethylamine						✓				
Dust	✓									
Formaldehyde			✓	✓			✓	✓		
Furfuryl alcohol				✓				✓		
Hexamethylene tetramine						✓				
Hydrogen cyanide					✓	✓	✓	✓		
Hydrogen sulphide			✓	✓						✓
Isophorone (resin solvent)					✓					
Isocyanates (MDI,TDI)					✓					
Phenols			✓		✓	✓	✓			
Silica	✓	✓	✓	✓	✓	✓	✓	✓		
Stearates						✓				
Sulphur dioxide			✓	✓					✓	
Toluene					✓				✓	
Triethylamine					✓					
Xylene							✓	✓		

and Dupuytren's contracture have all been found amongst fettlers. Vibration syndrome is severe and occurs on average within a few years of starting work as a fettler. Compaction of the sand in mould-making is achieved with wind-rammers which also cause hand-arm vibration.

UV light

The hazards of arc-air gouging are similar to those to those of a welding process so that a UV "flash" hazard exists from exposure to the arc.

Accidents

Burns are common in many areas of the foundry including fettling, where larger castings may be worked on while still hot. Crushing and trapping injuries are common. Eye injuries and blows to the body frequently occur.

Diseases

- Silicosis. Chronic obstructive lung disease. Asthma. Mixed dust fibrosis. Lung cancer.
- Hand-arm vibration syndrome.
- Dupuytren's contracture. Musculo-skeletal disorders (back, upper limb). Arthritis.
- Occupational deafness.
- Occupational dermatitis.

1.10 CRANE DRIVING AND INTERNAL TRANSPORT

Drivers of cranes and ground level vehicles, including locomotives, are exposed to all the hazards of the areas they work in, and to special hazards too.

Dust and fumes

The levels of dust and fumes carried upwards by heat have been shown in many studies to be higher in overhead crane cabs than at floor level. Internal transport exposes workers in many occupations to diesel exhaust fumes.

Whole-body vibration

Levels of vibration in the cabs of several types of transport; cranes, furnace chargers, and fork-lifts, have been shown to cause spinal damage to drivers.

Musculoskeletal problems

Working on internal transport frequently involves awkward postures. Crane drivers and fork-lift drivers must bend into awkward positions to see what they are doing, resulting in chronic musculoskeletal disorders.

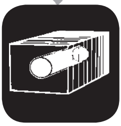
Heart disease and stroke

Internal transport work in a steelworks is psychologically demanding, but sedentary. Both these aspects of the job carry a risk of cardiovascular disease.

Injuries

Accident risks are high in internal transport with trapping and crushing injuries particularly common.

HEAT TREATMENT



Heat treatment gives steel products special properties of machinability or hardness. Annealing involves reheating in a furnace to a precisely controlled temperature for a given time, and cooling at a controlled rate. Cooling is carried out in a furnace (for slow cooling), in the air, or in a liquid such as oil or water (for increased rates of cooling). Saltbaths for controlled heat treatment may use various salts.

Surface hardening is achieved by increasing the carbon or nitrogen content of the surface of the product or by localised heating. Contact is made with a source of carbon (carburising) or nitrogen (nitriding) or both (cyanide hardening). Carbon monoxide is a common source of carbon for carburising. Hardening by local heating is carried out using oxyacetylene flames (flame-hardening) or local induction heating.

Hazards

The hazards involved include

- Noise from furnaces, cranes, steel products.
- Fumes from
  - carburising: carbon monoxide.
  - nitriding: ammonia.
  - hardening: cyanide.
  - quenching: oil combustion fumes.
  - patenting: lead.

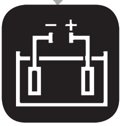
Other chemicals used include sodium carbonate, sodium cyanide, sodium nitrate, sodium fluoride, barium carbonate, and Borax.

Hydrogen and fuel gases may pose an explosion hazard. Temperatures involved in pre-heating may breakdown air with production of nitrogen oxides. Use of refined oils for quenching reduces the risk of carcinogenic combustion products. High levels of radio frequency radiation have been recorded close to an ultra rapid annealing furnace.

Diseases

Very little research has been carried out into the health problems of workers in heat treatment and surface hardening departments. Occupational deafness, obstructive lung disease and injuries are known to occur. Chemical poisoning from carbon monoxide or cyanide fumes have occurred. One study showed more cases of lymphatic cancer than expected amongst heat treatment workers.

1.12 SURFACE COATING



Steel products may pass straight from finishing and cleaning through to coating plants; principally galvanising, electroplating or plastic coatings.

These are extremely hazardous processes with quite specific risks associated with the particular processes used. Thorough research into all the chemicals used is required in any given workplace. In general however the hazards arise from

- Cleaning processes; pickling (described earlier), degreasing, and use of alkali baths.
- Coating processes:
  - Galvanising: zinc chloride, lead baths, pickling, caustic soda for cleaning.
  - Electroplating; depending on the finish: chromium, cadmium, nickel salts including cyanides, degreasing solvents, caustic soda.
  - Plastic coating; monomer, (colourants, plasticisers, anti-oxidants and other additives to the plastic used e.g. PVC, polyurethane (isocyanates) solvents.
  - Rustproofing chemicals are used to protect many steel products during storage and transport.

The hazards of the metals and metal salts used are discussed in a later section.

Diseases

A chrome plating plant attached to a steelworks in Wales had many cases of nasal perforation caused by chromate fumes.

Plastics give rise to a range of lung and upper respiratory diseases - including occupational asthma - caused by combustion fumes, plasticisers and monomers.

It has been suggested that certain monomers and other additives as well as plastic combustion fumes increase risk of cancer particularly of the throat.

Rustproofing oils may cause dermatitis, and produce irritant fumes when treated steel is heated.

Illnesses

- Brain function (solvent exposure).
- Chronic obstructive lung disease.
- Lung and nasal cancer.
- Laryngeal cancer.
- Nasal septum perforation.
- Dermatitis.

MAINTENANCE OPERATIONS

Maintenance work is carried out by workers with many skills; electricians, pipe-fitters, laggers, industrial cleaners, furnace bricklayers, labourers.

Maintenance operations are carried out at any point in the steel works or foundry, frequently under time pressure, or in situations in which working would not normally be permitted. At times it may be necessary to work close to processes to identify faults. Maintenance workers are therefore at special risk of heavy short-term exposures to hazardous conditions and of accidents.

Certain areas such as power plant and pipework are restricted to maintenance workers and have special risks. Power plant is extremely noisy. Where power is generated on site, there will be problems from fuel dust and ash. Gas pipelines carry explosion and asphyxiation risks.

Furnace bricklayers and labourers

Furnace bricklayers and their labourers have special risks due to their exposure to dust from the refractory linings of furnaces and ladles during wrecking and relining. The work is heavy and frequently hot. Back injuries, musculoskeletal disorders affecting the hands and arms, heat stress, chronic obstructive lung disease and lung fibrosis are common amongst furnace bricklayers and their labourers. Exposure to mineral fibre linings in re-heating furnaces carries risks which are still not fully understood.

Asbestos, the traditional high temperature insulation material, is responsible for deaths from asbestos-related diseases amongst maintenance workers in all trades.

Diseases

- Occupational deafness.
- Hand-arm vibration syndrome,
- Chronic obstructive lung disease, silicosis, asbestos-related diseases.
- Musculoskeletal problems.
- Poisoning from PCBs, lead, mercury.
- Skin and eye irritation (fluxes, resins, grease).
- Stress (unsocial hours, work pressure, lack of control over deadlines, staffing levels).
- Accidents.