
INTERNATIONAL LABOUR ORGANIZATION
Sectoral Activities Programme

**Draft code of practice on safety
and health in the non-ferrous
metals industries**

**Tripartite Meeting of Experts on Safety and Health
in the Non-ferrous Metals Industries**

Geneva, 2001



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Introductory note

In accordance with the decision taken by the Governing Body of the ILO at its 279th Session in November 2000, a Meeting of Experts on Safety and Health in the Non-ferrous Metals Industries will be convened in Geneva from 28 August to 4 September 2001 to draw up and adopt a code of practice on safety and health in the production of non-ferrous metals. The Meeting will be composed of eight experts appointed following consultations with governments, eight experts appointed following consultations with the Employers' group and eight experts appointed following consultations with the Workers' group of the Governing Body.

The draft code focuses on the production of primary non-ferrous metals, including from recycled material. It does not deal with fabrication.

This draft is based on principles established in international instruments relevant to the protection of safety and health of workers. The more general chapters deal with issues common to many industrial processes, including non-ferrous metal production. They draw on relevant parts of existing codes of practice, including: *Guidelines on occupational safety and health management systems* (Geneva, 2001); *Safety in the use of synthetic vitreous fibre insulation wools (glass wool, rock wool, slag wool)* (Geneva, 2001); *Ambient factors in the workplace* (Geneva, 2001); *Safety in the use of chemicals at work* (Geneva, 1993); and *Occupational safety and health in the iron and steel industry* (Geneva, 1983). More detailed treatment of some of the broader aspects of safety and health in non-ferrous metals production than are contained in this draft can be found in these codes of practice, particularly the codes *Ambient factors in the workplace* and *Safety in the use of chemicals at work*. Other chapters address issues concerning non-ferrous metals in general and aspects that are specific to individual metals and processes.

The practical recommendations of ILO codes of practice are intended for the use of all those, both in the public and private sectors, who have responsibility for safety and health management in relation to specific occupational hazards (e.g. chemicals, heat, noise and vibration), sectors of activity (e.g. forestry, mining), or equipment. Codes of practice are not intended to replace national laws or regulations or accepted standards. They are drawn up with the objective of providing guidance to all those who may be engaged, through social dialogue, in the framing of provisions of this kind or to elaborate programmes of prevention and protection at the national or enterprise levels. They are addressed in particular to governmental and public authorities, employers and workers and their organizations as well as management and safety and health committees in related enterprises.

Codes of practice are primarily designed as a basis for prevention and protective measures and are considered as ILO technical standards in occupational safety and health. They contain general principles and specific guidance which concern in particular the surveillance of the working environment and of workers' health; education and training; record-keeping; the role and duties of the competent authority, employers, workers, manufacturers and suppliers; and consultation and cooperation.

The provisions of this code of practice should be read in the context of the conditions in the country proposing to use this information, the scale of operation involved and technical possibilities. In this regard, the needs of developing countries are also taken into consideration.

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1. General provisions

1.1. Objectives

1.1.1. The objectives of this code are:

- (i) to protect workers in the non-ferrous metals industries from occupational safety and health hazards or risks in the production of non-ferrous metals;
- (ii) to prevent or reduce the incidence and severity of illness and injury in the production of non-ferrous metals;
- (iii) to promote the fullest consultation and cooperation between governments, employers and workers' organizations in the improvement of occupational safety and health in the production of non-ferrous metals.

1.1.2. This code provides practical guidance on the role and obligations of the competent authorities and the responsibilities, duties and rights of employers, workers and all other parties involved, with regard to workplace hazards, in particular in:

- (i) setting up legal, administrative and effective frameworks for the prevention and reduction of hazards and risks;
- (ii) the aims of any mechanisms for identifying, eliminating, minimizing and controlling hazards;
- (iii) the assessment of risks and the measures that need to be taken;
- (iv) the surveillance of the working environment;
- (v) providing information and training to workers;
- (vi) establishing a system to record, report and monitor occupational accidents and disease and dangerous occurrences.

1.1.3. More specific guidance on chemicals, particularly classification and labelling, is provided by the ILO code of practice *Safety in the use of chemicals at work* (Geneva, 1993). Recent guidance on ambient factors at the workplace – such as heat, noise, vibration – over and above that contained in this code, is provided by the ILO code of practice *Ambient factors in the workplace* (Geneva, 2001).

1.2. Scope and application

1.2.1. This code applies to:

- (i) all those institutions, whether legislative or advisory, whose activities influence the safety, health and welfare of persons engaged in the production of non-ferrous metals, as appropriate to their function;

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- (ii) all those individuals at the level of the enterprise or undertaking, i.e. employers, persons in control of premises, workers and service contractors, as appropriate to their duties and responsibilities for safety and health;
 - (iii) all activities in the production of non-ferrous metals, including the treatment and regulation of own scrap metal and scrap metal from external sources.

1.2.2. The provisions of this code should be considered as minimum requirements; they are not intended to replace applicable laws, regulations or accepted standards laying down higher requirements. More stringent applicable requirements should have priority over the provisions of this code.

1.2.3. The code contains references to those institutions responsible for the delivery and award of vocational qualifications. Such institutions are urged to review existing curricula in the light of the code's recommendations for training and the allocation of worksite responsibilities.

2. General principles and practices

2.1. Principles

2.1.1. Satisfactory safety and health levels are achieved in the production of non-ferrous metals when a number of closely related principles have been applied at national, enterprise and worksite levels. These principles include compliance with laws and regulations, and a clearly defined policy which identifies the nature and severity of the risks associated with the production of non-ferrous metals as well as with the allocation of responsibility to those persons employed at the levels of management, supervision and execution.

2.1.2. Non-ferrous metals production enterprises vary considerably in terms of type of metal produced, size, technology, economic stability and culture. These differences should not, however, serve as a justification for diluting the application of those general principles essential to the promotion of working conditions which prevent or reduce the risk of injury or ill health.

2.2. Organizational measures

2.2.1. The prevention or reduction of occupational risks due to the production of non-ferrous metals should be:

- (i) based on the general principles of occupational safety and health, taking due account of the relevant provisions of the Occupational Safety and Health Convention, 1981 (No. 155), and Recommendation, 1981 (No. 164), of the Working Environment (Air Pollution, Noise and Vibration) Convention, 1977 (No. 148), and Recommendation, 1977 (No. 156), and of the Labour Inspection Convention, 1947 (No. 81), and Recommendation, 1947 (No. 81); and
- (ii) conducted within the general framework of the organization of occupational safety and health at the enterprise level, taking due account of the relevant provisions of the Occupational Health Services Convention, 1985 (No. 161), and its Recommendation, 1985 (No. 171).

2.2.2. The basic approach of the assessment of occupational hazards, evaluation of risks, and control with a view to continuing improvement should be followed as regards occupational hazards due to the production of non-ferrous metals, as it should for other occupational hazards present at the workplace (such as chemicals, dust, heat, noise and vibration). This approach should include surveillance of the working environment and of workers' health.

2.2.3. The application of the provisions of this code should take into account the following recognized hierarchy of preventive and protective measures:

- (i) eliminate the risks by using products or technologies which permit risks to be eliminated or reduced to a minimum;

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- (ii) control the risks at source, e.g. by isolation of the process and by engineering control measures;
 - (iii) minimize the risks, e.g. by technical and administrative measures and safe work practices;
 - (iv) use appropriate personal protective equipment.

2.3. Procedures

2.3.1. Procedures should be developed for the specific needs of each operation,¹ and include provisions on:

- (i) hazard assessment and risk assessment;
- (ii) engineering control measures and technical measures;
- (iii) protective clothing and equipment;
- (iv) adequate information, such as chemical and material safety data sheets;
- (v) education and training, such as working manuals on work procedures;
- (vi) allocation of responsibility to supervisors and workers, including arrangements for consultation; and
- (vii) review of process and improvement plans.

2.3.2. Procedures, such as safe work practices, should be developed for all stages of the production of non-ferrous metals. They should be developed, and their implementation should be monitored, in consultation with workers and/or their representatives so as to benefit from knowledge gained from experience.

2.4. Classifying hazards in the production of non-ferrous metals

2.4.1. The competent authority should:

- (i) identify any intrinsic properties of raw materials in isolation and when mixed in any combination, intermediary products, metals or waste products from non-ferrous metals which require a hazard classification;
- (ii) establish or select the criteria for determining the hazards arising from the production of non-ferrous metals;

¹ Technical information and guidance documents can be found in the ILO-CIS database on occupational safety and health (CISDOC).

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- (iii) ensure that the raw materials, intermediary products, metals or waste products are classified as appropriate, taking into account the abovementioned properties and criteria.

2.4.2. Classification should be considered as a tool to guide preventive action (e.g. the labelling of chemicals, materials and equipment). The competent authority should establish criteria to determine whether specific chemicals, materials or equipment should be classified, on the basis of which property and at what level, considering the guidance available at the international level.

2.4.3. In elaborating the abovementioned criteria and determining the need for classification, the competent authority should take into account the opinions of technically qualified persons nominated by the most representative organizations of employers and workers concerned.

2.5. Exposure limits

2.5.1. Exposure limits should be based on sound scientific and technical knowledge as well as on an evaluation of occupational health hazards and risks based on the criteria in paragraph 2.4.1(ii).

2.5.2. In accordance with national legislation and practice or guidance, and taking due account of the consultation provided for in paragraph 2.3.2, the exposure limits should be established by:

- (i) statutory provisions; or
- (ii) an agreement between employers and workers at the national level which is approved by the competent authority; or
- (iii) other means approved by the competent authority, after consultation with competent scientific bodies and with the most representative organizations of employers and workers concerned.

2.5.3. Where it is reasonably practicable, or required by the competent authority, to achieve exposures below the exposure limits, then these lower exposures should be maintained. Exposure limits should be regarded as values above which remedial action should necessarily be taken and as a tool to guide preventive and protective action with a view to continuing improvement.

2.5.4. The exposure limits should be regularly reviewed in the light of technological progress and advances in scientific knowledge, as well as the results of workplace monitoring and experience.

3. General duties

3.1. Competent authority

3.1.1. The competent authority should, in the light of national conditions and practice and the provisions of this code, in consultation with the most representative organizations of employers and workers concerned:

- (i) devise and maintain a national policy on occupational safety and health;
- (ii) consider making new, or updating existing, statutory provisions for eliminating or controlling hazards in the production of non-ferrous metals.

3.1.2. Statutory provisions should include regulations, approved codes of practice, exposure limits, as required, and procedures for consultation and dissemination of information, as appropriate.

3.1.3. The competent authority should secure the enforcement of national laws and regulations concerning the policy through an adequate and appropriate system of inspection. The system of enforcement should provide for corrective measures and adequate penalties for violations of national laws and regulations concerning the policy.

3.1.4. If justified on safety and health grounds, the competent authority should have the power to:

- (i) prohibit or restrict the use of certain hazardous processes or substances in the production of non-ferrous metals; or
- (ii) require advance notification and authorization before such processes and substances are used; or
- (iii) specify categories of workers who, for reasons of safety and health, are not allowed to use specified processes or substances or are allowed to use them but only under conditions prescribed in accordance with national laws or regulations.

3.1.5. The competent authority should ensure that guidance is provided to employers and workers to help them comply with their legal obligations under the policy.

3.2. Employers

3.2.1. Employers should comply with the safety and health measures to be taken regarding hazards or risks to safety and health from the production of non-ferrous metals, including appropriate standards, codes and guidelines as prescribed, approved or recognized by the competent authority.

3.2.2. Employers should provide and maintain workplaces, plant, equipment, tools and machinery and organize work so as to eliminate or control hazards in the production of non-ferrous metals, and be consistent with national laws and regulations.

3.2.3. Employers should set out in writing their respective programmes and arrangements as part of their general policy and arrangements in the field of occupational safety and health, and the various responsibilities exercised under these arrangements. This information should be clearly communicated to their workers.

3.2.4. Employers, in consultation with workers and/or their representatives, should:

- (i) make an assessment of the hazards and risks to the safety and health of workers arising from the production of non-ferrous metals, requesting and making effective use of the information provided by the supplier of equipment or materials and from other reasonably available sources;
- (ii) take all practicable measures to reduce exposure to hazards and in any case ensure that the exposure does not exceed limits prescribed by the competent authority. Unnecessary exposure should be avoided; and
- (iii) give due consideration to the particular hazards or risks associated with the production of non-ferrous metals which have reproductive, teratogenic, mutagenic and/or endocrine disruptive effects.

3.2.5. In taking preventive and protective measures, the employer should address the hazardous factor or risk in accordance with the hierarchy set out in paragraph 2.2.3, having regard to what is reasonable, practicable and feasible, and to good practice and the exercise of due diligence. Employers should be provided with assistance by the competent authority whenever practicable.

3.2.6. In accordance with national laws and regulations, employers should make the necessary arrangements to provide for:

- (i) regular surveillance of the working environment and, where necessary, occupational health surveillance;
- (ii) adequate and competent supervision of work and work practices;
- (iii) the application and use of appropriate control measures and the periodic review of their effectiveness; and
- (iv) appropriate and periodic education and training to workers and, where appropriate, to workers' safety and health representatives, on issues relating to hazards in the production of non-ferrous metals.

3.2.7. Employers should have in place arrangements to:

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- (i) deal with accidents, dangerous occurrences and incidents which may involve hazards or risks to safety and health from the production of non-ferrous metals;
 - (ii) eliminate or control any threat to the safety and health of workers, and thereby to the public and the environment.

3.2.8. When an employer is also a national or multinational enterprise with more than one establishment, the employer should provide safety and health measures relating to the prevention and control of, and protection against, injuries and risks to safety and health from the production of non-ferrous metals, without discrimination, to all workers.

3.2.9. In all countries in which they operate, multinational enterprises should make available to their workers and to the representatives of the workers in the enterprise and, on request, to the competent authorities and the workers' and employers' organizations, information on the standards related to injuries and risks to safety and health from the production of non-ferrous metals, relevant to their local operations, which they observe in other countries.

3.2.10. Employers should initiate and maintain a process of consultation and cooperation with workers and their representatives concerning all aspects of safety in the production of non-ferrous metals specified in this code, in particular as regards the measures of prevention and protection listed in paragraphs 3.2.1 to 3.2.9. This process should be carried out within the framework of safety and health committees, where they exist, or through another mechanism determined by the competent authority or by voluntary agreements.

3.3. Managers and supervisors

3.3.1. Managers and supervisors should implement the enterprise's safety and health policy, including through the selection of safe equipment, work methods and work organization and the maintenance of high levels of skill. They should endeavour to reduce risks and hazards to safety and health in the activities for which they are responsible to as low a level as possible.

3.3.2. Managers and supervisors should ensure that workers receive adequate information on safety and health regulations, policies, procedures and requirements in accordance with Chapter 4 of this code and satisfy themselves that this information is understood.

3.3.3. Managers and supervisors should assign tasks to their subordinates in a clear and precise way. Managers and supervisors should satisfy themselves that workers understand and implement the safety and health requirements.

3.3.4. Managers and supervisors should ensure that work is planned, organized and carried out in such a way as to minimize the risk of accidents and the exposure of workers to conditions that may lead to injury or damage their health (see below for guidance).

3.3.5. In consultation with workers and/or their representatives, managers and supervisors should assess the need for additional instruction, training or further education of workers by monitoring compliance with safety requirements.

3.3.6. When managers, supervisors or workers observe non-compliance with safety and health regulations or codes of practice by any person, they should immediately take appropriate action. If such action is unsuccessful, the problem should be referred to a higher level of management immediately.

3.3.7. Supervisors should verify:

- (i) compliance with safety regulations;
- (ii) maintenance of safe working techniques;
- (iii) care taken of machines and equipment, particularly any devices which are provided in the interest of safety.
- (iv) use and care taken of personal protective equipment;

3.4. Workers

3.4.1. Workers should have the duty, in accordance with their training, and the instructions and means given by their employers, to:

- (i) comply with prescribed safety and health measures;
- (ii) take all reasonable steps to eliminate or control hazards or risks to themselves and to others arising during the production of non-ferrous metals, including proper care and use of protective clothing, facilities and equipment placed at their disposal for this purpose;
- (iii) report forthwith to their immediate supervisor or safety and health representative any unusual conditions at the workplace or affecting installations and equipment which they believe could present a hazard or risk to their safety or health or that of other persons arising from the production of non-ferrous metals, and which they cannot deal with effectively themselves;
- (iv) cooperate with the employer and other workers to permit compliance with the duties and responsibilities placed on the employer and workers pursuant to national laws and regulations.

3.4.2. Workers should participate in instruction and training programmes provided by the employer or required by the competent authority.

3.4.3. Workers should participate in exposure monitoring and health surveillance programmes required by the competent authority or provided by the employer for the protection of their health.

3.4.4. Workers and their representatives should participate in the process of consultation and cooperate with employers concerning all aspects of safety in the

production of non-ferrous metals specified in this code and in particular as regards measures of protection and prevention listed in 3.2.1 to 3.2.9.

3.5. Rights of workers

3.5.1. Workers and their representatives should have the right to:

- (i) be consulted regarding any hazards or risks to safety and health from the production of non-ferrous metals;
- (ii) inquire into and receive information from the employer regarding any hazards or risks to safety and health arising from the production of non-ferrous metals, including information from suppliers. This information should be provided in forms and languages easily understood by the workers;
- (iii) take adequate precautions, in cooperation with their employer, to protect themselves and other workers against hazards or risks to safety and health from the production of non-ferrous metals;
- (iv) request and be involved in the assessment of hazards and risks to safety and health from hazardous factors to be conducted by the employer and/or by the competent authority, and in relevant control measures and investigations.

3.5.2. Workers and/or their representatives should be involved in the inception and development of workers' health surveillance, and participate and cooperate with occupational health professionals, with their employers and occupational health professionals in its implementation.

3.5.3. Workers should be informed in a timely, objective and comprehensible manner:

- (i) of the reasons for the examinations and investigations relating to the health hazards involved in their work;
- (ii) individually of the results of medical examinations, including pre-assignment medical examinations, and of the respective assessments of health. The results of medical examinations should not be used to discriminate against workers.

3.5.4. In accordance with national laws and regulations, workers should have the right:

- (i) to bring to the attention of their representatives, the employer or the competent authority hazards or risks to safety and health arising from the production of non-ferrous metals;
- (ii) to appeal to the competent authority if they consider that the measures taken and the means employed by the employer are inadequate for the purpose of ensuring safety and health at work;
- (iii) to remove themselves from danger resulting from the production of non-ferrous metals when they have reasonable justification to believe that there is

an imminent and serious risk to their safety and health. Such workers should inform their supervisor and/or safety and health representative immediately.

- (iv) in the case of a health condition that places them at increased risk of harm, to be transferred to alternative work not exposing them to that increased risk, if such work is available and if the workers concerned have the qualifications or can reasonably be trained for such alternative work;
- (v) to adequate compensation if the case referred to in (iv) above results in loss of employment;
- (vi) to adequate medical treatment and compensation for occupational injuries and diseases resulting from the production of non-ferrous metals;
- (vii) to refrain from using or to shut down equipment or a process or a substance which can reasonably be expected to be hazardous, if the relevant information is not available to assess the hazards or risks to safety and health.

3.5.5. Workers who remove themselves from danger in accordance with the provisions of paragraph 3.5.4(iii) should be protected against undue consequences in accordance with national conditions and practice.

3.5.6. Workers who justifiably take those actions specified in paragraph 3.5.4(i), (ii) and (vii) should be protected from unwarranted discrimination, for which there should be recourse in national laws and practice.

3.5.7. Workers and their elected safety and health representatives should receive appropriate education and training and, where necessary, retraining in the most effective methods which are available for minimizing risks to safety and health from the production of non-ferrous metals, in particular in those areas referred to in Chapters 6-13 of this code.

3.5.8. Women workers should have the right, in the case of pregnancy or when breastfeeding, to alternative work not hazardous to the health of the unborn or nursing child, where such work is available, to prevent exposure to hazards during the production of non-ferrous metals, and to return to their previous jobs at the appropriate time.

3.6. Cooperation

3.6.1. Employers, workers and their representatives should cooperate as closely as possible in the application of the measures provided by this code, those relevant measures of the codes of practice *Ambient factors in the workplace* (Geneva, 2001) and *Safety in the use of chemicals at work* (Geneva, 1993) and the relevant provisions of the Working Environment (Air Pollution, Noise and Vibration) Convention, 1977 (No. 148), and Recommendation, 1981 (No. 156), the Occupational Safety and Health Convention, 1981 (No. 155), and Recommendation, 1981 (No. 164), the Occupational Health Services Convention, 1985 (No. 161), and Recommendation, 1985 (No. 171), and the Chemicals Convention, 1990 (No. 170), and Recommendation, 1990 (No. 177), to ensure the

elimination or control of hazards or risks to safety and health from the production of non-ferrous metals.

3.6.2. In accordance with national laws and regulations, measures for cooperation relating to the elimination or control of risks to safety and health from the production of non-ferrous metals should be taken, including the following:

- (i) employers, in discharging their responsibilities, should cooperate as closely as possible with workers and/or their representatives;
- (ii) workers should cooperate as closely as possible with their fellow workers and their employers in the discharge by the latter of their responsibilities and should comply with all prescribed procedures and practices;
- (iii) suppliers should provide employers with all necessary information as is available and required for the evaluation of any unusual hazards or risks to safety and health which might result from a particular hazardous factor in the production of non-ferrous metals.

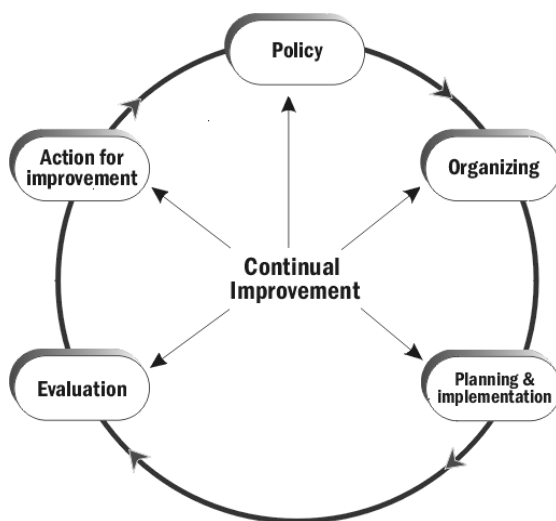
4. General measures of prevention and protection

4.1. Enterprise safety and health policy and management system

4.1.1. Occupational safety and health is the responsibility and duty of the employer, including compliance with the OSH requirements pursuant to national laws and regulations. The employer should show strong visible leadership and commitment to occupational safety and health activities in the organization and make appropriate arrangements for the establishment of an occupational safety and health management system. The occupational safety and health management system should contain the main elements of policy, organizing, planning and implementation, evaluation and action for improvement, as shown in figure 4.1 and as elaborated in the *ILO Guidelines on occupational safety and health management systems* (Geneva, 2001).

4.1.2. All those participating in the OSH management system and/or safety and health committee should have the authority bestowed on them that is necessary for them to properly fulfil their function.

Figure 4.1. Occupational safety and health (OSH) management system



Source: ILO: *Guidelines on occupational safety and health management systems* (Geneva, 2001).

4.2. Chemical safety data sheets and labels

4.2.1. Chemical safety data sheets should, as a minimum, meet the requirements of the competent authority and are recommended to contain the following core information:

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- (i) identification of manufacturer, product and ingredients;
 - (ii) physical and chemical properties; and information on the health effects, physical hazards, environmental impact and relevant exposure limits;
 - (iii) recommendations concerning safe work practices; transport, storage and handling; waste disposal; protective clothing and personal protective equipment; first aid and fire-fighting.

4.2.2. Labels should, as a minimum, meet the requirements of the competent authority, and are recommended to contain the following core information:

- (i) signal word or symbol; identification information, including the manufacturer, product and ingredients;
- (ii) risks and safety phrases, first-aid and disposal procedures; and
- (iii) reference to the chemical safety data sheets, and date of issue.

4.2.3. The ILO code of practice *Safety in the use of chemicals at work* (Geneva, 1993) provides comprehensive guidance on the foregoing issues for chemicals and on their use.

4.3. Heat

4.3.1. This section is drawn from Chapter 8 of the ILO code of practice *Ambient factors in the workplace* (Geneva 2001). It applies to conditions in which:

- (i) temperatures or humidity and/or both are unusually high;
- (ii) workers are exposed to high radiant heat;
- (iii) high temperature or humidity and/or both occur in combination with protective clothing or high work rate.

4.3.2. Workers should be allowed sufficient time to acclimatize to severe hot environments, including major changes in climatic conditions.

4.3.3. Assessment

4.3.3.1. If workers are exposed for all or part of their tasks to any conditions listed in paragraph 4.3.1 above, and the hazard cannot be eliminated, employers should assess the hazard and risk to safety and health from the thermal conditions, and determine the controls necessary to remove the hazards or risks or to reduce them to the lowest practicable level.

4.3.3.2. The assessment for the thermal environment should take into account risks arising from working with hazardous substances in work situations such as:

- (i) the use of protective clothing against hazardous substances that may increase the risk from heat stress; and

(ii) a hot environment that makes respiratory protection uncomfortable and less likely to be used and necessitates restructuring of jobs in order to reduce the risks, for example by:

- (a) minimizing exposure to hazardous substances so that less protective clothing is needed;
- (b) changing the tasks so that work rates in hot conditions can be reduced.

4.3.3.3. In assessing the hazard and risk, employers should:

- (i) make comparisons with other similar workplaces where measurements have been made;
- (ii) where this is not practicable, arrange for measurements to be performed by a technically capable person, using appropriate and properly calibrated equipment;
- (iii) seek the advice of the occupational health service or a competent body about exposure standards to be applied (see also section 7 of Appendix A).

4.3.3.4. Measurements of thermal conditions should take account of:

- (i) all stages of work cycles and the range of temperature and humidity under which the tasks are performed;
- (ii) the range of clothing worn during the tasks;
- (iii) major changes in physical activity level (metabolic heat production);
- (iv) occasional tasks such as cleaning and maintenance of hot equipment, and renewal of insulation.

4.3.3.5. The measurement survey should be structured so as to identify the sources of any problem, and the tasks in which it occurs. If the risk assessment shows that thermal conditions are outside the ranges recommended by the standards referred to in section 7 of Appendix A, the employer should assess control options and take effective control measures.

4.3.3.6. The plan for monitoring should take account of varying thermal conditions, especially seasonal variations where these are significant.

4.3.4. Prevention and control in hot environments

4.3.4.1. Where assessment shows that the workers may be at risk from heat stress, employers should, if practicable, eliminate the need for work in hot conditions or, if elimination is not practicable, take measures to reduce the thermal load from the environment.

4.3.4.2. Where workers are at risk from exposure to radiant heat by working near hot surfaces:

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- (i) the employer may increase the distance between the equipment (taking care not to do so to the detriment of other workplaces) and the exposed workers;
 - (ii) when this is not practicable, the employer should:
 - (a) reduce the temperature of the surface by changing plant-operating temperatures, insulating the surfaces, or reducing the emissivity of the surface; or
 - (b) change plant temperature.

4.3.4.3. Where surface temperature reduction is not practicable, employers should consider:

- (i) the use of radiation barriers (of low conductivity and high emissivity) between the surface and the workplace and maintain them in a clean state;
- (ii) water-cooling the hot surfaces, where practicable;
- (iii) the use of portable reflective shielding;
- (iv) arranging for remote control operations.

4.3.4.4. Where the assessment shows that unhealthy or uncomfortable conditions arise from increased air temperature, the employer should implement means to reduce air temperature, which may include ventilation or air cooling.

4.3.4.5. Employers should take particular care with ventilation design where work is undertaken in enclosed spaces or areas. When fail-safe systems are not in operation, there should be adequate supervision of workers at risk to ensure that they can be removed from danger.

4.3.4.6. Where part of the risk arises from the metabolic heat produced during work, and other methods of eliminating the risk are impracticable, employers should arrange a work-rest cycle for exposed workers, either in the workplace or in a cooler restroom. The rest periods should be as prescribed by the competent authority and/or sufficient to allow the worker to recover (see paragraph 7.2 of Appendix A). Employers should ensure that appropriate mechanical aids are available to reduce workloads and that tasks performed in hot environments are well designed ergonomically to minimize physical stress.

4.3.4.7. Where other methods of controlling thermal risk, including a work-rest regime, are not practicable, employers should provide protective clothing. In the selection of protective clothing, consideration may be given to the following:

- (i) reflective clothing where heat gain is mostly by radiation;
- (ii) insulated clothing with reflective surfaces during simultaneous exposure to high radiant heat and hot air (allowing freedom of movement to perform tasks);

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- (iii) air-, water- or ice-cooled clothing in other instances and as a possible complement to (i) and (ii) above.

4.3.4.8. Where failure of the protective clothing could expose the worker to extremes of temperature, the clothing should be carefully selected and its use monitored by a technically capable person, taking account of the environmental conditions. A system should be installed to ensure that any failure of the cooling system is immediately detected and the worker removed from the environment.

4.3.4.9. For hydration maintenance, employers should make water at low salt concentration or diluted flavoured drinks readily available to workers, and should encourage them to drink at least hourly by providing a close source or arranging for drinks to be brought to the workers. Drinks at 15-20°C are preferable to iced drinks. Alcohol, caffeine, carbonated drinks or drinks with a high salt or sugar content are unsuitable, as are drinking fountains because they are too difficult to drink from in sufficient volume.

4.3.4.10. Where a residual risk of heat stress remains even after all the control measures have been taken, workers should be adequately supervised so that they can be withdrawn from the hot conditions if symptoms occur. Employers should ensure that first-aid facilities, and staff trained in the use of such facilities are available.

4.3.5. Health surveillance

4.3.5.1. In cases where control is provided by work-rest systems (see paragraph 4.3.4.6 above) or protective clothing, workers should be examined by qualified occupational health personnel who should determine:

- (i) their fitness for the conditions of work;
- (ii) any limitations that should be applied to their work;
- (iii) the programme of training and information for workers;
- (iv) the measures for providing such training and information;
- (v) any pre-existing conditions among workers which might affect their tolerance to heat or cold (such as heart disease, overweight or some skin diseases); and
- (vi) measures to minimize risks among vulnerable groups (such as older workers).

4.3.6. Training and information

4.3.6.1. Workers at risk from heat and their supervisors should be trained:

- (i) to recognize symptoms which may lead to heat stress, in themselves or others, and the steps to be taken to prevent onset and/or emergencies;
- (ii) in the use of rescue and first-aid measures; and

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- (iii) about action to be taken in the event of increased risks of accidents at high and low temperatures.

4.3.7. Workers should be advised of:

- (i) the importance of physical fitness for work in hot environments;
- (ii) the importance of drinking sufficient quantities of liquid and the dietary requirements providing intake of salt and potassium and other elements that are depleted due to sweating;
- (iii) effects of drugs which can reduce their tolerance to heat.

4.4. Noise

4.4.1. This section is drawn from Chapter 9 of the ILO code of practice *Ambient factors in the workplace* (Geneva, 2001).

4.4.2. Assessment

4.4.2.1. The level of noise and/or duration of exposure should not exceed the limits established by the competent authority or other internationally recognized standards. The assessment should, as appropriate, consider:

- (i) the risk of hearing impairment;
- (ii) the degree of interference to speech communications essential for safety purposes;
- (iii) the risk of nervous fatigue, with due consideration to the mental and physical workload and other non-auditory hazards or effects.

4.4.2.2. For the prevention of adverse effects of noise on workers, employers should:

- (i) identify the sources of noise and the tasks which give rise to exposure;
- (ii) seek the advice of the competent authority and/or the occupational health service about exposure limits and other standards to be applied;
- (iii) seek the advice of the supplier of processes and equipment about expected noise emission;
- (iv) if this advice is incomplete or otherwise of doubtful value, arrange for measurements by persons who are able to undertake these in accordance with current national and/or internationally recognized standards.

4.4.2.3. Noise measurements should be used to:

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- (i) quantify the level and duration of exposure of workers and compare it with exposure limits as established by the competent authority or internationally recognized standards to be applied (see also section 9 of Appendix A);
 - (ii) identify and characterize the sources of noise and the exposed workers;
 - (iii) create a noise map for the determination of risk areas;
 - (iv) assess the need both for engineering noise prevention and control and for other appropriate measures and for their effective implementation;
 - (v) evaluate the effectiveness of existing noise prevention and control measures.

4.4.2.4. Based on the assessment of the exposure to noise in the working environment, the employer should establish a noise prevention programme with the aim of eliminating the hazard or risk or reducing it to the lowest practicable level by all appropriate means.

4.4.3. Prevention and control

4.4.3.1. In the case of new processes and equipment, employers should, where feasible:

- (i) specify low noise output of the processes and equipment as a condition of purchase alongside production-related specifications;
- (ii) arrange the workplace layout to minimize noise exposure to the workers.

4.4.3.2. In the case of existing processes and equipment, employers should first consider whether the noisy process is necessary at all, or whether it could be carried out in another way without generating noise. If elimination of the noisy process as a whole is not practicable, employers should consider replacing its noisy parts with quieter alternatives.

4.4.3.3. If the elimination of noisy processes and equipment as a whole is impracticable, their individual sources should be separated out and their relative contribution to the overall sound pressure level identified. Once the causes or sources of noise are identified, the first step in the noise control process should be to attempt to control it at source. Such measures may also be effective in reducing vibration.

4.4.3.4. If prevention and control at source do not reduce exposure sufficiently, enclosure of the noise source should be considered as the next step. In designing enclosures, several factors should be taken into consideration if the enclosure is to prove satisfactory from both an acoustical and a production point of view, including worker access and ventilation. Enclosures should be designed and manufactured in accordance with the requirements and needs indicated by the user, consistent with internationally recognized plant and equipment standards.

4.4.3.5. If enclosure of the noise source is impracticable, employers should consider an alternative sound transmission path treatment using a barrier to block or shield the worker at risk from the noise hazard from the direct sound path. The

effectiveness of a barrier is a function of its location relative to the noise source or workers to be protected and of its overall dimensions. Barriers should be designed and manufactured in accordance with the requirements and needs indicated by the user, consistent with internationally recognized plant and equipment standards.

4.4.3.6. If reducing the noise at source or intercepting it does not sufficiently reduce worker exposure, then the final options for reducing exposure should be:

- (i) to install an acoustical booth or shelter for those job activities where workers' movement is confined to a relatively small area;
- (ii) to minimize by appropriate organizational measures the time workers spend in the noisy environment.

4.4.3.7. Where the combination of all other practicable measures fails to reduce worker exposure sufficiently, employers should provide hearing protection devices and supervise their correct use by exposed workers and other persons. These devices should:

- (i) be selected in accordance with the needed reduction of the noise level;
- (ii) be comfortable and practical for the working environment concerned;
- (iii) take into account the individual's auditory needs (ability to hear warning signals, speech, etc.);
- (iv) be used, maintained and stored properly, in accordance with the technical specifications provided by the manufacturer.

4.4.4. Health surveillance

4.4.4.1. Appropriate health surveillance should be conducted for all workers whose noise exposures reach a certain level prescribed by national laws and regulations or by national or internationally recognized standards above which health surveillance should be carried out.

4.4.4.2. Workers' health surveillance may include:

- (i) a pre-employment or pre-assignment medical examination;
- (ii) periodical medical examinations at intervals prescribed as a function of the magnitude of the exposure hazards;
- (iii) medical examinations after periods of extended sickness or for conditions as may be specified in national legislation or internationally recognized standards;
- (iv) medical examinations performed on cessation of employment to provide a general picture of the eventual effects of exposure to noise;
- (v) supplementary and special medical examinations when an abnormality is found and it requires further investigation.

4.4.4.3. The results of the medical examinations and of supplementary examinations and tests, such as audiometric testing, of each individual should be recorded in a confidential medical file. The worker should be informed of these results and their significance.

4.4.5. Training and information

4.4.5.1. Employers should ensure that workers who may be exposed to significant levels of noise are trained:

- (i) in the effective use of hearing protection devices;
- (ii) to identify and report on new or unusual sources of noise that they become aware of;
- (iii) in the role of audiometric examination.

4.4.5.2. Employers should ensure that workers in noisy environments are informed of:

- (i) the factors leading to noise-induced hearing loss and the consequences for the victim, including non-auditory effects and social consequences, especially for young workers;
- (ii) the precautions necessary, especially those requiring worker intervention or use of hearing protection devices;
- (iii) the effects that a noisy environment may have on their general safety;
- (iv) the symptoms of adverse effects of exposure to high levels of noise.

4.5. Vibration

4.5.1. This section is drawn from Chapter 10 of the ILO code of practice *Ambient factors in the workplace* (Geneva, 2001).

4.5.2. Exposure of workers to hazardous vibration is mainly known as:

- (i) whole-body vibration when the body is supported on a surface which is vibrating, which occurs in all forms of transport and when working near vibrating industrial machinery;
- (ii) hand-transmitted vibration, which enters the body through the hands and is caused by various processes in which vibrating tools or work pieces are grasped or pushed by the hands or fingers.

4.5.3. Exposure limits should be established according to current international knowledge and data. Further detailed information can be found in section 9 of Appendix A.

4.5.4. Assessment

4.5.4.1. If workers or others are frequently exposed to hand-transmitted or whole-body vibration, and obvious steps do not eliminate the exposure, employers should assess the hazard and risk to safety and health resulting from the conditions, and the prevention and control measures to remove or to reduce them to the lowest practicable level by all appropriate means.

4.5.4.2. For the prevention of adverse effects of vibration on workers, employers should:

- (i) consider the sources of vibration and the tasks which give rise to exposure;
- (ii) seek the advice of the competent authority about exposure limits and other standards to be applied;
- (iii) seek the advice of the supplier of vehicles and equipment about their vibration emission;
- (iv) if this advice is incomplete or otherwise of doubtful value, arrange for measurements by a technically capable person, to be carried out in accordance with currently available national and international knowledge.

4.5.5. Vibration measurements should be used to:

- (i) quantify the level and duration of exposure of workers and compare it with exposure limits as established by the competent authority or other standards to be applied;
- (ii) identify and characterize the sources of vibration and the exposed workers;
- (iii) assess the need both for engineering vibration control and for other appropriate measures and for their effective implementation;
- (iv) evaluate the effectiveness of particular vibration prevention and control measures.

4.5.5.1. The assessment should identify the ways in which vibrating tools are used, and determine in particular whether:

- (i) high-risk uses can be eliminated;
- (ii) workers have had the right training in the use of the tools;
- (iii) their use can be improved by supports.

4.5.5.2. With a view to establishing appropriate prevention and control measures, the assessment should take into account:

- (i) exposure to cold at the workplace which can bring on symptoms of vibration white finger (Raynaud's phenomenon) in those exposed to vibration;

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- (ii) vibration of the head or eyes as well as vibration of the displays themselves which can affect the perception of displays;
 - (iii) body or limb vibration which can affect the manipulation of controls.

4.5.6. Prevention and control

4.5.6.1. Manufacturers should, in accordance with national laws and regulations:

- (i) provide vibration values for their tools;
- (ii) redesign processes to avoid the need to use vibrating tools;
- (iii) provide information to ensure that vibration is controlled by correct installation;
- (iv) avoid resonance frequencies of the component parts of machinery and equipment;
- (v) use, as far as practicable, anti-vibration handles.

4.5.6.2. When purchasing equipment and industrial vehicles, employers should ascertain that the vibration exposure to the user is within prescribed national standards and otherwise does not pose a significant hazard or risk to the worker's safety and health.

- (i) Where old machinery is still in use, sources of vibration that present a risk to the safety and health should be identified and suitable modifications made by employing current knowledge of vibration-damping techniques.

4.5.6.3. Seating in vehicles, including static plant with integral seating, should be designed to minimize transmission of vibration to the rider, and should permit an ergonomically good working position.

4.5.6.4. Many of the measures listed for noise control in paragraph 4.4.3 of this code will also be effective in reducing vibration generated by machinery and tools. Where workers are directly or indirectly exposed to vibration transmitted via the floor or other structures, the vibrating machines should be mounted on vibration isolators (anti-vibration mounts), installed according to the instructions of the manufacturer or designed and manufactured according to internationally recognized plant and equipment standards.

4.5.6.5. Machinery or vibrating tools should be maintained regularly because worn components combine to increase vibration levels.

4.5.6.6. Where the exposure might lead to injury if continued for a working lifetime, and reduction of the vibration is impracticable, the work should be rearranged to give rest periods or job rotation sufficient to reduce the overall exposure to a safe level.

4.5.7. Health surveillance

4.5.7.1. A pre-employment medical examination should examine candidates for jobs affected by hand-arm vibration for Raynaud's phenomenon of non-occupational origin and for hand-arm vibration syndrome (HAVS) from previous employment. Where these symptoms are diagnosed, such employment should not be offered unless vibration has been satisfactorily controlled.

4.5.7.2. If a worker is exposed to hand-transmitted vibration, the occupational health professional responsible for health surveillance should:

- (i) examine the worker periodically, as prescribed by national laws and regulations, for HAVS and ask the worker about symptoms;
- (ii) examine the worker for symptoms of possible neurological effects of vibration, such as numbness and elevated sensory thresholds for temperature, pain and other factors.

4.5.7.3. If it appears that these symptoms exist and may be related to vibration exposure, the employer should be advised that control may be insufficient. The employer should review the assessment and in particular control the causative vibration.

4.5.7.4. Because of possible association of back disorders with whole-body vibration, workers exposed should be counselled during health surveillance about the importance of posture in seated jobs, and about correct lifting techniques.

4.5.8. Training and information

4.5.8.1. Employers should ensure that workers who are exposed to significant vibration hazards are:

- (i) informed about the hazards and risks of prolonged use of vibrating tools;
- (ii) informed on the measures within the workers' control which will minimize risk, particularly the proper adjustment of seating and working positions;
- (iii) instructed in the correct handling and use of hand tools with a light but safe grip;
- (iv) encouraged to report finger blanching, numbness or tingling, without unwarranted discrimination, for which there should be recourse in national law and practice.

5. Personal protection

5.1. Personal protective equipment

5.1.1. Where adequate protection against exposure to hazardous factors in the production of non-ferrous metals cannot be ensured by other means, such as eliminating the risk, controlling the risk at source, or minimizing the risk (see paragraph 2.2.3), suitable personal protective equipment (PPE) and protective clothing, having regard to the type of work and risks, and in consultation with workers and/or their representatives, should be provided and maintained by the employer, without cost to the workers, as may be prescribed by national laws and regulations.

5.1.2. Protective clothing should not be used as an alternative to technical control in the production of non-ferrous metals.

5.1.3. The selection of protective clothing should take into account:

- (i) the adequacy of the design and the fit of the clothing, allowing freedom of movement to perform tasks, and whether it is suitable for the intended use;
- (ii) the environment in which it will be worn, including the ability of the material from which it is made to resist penetration by chemicals, to minimize heat stress, to release dust, to resist catching fire, to not discharge static electricity;
- (iii) the special requirements of workers exposed to molten metal and associated hazards, such as the need for reflective clothing or insulated clothing with reflective surfaces during exposure to high radiant heat and hot air (see also section 4.3.4).

5.1.4. Personal protective equipment (PPE) should not be regarded as a substitute for engineering and technical measures. It should be regarded as a last resort, as a temporary measure, or in an emergency.

5.1.5. Personal protective equipment should be selected, used, maintained, stored and replaced in accordance with standards or guidance for each hazard set or recognized by the competent authority.

5.1.6. Different items of PPE should be compatible with each other when they are worn together.

5.1.7. PPE should not restrict the user's mobility or field of vision.

5.1.8. Sufficient appropriate PPE, which has been approved by the competent authority, should be provided, maintained and replaced by the employer as needed.

5.1.9. Employers should ensure that workers required to wear PPE are fully informed of the requirements and of the reasons for them, and are given adequate training in the selection, wearing, maintenance and storage of this equipment.

5.1.10. When workers have been informed accordingly, they should use the equipment provided throughout the time they are exposed to the risk that requires its use for protection.

5.1.11. Items of special equipment for use in proximity to molten metal should protect the wearer from heat and should withstand splashes of molten metal. It should be possible to remove them easily if molten matter gets between the body and the protective clothing.

5.1.12. When tasks are performed using hazardous chemicals, personal protective equipment should be provided in accordance with the ILO code of practice *Safety in the use of chemicals at work* (Geneva, 1993).

5.1.13. Employers should provide supervision to ensure that the equipment is properly used.

5.1.14. All personal protective equipment that is necessary for safety in the production of non-ferrous metals should be provided by the employer without cost to the worker.

5.2. Housekeeping, cleaning and personal hygiene

5.2.1. All protective equipment necessarily provided should be maintained in good condition and replaced, at no cost to the worker, when no longer suitable for the purpose.

5.2.2. The protective equipment should not be used longer than the time indicated by the producer.

5.2.3. Workers should make proper use of the equipment provided, and maintain it in good condition, as far as this is within their control.

5.2.4. Employers should provide for the laundering, cleaning, disinfecting and examination of protective clothing or equipment which has been used and may be contaminated by materials that are hazardous to health.

5.2.5. Protective equipment which may be contaminated by materials hazardous to health should not be laundered, cleaned or kept at workers' homes.

5.2.6. Adequate washing facilities should be provided to enable workers to meet a standard of personal hygiene consistent with the adequate control of exposure and the need to avoid the spread of materials hazardous to health.

5.2.7. The washing facilities should be conveniently accessible but situated so that they are not themselves exposed to contamination from the workplace.

5.2.8. The type of washing facilities should be related to the nature and degree of exposure.

5.2.9. Clothing accommodation should be provided when protective clothing is used or when there is a risk of the contamination of outdoor clothing by hazardous materials.

5.2.10. Changing facilities should be so situated and designed as to prevent the spread of contamination from protective clothing to personal clothing and from one facility to another.

5.2.11. To reduce the risk of ingesting materials hazardous to health, workers should not eat, chew, drink or smoke in a work area which is contaminated by such materials.

5.2.12. Employers should prohibit eating, chewing, drinking or smoking in work areas in which adequate control of exposure can only be achieved by employees wearing personal protective equipment to prevent exposure to materials hazardous to health and in any other area where such materials are likely to be present.

5.2.13. Where it is necessary to prohibit eating or drinking, suitable facilities should be set aside for these activities to be carried out in an uncontaminated area, which should be conveniently accessible to the work area.

5.2.14. Floors should be slip resistant and well drained.

5.2.15. Spillages, leaks and splashes should be promptly cleaned up in accordance with the handling protocol for the relevant chemical.

5.2.16. Ventilation systems should be designed/evaluated to ensure that they do not inadvertently recirculate contaminated air.

5.2.17. Waste and effluent should be disposed of in an environmentally friendly manner.

6. Prevention and protection specific to non-ferrous metal production processes

6.1. Hazards and health effects

6.1.1. The choice and implementation of specific measures for preventing workplace injury and ill health in the workforce of the non-ferrous metal industries depend on the recognition of the principal hazards and the anticipated health effects. Some of the occupational health and safety hazards are similar in many respects for both ferrous and non-ferrous metal industries. The main hazards and health effects are:

- (i) injury from slips, trips and falls;
- (ii) burns from hot metal splashes and fire;
- (iii) health effects of heat, noise, dust and fumes;
- (iv) respiratory effects from the inhalation of:
 - (a) phenol- or urea-formaldehyde resin or their by-products used as a binder for sand moulds;
 - (b) silica dust and other mineral fibres during the stripping of furnaces during maintenance;
 - (c) dust from some hard woods used in pattern making;
 - (d) oxides of zinc, copper, magnesium and other metals. Inhalation over several hours can produce symptoms similar to influenza known as “metal fume fever”;
- (v) exposure to toxic chemicals and waste gases, including but not limited to: formaldehyde, urethane, hydrogen cyanide, benzene, toluene, phosphoric acid, sulphuric acid, ammonia, carbon monoxide, chlorine, phenol and cyclohexane;
- (vi) eye effects. Frequent, unprotected viewing of white hot metals in furnaces and pouring areas can result in cataracts. Dimethylethylamine, used as a catalyst in making sand moulds, has been reported to cause visual disturbance presenting as perceiving foggy blue halos around light sources;
- (vii) musculoskeletal problems and lower back pain from manual handling injuries, especially where the pouring of metal into moulds is carried out manually, as in old or small foundries;
- (viii) exposure to vibration (see section 4.5); this can cause:

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- (a) painful fingers, blanching of fingers when triggered by cold or wet conditions;
 - (b) loss of sense of touch, numbness and tingling;
 - (c) loss of manual dexterity, grip strength and fine finger manipulation;
- (ix) legionella, a bacterium associated with cooling systems that recirculate water. This can be a serious hazard to susceptible, immunocompromised individuals. In non-ferrous metal foundries it is most likely to be found in ladle/crucible temperature moderating systems. To prevent this organism:
- (a) water in these systems should be chlorinated;
 - (b) long-term recirculation of the same water should be avoided;
 - (c) water from the cooling system should not be allowed to form an aerosol;
 - (d) pipes and tanks should be insulated and storage tanks covered;
 - (e) materials that do not encourage the growth of legionella should be used.

6.2. Risk assessment and risk management

6.2.1. For effective prevention and protection against hazardous exposure in the non-ferrous metals industries there should be collaboration between the planners and developers of processes, procedures and premises, and cooperation between workers and their representatives, managers, and occupational health and safety professionals.

6.2.2. Such collaboration should focus on the identification and assessment of potential hazards in the workplace, and ensuring suitable provisions are made to reduce exposure that may result in occupational ill health and injury from such hazards.

6.2.3. The full range of data sheets and suppliers' information should be available to the risk assessor. (See section 4.2 on chemical safety data sheets.) All systems of work and processes should be evaluated by competent persons as part of the risk assessment process.

6.2.4. Individuals who are responsible for assessing and providing advice on the management of occupational risks should have sufficient information, instruction and training to be deemed competent persons. Such individuals may be staff from within the organization or external consultants. Specific criteria for competent persons include:

- (i) sufficient training and experience in occupational health and safety to identify effectively hazards in the working environment and be able to assess the likelihood and severity of ill health and/or injury from exposure to such hazards;

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- (ii) ability to carry out the process of risk assessment, keep suitable records of the assessment, and make recommendations to management and workers to reduce identified occupational risks through measures that are reasonably practicable;
 - (iii) awareness of their limitations in expertise, and of the appropriate stages for referral to other sources when additional advice is required;
 - (iv) participation in continuous professional development initiatives in order to maintain and update their knowledge and skills.

6.2.5. Risk assessment may result in recommendations for further, specified action to reduce the occupational risk factors identified, or that no further action is indicated as the extent of risks has been assessed as negligible, or that the current measures to minimize the risks are sufficient.

6.2.6. Steps to minimize occupational risk factors centre on the reduction or elimination of harmful exposures (see paragraph 2.2.3). An expanded hierarchy of preventive and protective measures to be considered is:

- (i) eliminating hazardous substances from the processes and removing them from the site, wherever substances prohibited by local statute or regulations are encountered;
- (ii) substituting harmful substances by harmless or less harmful agents;
- (iii) enclosing the process to reduce the escape of hazardous substances into the work environment;
- (iv) automating work processes and systems to minimize the extent of direct exposure to the workforce;
- (v) limiting the quantities of hazardous agents kept on site;
- (vi) restricting persons who have access to the area of work, or reducing the time a worker spends in areas where workplace hazards are identified;
- (vii) minimizing cross-contamination and pollution of other workplaces or public environments from harmful substances generated by the work process.

6.3. Exposure monitoring

6.3.1. Appropriate instrumentation for sampling and analysis should be used.

6.3.2. A sampling strategy should include location, timing, duration, frequency, and number of samples; each of these variables affects the interpretation of the results.

6.3.3. Trained and competent personnel should carry out sampling.

6.3.4. Regulatory authorities should provide maximum and occupational exposure limits.

6.4. Engineering controls

6.4.1. Engineering methods to control hazardous conditions in the non-ferrous metals industries include mechanical local exhaust ventilation, process or personnel enclosure and control of process conditions.

6.4.2. A ventilation system separate from other exhaust ventilation systems should be used.

6.4.3. Exhaust should be transferred directly to the outside and dust collectors should be located outside, or wherever permitted by regulation.

6.4.4. Sufficient replacement air should be supplied to make up for air removed by exhaust systems.

6.4.5. Supervisors and colleagues should be aware of the danger of heatstroke, particularly among foundry workers wearing full PPE. Regular breaks away from the furnace area should be taken as required and fluid replaced (see section 4.3).

6.4.6. The choice of PPE is important, as devices suitable for temperate countries may be uncomfortable and impractical for use in hot and humid climates. See Chapter 5 for details on personal protection.

6.5. Training

6.5.1. New workers should receive specific training regarding the properties and hazards of the chemicals, materials and processes with which they are working.

6.5.2. Following any changes in production procedures, the relevant competence of existing workers should be assessed and if necessary re-evaluated to determine the need for retraining and/or further training.

6.5.3. All workers should be subject to periodic supervision by a competent person to ensure that safe working practices are being adhered to.

6.6. Monitoring and review

6.6.1. Biological monitoring and/or health surveillance should be used, as appropriate, as an additional measure for monitoring ongoing exposure and to confirm the effectiveness of control measures.

6.6.2. Competent persons should also determine and specify the time intervals for specific review of risk assessment findings.

6.6.3. The frequency of review should depend, in part, on the nature and extent of risks identified and the availability and adequacy of control measures in place.

6.7. Prevention

6.7.1. Equipment should be maintained and checked regularly in accordance with the manufacturer's recommendations. It should be inspected after an accident or dangerous occurrence at work.

6.7.2. Accidents and dangerous occurrences should be reported to the relevant authorities within the time frame stipulated. Details of the accident or incident should be reviewed by competent persons and action taken to prevent recurrence.

6.7.3. First-aid provisions (equipment, personnel, first-aid rooms) should be available in accordance with the requirements of local regulations.

7. Furnaces

7.1. General

7.1.1. The non-ferrous metals industries use a range of furnaces including: electric furnaces, arc furnaces, induction furnaces, crucible furnaces, roasting ovens, simple blast furnaces or, more commonly, reverberatory type furnaces.

7.1.2. Only authorized persons should be allowed near furnaces.

7.1.3. There should be suitable and sufficient general and local exhaust ventilation with dust and fume collecting devices incorporated into the design of the exhaust ventilation systems.

7.1.4. The adequacy of local and general exhaust ventilation to remove fumes and gases from the furnace area should be tested regularly. Collection bags for dusts should be replaced when indicated.

7.1.5. Ultra violet (UV) light-resistant goggles or face shields should be provided where there is a requirement for the authorized visual inspection of furnaces.

7.1.6. Continuous detectors should be installed to provide early warning of raised levels of carbon monoxide.

7.1.7. Positive pressure self-contained breathing apparatus should be available to enable rapid rescue in the event of a build-up of carbon monoxide. The breathing apparatus should be checked and maintained regularly.

7.1.8. Persons working in and around the furnace area should be provided with suitable personal protective equipment (PPE) to protect against molten metal burns, noise and physical and chemical hazards (see also Chapter 5). PPE should be to molten metal standard for casters and others exposed to molten metal. Specific PPE should include, but not be limited to:

- (i) molten metal resistant jackets and trousers;
- (ii) face shields or vented goggles;
- (iii) molten metal resistant gloves;
- (iv) safety footwear insulated against heat;
- (v) respiratory protective equipment;
- (vi) protective helmets;
- (vii) hearing protection.

7.2. Preventing fires and explosions

7.2.1. Fires and explosions in furnaces most often result from water coming into contact with molten metal at temperatures up to 2000°C. The water may be present in scrap materials or damp moulds.

7.2.2. Fires and explosions in furnaces can also result from the ignition of volatile materials and fuels.

7.2.3. The most hazardous procedures are during the firing-up and shutting-down procedures. Gas-fired furnaces should have safeguards to ensure that unspent fuel does not accumulate and ignite. The fuel supply to oil-fired furnaces should be fitted with an automatic shut-off mechanism.

7.2.4. Operators should be trained in safe systems of work. The building should be designed to be non-combustible with automatic fire suppression engineered or designed into the process wherever possible.

7.2.5. Risk assessments should be carried out to consider the potential dispersal of toxic chemicals from non-furnace processes and combustion products and the potential impact of an explosion on other plant or premises.

7.2.6. Regular safety audits should be undertaken to ensure that hazards are clearly identified and risk control measures are maintained at an optimum level.

7.2.7. Refractories (e.g. crucibles, troughs, ladles) and tools should be preheated and dried before use to minimize the risk of explosion. Refractory linings should be regularly inspected for wear.

7.3. Lighting furnaces

7.3.1. Before lighting a furnace, fittings and appliances should be inspected to ensure that they are in working order. Particular attention should be paid to the furnace control settings, the air supply, the emission stacks, the fuel supply and its associated pipe work.

7.3.2. Hand-held torches used to light small furnaces should have a handle of adequate length, and the operator should use a suitable protective shield and heat-insulated gloves to prevent possible burns.

7.3.3. A slight draught should be allowed via the air supply to support ignition when the fuel has been switched on and the flame applied.

7.3.4. Persons responsible for operating the furnace should keep a close watch on the fuel supply.

7.4. Dust and fibres

7.4.1. When a furnace is stripped for maintenance purposes particular care should be taken to avoid inhaling dusts or fibres from the insulating material. Dust

and fume collectors should be incorporated into the furnace design. Further information on working with mineral wool fibres can be found in the ILO Code of practice *Safety in the use of synthetic vitreous fibre insulation wools (glass wool, rock wool, slag wool)* (Geneva, 2001).

7.5. Confined spaces

7.5.1. In the non-ferrous metals industries many foundries have confined spaces where concentrations of harmful agents in the air may be significantly higher than the permissible exposure levels if controls in the workplace are inadequate. Both furnace operators and maintenance personnel are at increased risk of exposure in confined spaces.

7.5.2. Confined spaces should be clearly marked with warning notices prohibiting unauthorized entry as serious injury or loss of life could occur if safe systems of work are not followed.

7.5.3. Because of the explosion hazard that is inherent in confined spaces, compressed air or oxygen should not be used for artificial ventilation. Compressed gas cylinders should be excluded from these spaces for the same reason.

7.5.4. Low voltage portable lamps should be used for inspection purposes.

7.5.5. A system of tags should be used to ensure that no personnel or equipment remain in the confined space before any openings are resealed or power and process piping reconnected.

7.6. Maintaining tap holes

7.6.1. Tap holes should be checked regularly for damage and build-up of corundum, to prevent molten metal splashes.

7.7. Preventing slips and falls in furnace areas

7.7.1. Floors in furnace areas should be of robust construction, using non-combustible materials.

7.7.2. Floor surfaces should be maintained regularly and kept clean and free of oil spills and obstructions.

7.7.3. Floors adjoining tracks in the foundry should be level with the tops of the track rails.

7.7.4. Steel floor plates should be made slip resistant through the use of appropriate materials or surface design.

7.7.5. Pits and other floor openings should be covered or cordoned off with clear warning signs when not in use. Such areas should always be well lit.

7.7.6. Furnaces with elevated points of access should be provided with suitable platforms or walkways equipped with handrails and protective barriers.

7.7.7. Platforms and walkways should be accessible via permanent, fire-resistant elevators, stairways or ladders.

7.7.8. Open-mesh walkways or platforms should be constructed so that any apertures in the mesh are small enough to prevent heavy objects from falling through resulting in injury to persons below.

7.7.9. Platforms, walkways and stairways with open sides should be provided with railings with panelling up to the height of the railings. Alternatively, they should have kick boards or toe boards extending part-way up the railings.

8. Handling molten metal

8.1. Casting and transport of molten metal

8.1.1. The molten metal from these furnaces is cast in one of several ways, including sand casting, die-casting, investment casting and continuous casting. Hazards associated with each process are listed in table 8.1.

Table 8.1. Detailed hazards relative to each casting process

Hazard	Sand casting	Die-casting	Investment casting	Continuous casting
Physical				
HAVS	xxx	x	xx	–
Noise	xxx	xx	xx	–
Molten metal splashes	xxx	xxx	xxx	xxx
Guarding	xxx	xxxx	xx	xxx
Manual handling	xxx	xxx	xxxx	xxx
Slips, falls, etc.	xxx	xxx	xxx	xxx
Mechanical lifting	xxxx	x	x	xxx
Transport accidents	xxxx	xxxx	xxxx	xxxx
Chemical				
Binder fumes	xxx	xx	–	–
Chemicals	xxx	x	xx	xxx
Dust	xxxx	x	xxx	xxx
Metal fumes	xxxx	xx	xxx	xxx
Mineral fibres in refractories	xxx	xxx	xxx	xxx
Biological				
Legionella	xx	xxx	x	x

Key:

HAVS = hand-arm vibration syndrome. – = negligible hazard. x = minor hazard. xx = moderate hazard. xxx = definite hazard. xxxx = extreme hazard.

8.1.2. Only essential personnel should be in the vicinity of pouring operations.

8.1.3. Persons who are untrained should not be employed in the transport of molten metal without supervision.

8.1.4. Moulds should not be damp, nor should there be any water in the melt because of the risk of explosion.

8.1.5. The area should be cordoned off prior to the transport of molten metal if there is a possibility of spillage.

8.2. Hand-tilted transport ladles

8.2.1. Hand-tilted transport ladles should have an integral locking device to prevent accidental tipping. Large transport ladles (>500 kg) should have a self-restraining anti-tipping device.

8.2.2. Casting ladles with rigid ladle bails should have safety devices to prevent the bails from swinging or overturning. The ladle bails should be insulated against radiant heat.

8.2.3. Ladles that are transported by forklift truck should have fittings to ensure their stability in forklift devices.

8.2.4. Ladles should not be suspended from a crane or other lifting device during filling.

8.2.5. Ladles should not be overfilled.

8.2.6. Locking devices on casting and transport ladles should be engaged prior to filling to prevent accidental spillage; they should only be released immediately before tipping the ladles.

8.2.7. Lubricants which could affect the efficiency of the locking devices and self-restraining drives should not be used.

8.2.8. Ladles and other equipment used on molten metal should be dry and, ideally, preheated before use.

8.2.9. Stopper operating mechanisms on bottom-pouring ladles should be secured prior to transport to ensure they do not accidentally operate while in motion.

8.3. Safety inspection of ladles

8.3.1. A competent person should regularly inspect ladle buckets and their supporting, locking and tipping mechanisms.

8.3.2. Prior to each filling, the pouring, transport and slag ladles and their related appliances should be visually inspected.

8.3.3. Test results, including remedies for cracks and other defects, should be recorded.

8.3.4. Corrective repair measures that are recommended should be implemented within a specified time.

8.3.5. There should be a system for checking and ensuring compliance.

8.4. Vehicle/crane transport

8.4.1. Transport routes for molten metal should be clear of obstructions, without irregular surfaces and be level.

8.4.2. The speed of the transporting vehicle or device should be limited (e.g. not to exceed walking pace) and it should be fitted with an automatic warning device).

8.4.3. The load should be lowered slowly and smoothly (e.g. not more than 20 cm/sec.).

8.4.4. Forklift controls should be designed to stop if released.

8.4.5. Forklift trucks used to transport molten material should have solid tyres and their fuel tanks should be protected and insulated from ignition. The driver's station should have rigid splashguards fitted.

8.4.6. Cranes with a lifting capacity exceeding 25 tonnes that are used to transport molten metal should have two independent braking devices, each capable of supporting the load in either direction.

8.4.7. Cranes with a lifting capacity of less than 25 tonnes may be used with a single braking device, provided they carry no more than two-thirds of their maximum operating capacity.

8.4.8. When the controls are released, the braking devices should be able to stop the drive mechanism.

8.4.9. Lifting hooks should be made of steel that is not prone to hydrogen embrittlement and should be shielded from radiant heat.

8.4.10. Workstations should not be located underneath overhead tracks used for the transport of molten material.

8.4.11. With regard to overhead ladles, no fixtures, which might cause spillage en route, should be within a short distance (approximately 50 cm) of their external limit of travel.

9. Process and waste gases

9.1. Gases are added during specific processes and are generated as waste by the action of heat on chemicals used in various non-ferrous metals production processes. Besides metal fume, which is described in section 6.1, gases are associated with a variety of processes, including:

- (i) *Moulding*. Resin-bonded sand is coated with phenol- or urea-formaldehyde resin and heated until the mould has set. In hot box moulding, the resin-sand mix is forced over a heated pattern to produce the mould. In cold box moulding (“no-bake” moulding), curing takes place at room temperature. Gas catalysts (e.g. carbon dioxide, sulphur dioxide) are sometimes used to facilitate curing. Carbon dioxide causes hyperpnoea at concentrations of 3 per cent and above. At a concentration of 10 per cent rapid loss of consciousness occurs which can be reversed if the worker is quickly removed from the source and allowed to breathe oxygen. When sulphur dioxide is dissolved in water it produces sulphuric acid which, if inhaled, causes acute irritation of the mucous membranes. In extreme cases this leads to severe pulmonary oedema and death. Exposure to sulphur dioxide can induce asthma in susceptible individuals.
- (ii) *Pattern making*. Mould patterns are produced using wood, reinforced polyester, plastics, foam or wax. The wax material often contains colophony, a respiratory sensitizer, that is given off during the heated aspects of pattern making.
- (iii) *Core making*. Where a central design or opening is required in the moulded item, cores made of refractory materials are incorporated into the mould. The refractory materials often consist of man-made mineral fibres, which are skin irritants. Carbon dioxide and sulphur dioxide are often given off from “binders” during the core-making process.
- (iv) *Shell moulding*. Resin-bonded sand is used to produce moulds. These phenol- or formaldehyde-based resins are a hazard if they are inhaled, ingested or come into contact with the skin. The individual characteristics of the chemical binder should be obtained from the supplier who should advise on precautions for general use, handling and storage.
- (v) *Hot box moulding*. Workers are at risk from exposure to a number of agents that are hazardous to health, including phenol-formaldehyde, urea-formaldehyde, furfuryl alcohol-urea, formaldehyde, ammonia, hydrogen cyanide, benzene and toluene.
- (vi) *Cold box or no-bake moulding*. Core box heating is avoided by the use of sand-resin catalyst systems that cure at room temperature or urethane systems which use a gas catalyst. The potentially hazardous by-products of these catalysts include urea-formaldehyde, furfuryl alcohol-urea, formaldehyde, phosphoric acid, sulphuric acids, phenol-formaldehyde and isocyanate.

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- (vii) *Metal melting and casting.* Molten metal is prepared in high-temperature furnaces and then cast into the shape of the preformed mould. Workers are exposed to various fumes and gases depending on the materials being melted.
 - (viii) *Fettling and machining.* Exposure to silica dust is a recognized hazard of fettling and machining.

9.2. Further specific information and recommendations for different gases and other compounds can be found in Appendix B.

10. Chemicals and alloys

10.1. Data sheets

10.1.1. Manufacturers' safety data sheets that include advice on the safe handling of any chemical to ensure adequate prevention and protection should be readily available. All those concerned with the storage and handling of chemicals and with general housekeeping should be trained and should adopt safe systems of work at all times.

10.2. Prevention and protection from specific chemical hazards

10.2.1. Two of the most significant chemical risks in the non-ferrous metals industries are associated with the use of organic solvents in degreasing and the use of chemicals that release cyanide during electrolytic degreasing.

10.2.2. Precautions described in Chapters 4-6 on general and local exhaust ventilation, protective clothing, personal protective equipment and chemical safety data sheets should be taken to offset the flammable and irritant properties of these solvents.

10.2.3. A number of the relevant chemical hazards incorporated in the processes are listed in Appendix B.

10.3. Alloys in the non-ferrous metals industries

10.3.1. The principal metals used in making non-ferrous alloys are aluminium, cadmium, copper, lead, nickel and zinc. The effects of exposure, both acute and chronic, to these metals, and health surveillance measures, are listed below. Relevant chemical data sheets should be consulted as far as specific prevention and protection measures are concerned.

10.4. Aluminium

10.4.1. Short-term (acute) exposure through excess ingestion causes nausea, vomiting, diarrhoea and mouth ulcers. Long-term (chronic) exposure through inhalation may result in obstructive lung disease and silicosis. Symptoms include cough, excessive mucous production and shortness of breath on exertion.

10.4.2. Health surveillance should include lung function testing by a qualified and competent physician or nurse.

10.5. Cadmium

10.5.1. Cadmium is most commonly absorbed by inhalation resulting in an accumulation of the metal bound to plasma globulin in the kidneys, reducing renal excretion. Short-term (acute) exposure through ingestion can cause salivation, nausea, vomiting, diarrhoea and shock. High levels of cadmium fumes cause acute pneumonitis with pulmonary oedema, which can be fatal. Long-term (chronic) exposure can lead to lung damage (emphysema) and kidney damage (renal tubular damage).

10.5.2. Health surveillance should include lung function tests and regular urine analysis.

10.6. Copper

10.6.1. Copper is absorbed by ingestion, across the skin, or by inhalation of fumes or dust. Toxic effects are more commonly seen with exposure to metallic copper rather than to copper salts. Short-term (acute) exposure through the inhalation of copper fume can cause acute poisoning consistent with metal fume fever. This is characterized by fever, chills, muscle pain and vomiting, but the onset of symptoms is delayed. Copper dust acts as an irritant to eyes, skin and mucous membranes. Long-term (chronic) exposure can result in nausea, vomiting, anorexia, hepatomegaly and discoloration of the skin and hair.

10.6.2. Health surveillance should include questionnaires and physical examination, checks for free copper in the blood, liver function tests and measurement of urea electrolytes and arterial pH, depending on the extent of exposure.

10.7. Lead

10.7.1. Absorption of lead mainly occurs via the lungs. Short-term (acute) exposure to inorganic lead can lead to vague symptoms including headache, fatigue, nausea, abdominal cramps, joint pain, vomiting, constipation or bloody diarrhoea. Long-term (chronic) exposure to inorganic lead causes peripheral motor neuropathy and anaemia. Chronic exposure to organic lead causes psychiatric symptoms of hyper-excitability, insomnia and mania.

10.7.2. Health surveillance should include the regular measurement of blood lead levels and urinary-aminolaevulinic acid, red cell zinc protoporphyrin and urinary lead (for organic lead absorption) should be measured regularly. The health effects of lead on children and young people include renal damage and encephalopathy. Stricter regimes of health surveillance of young workers and pregnant workers should be implemented. Local regulatory authorities should provide guidance on the occupational exposure limits and biological monitoring.

10.8. Nickel

10.8.1. Nickel is poorly absorbed and rapidly excreted but it distributes widely to body tissues, particularly the brain and lungs. Short-term (acute) exposure to nickel dust can cause allergic contact dermatitis. Nickel fume causes pneumonitis. Nickel carbonyl is acutely toxic and should be treated accordingly. Symptoms of exposure develop in two characteristic phases; initially headache, nausea, vomiting and irritability, followed by delayed pulmonary oedema, which may be mistaken for a viral illness. If allowed to progress acute respiratory distress syndrome and cerebral oedema will develop. Symptoms may persist for three to six months after exposure. Rapid and effective first-aid and medical management for casualties of nickel carbonyl poisoning is vital. All those who work in areas where nickel carbonyl is present should be fully trained in first aid and rescue techniques and use appropriate PPE. Long-term (chronic) exposure to nickel dust causes eczematous dermatitis, asthma and Loeffler's syndrome (pulmonary eosinophilia). Nasal mucosa irritation and perforation of the nasal septum with the loss of the sense of smell can develop from chronic exposure to nickel aerosols and mists. Nickel compounds are associated with carcinoma in the nose and sinuses, but the exact causative agent is not yet known. Chronic exposure to nickel carbonyl can cause a reduction in serum enzymes and abnormalities in EEG readings.

10.8.2. Health surveillance should start at the pre-employment stage with the consideration of any previous history of allergy. Ongoing symptoms should be kept under review. Pre-existing or possible synergistic respiratory problems should be monitored.

10.9. Zinc

10.9.1. Zinc oxide is absorbed via the lungs and through the digestive tract. Metallic zinc, which is stable in dry air, is an essential trace element needed for nucleic acid synthesis and certain enzyme functions. It has a role in wound healing. Short-term (acute) exposure to heated zinc oxide can lead to metal fume fever. The worker suffers flu-like symptoms of sweating, shivering, headache, fever, chills, thirstiness, aching muscles, nausea, vomiting, weakness and tiredness. Recovery is rapid once exposure has ceased. There are no long-term sequelae. Long-term (chronic) exposure by ingestion of zinc causes reduced copper absorption and an altered function of the immune system.

10.9.2. Health surveillance should comprise regular reviews of symptoms and pulmonary function tests as indicated.

11. Handling dross, slag and other waste

11.1. General

11.1.1. Dross and slag skimmed from the surface of the molten metal in the furnace should be stored in an enclosed container to minimize the effects of oxidation, a process that generates hydrogen and toxic fumes. Moreover, because of their potential for volatile reactions with water, these skimmings should be kept dry during transportation. Covered or enclosed vehicles should be used.

11.2. Prevention and protection

11.2.1. Hot dross processing is used to separate metals from hot slag by rotating the mixture in a refractory-lined barrel and extracting the metal through a hole in the base.

11.2.2. The low melting point of certain metals allows them to be separated from scrap, castings and dross with a high iron content. This “sweating” process is generally carried out in an open-flame reverberatory furnace. Precautions against noise and heat hazards should be taken, including the use of PPE, and hearing protection should be used by all those working in the vicinity of these furnaces. Local exhaust and general area ventilation should ensure that the gas and fumes that are produced are evacuated and collected.

11.2.3. Separating cold dross from dirt and other non-recoverable material requires a combination of screening and magnetic separation. This “dry milling” process generates dust and noise. Adequate local exhaust and general area ventilation should be installed and used. PPE and hearing protection should be used by all those working in the vicinity of this activity.

11.2.4. Supervisors should be alert to the dangers of noise and heat stress and ensure that workers take regular breaks and replace fluids.

12. Cleaning, finishing and other metal treatment

12.1. Metals are generally treated in order to: obtain a uniform structure (e. g. fettling and shot-blasting); provide stress relief following forming, welding or brazing; and to bring about re-crystallization.

12.2. The main hazards of these processes are: exposure to solvents, silica, heat and fumes; vibration; noise; and the risk of accidents and eye injuries. General precautions should be observed as outlined in Chapter 4, and specific additional PPE should be used as required (see Chapter 5 and paragraph 7.1.8).

12.3. Health surveillance by competent nursing and medical practitioners should include surveillance for noise-induced hearing loss, the effects of vibration, any reduction in respiratory function, and the impact of welding on vision.

12.4. Workers who have suffered significant ill-health effects should have their system of work assessed for further risks and have additional controls implemented where possible. Where changes to the system of work are not possible, the worker should be redeployed to alternative work to reduce the likelihood of health problems worsening.

13. Recycling non-ferrous metals

13.1. General treatment

13.1.1. Non-ferrous metals are recycled from factory offcuts (new scrap), from obsolete/salvaged sources (old scrap) and from foundry slag, ashes and dross. The range of processes used to reclaim metals from scrap depends on the donor source and the desired product. Recycling non-ferrous metals involves different processes from those used in the production of primary metal and presents different occupational safety and health hazards and risks. The following special provisions apply.

13.1.2. Bales of raw scrap received for recycling should be opened and physically inspected prior to adding them to the melt. Potential hazards include rainwater, gas cylinders, aerosols and munitions as well as radioactive-contaminated scrap. Reputable suppliers of scrap should be used to ensure that the specification of raw materials meets these criteria.

13.1.3. Charge materials should be stored under cover wherever possible.

13.1.4. Potential carriers of moisture should be preheated to dry them before charging.

13.1.5. Tubes and pipes that are closed at one or both ends should not be charged.

13.1.6. Bins for storing scrap metal should have holes in their base to facilitate drainage.

13.1.7. Corroded material should not be added to induction furnaces.

13.1.8. The risk from radioactive sources, such as luminous gauges, gas/smoke detectors, depleted uranium ballast from old aircraft, contaminated scrap obtained from nuclear power stations, atomic-powered ships and submarines, medical equipment and other sources should be assessed and controlled.

13.1.9. Natural radiation sources, such as scrap originating from offshore drilling work and the pipes or tubes used in extractive industries, pose a risk that should be assessed and controlled prior to recycling.

13.1.10. Besides using reputable suppliers, large-scale recycling operations should monitor incoming raw scrap for radioactivity prior to it entering the factory.

13.1.11. Smaller-scale operations should initiate quality control procedures to exclude contaminated objects.

13.1.12. General hazards encountered in metal reclamation include: manual handling of molten metal, dust, fumes, noise, heat and toxic vapours.

13.1.13. The burning and drying process used to separate industrial waste (e.g. lathes, milling and boring machines) exposes the operator to non-specific particulate matter, including metals, soot and condensed heavy organic compounds.

13.1.14. Workers should be aware of the dangers of heat stress and supervisors should ensure that these workers take frequent rest breaks and replenish fluids (see section 4.3).

13.1.15. When chlorine or fluorine is used in scrap conversion, precautions should be taken to deal with the specific hazards associated with reverberatory chlorine and fluorine refining, namely: pulmonary oedema from contact with chlorine or fluorine; pulmonary fibrosis and fluorosis of bones from contact with fluorine; acid burns from contact with hydrogen chloride or hydrogen fluoride; explosions from aluminium chloride and metal fluorides in contact with water.

13.1.16. General protection and prevention should be observed for these processes and specific effective first-aid measures should be available in the event of a serious incident.

13.2. Aluminium recycling

13.2.1. Aluminium is typically salvaged from machinery, automotive and aircraft parts, beverage cans and domestic appliances, or refined from offcuts and turnings from the manufacture of new alloy products. Scrap aluminium is first manually inspected and sorted from non-aluminium bearing material.

13.2.2. Mechanically separating aluminium-laden dross from dirt and other non-recoverable material, then crushing it, requires a combination of screening and magnetic separation. This “dry milling” process generates noise and dust. Local exhaust and general area ventilation that is sufficient to protect the operators should be used. Operators should wear hearing protection and, if necessary, dust masks.

13.2.3. When de-soldering scrap aluminium, workers should wear respiratory protection against the lead and cadmium fumes which are produced.

13.2.4. Workers involved in the burning and drying process to separate aluminium industrial waste from lathes, etc. should use appropriate PPE against particulate material and be aware of the dangers of heat stress. Supervisors should ensure that these employees take frequent rest breaks and replenish fluids.

13.2.5. Hot dross processing – the extraction of aluminium from hot slag by rotating the mixture in a refractory-lined barrel and tapping the metal out through a hole in the base – produces fumes that should be removed by using both local exhaust and general area ventilation.

13.2.6. The low melting point of aluminium allows it to be separated from scrap, castings and dross with a high iron content. This “sweating” process is generally carried out using open-flame reverberatory furnaces which create noise and heat hazards. Non-specific gases, fumes and particulates are produced in quantities which require the use of local exhaust and general area ventilation.

13.2.7. When reverberatory furnaces are used to convert scrap and sweated aluminium into alloys, solvent fluxes and alloying agents are added according to the product specification. The magnesium content of the molten charge is reduced by injecting chlorine or fluorine gas into the melt.

13.2.8. The risk of exposure to these gases or to their compounds should be countered by using the following precautions:

- (i) workers should use both respiratory and hearing protection;
- (ii) the noise source should be isolated from the rest of the factory;
- (iii) both local exhaust and general area ventilation should be in place;
- (iv) supervisors should be alert to the dangers of heat stress and ensure that workers take regular breaks and replace fluids (see also section 4.3).

13.3. Copper recycling

13.3.1. Hazards from noise and moving machinery are associated with the stripping of insulation from copper wire by shredding the wire and sorting the material by mechanical or pneumatic means. The noise source should be isolated as far as possible, hearing protection should be worn by operators and moving machinery should be guarded in accordance with regulations.

13.3.2. Copper slag, dross, ashes and dust may be ground and/or shredded, then separated by gravity in an aqueous medium. This process exposes the operators to noise, non-specific dusts and metal particulates from slag and dross. Operators should wear adequate ear protection and dust masks.

13.3.3. Volatile organic impurities that coat scrap copper can be removed by burning. This creates non-specific particulate matter, principally metals, soot and heavy organic compounds. Hazardous gases and vapours including oxides of nitrogen, sulphur dioxide, carbon monoxide and aldehydes are also generated.

13.3.4. Low vapour melting components can be removed from scrap by heating them to a temperature just above the melting point of the metals which are to be “sweated” out.

13.3.5. Sweating produces metal fumes, particulates and non-specific gases and vapours. In view of the risk of exposure to possible carcinogens, respiratory sensitizers and other vapours, respiratory protective equipment and PPE should be used by all operators.

13.3.6. Copper can be removed from clean scrap by dissolving it in ammonium carbonate solution. The copper oxide can then be recovered by steam distillation or by filtration in hydrogen. Since both these procedures expose the operator to ammonia fumes, PPE and respirators should be used to reduce the risk of health effects.

13.3.7. The production and treatment of “blister” copper during smelting expose the operator to high noise levels and to a range of airborne particulates. Local exhaust ventilation, respirators and PPE, including goggles, should be used.

13.3.8. Metallic copper fumes are acutely toxic. Copper dust will irritate mucous membranes and respiratory passages. Chronic exposure to metallic copper and copper salts causes liver damage and associated anaemia, anorexia and vomiting. Sufficient people trained in specific, effective first-aid skills should be present or available at all times when copper is being recovered from scrap.

13.4. Lead recycling

13.4.1. Material that is procured for the reclamation of its lead content often requires processing prior to melting. The nature of lead dust is such that it can permeate the whole facility; it is easily agitated by on-site traffic and readily adheres to skin and clothing.

13.4.2. Automotive batteries are a common and high yield source of reclaimed lead. Obtaining their lead involves shearing off the top of the battery and separating the components.

13.4.3. Secondary lead refining operations rely largely on the manual addition of alloying materials to the container of molten metal to produce the required product. Dross is subsequently swept to the rim of the container and removed with a shovel. The principal hazards are from lead particulates, alloying metals, fluxing agents and noise.

13.4.4. These processes generate varying amounts of acid mists, lead dust and other airborne contaminants. Besides general protection and prevention measures, the following specific ones should be implemented:

- (i) work areas should be washed and kept damp with water to minimize dust and a positive pressure filtered air system should be used where appropriate;
- (ii) conveyor systems that are used to transport furnace feed materials should be equipped with self-cleaning tail pulleys or belt wipes.

13.5. Zinc recycling

13.5.1. Zinc is reclaimed from “new” scrap from die-casting and galvanizing operations and “old” scrap from a variety of sources, notably die-castings. A number of separation processes are used, including sweating, crushing, precipitation, alloy formation and distillation. Where possible, the hazards should be eliminated using shields and ventilation. All process operators should be trained and should wear appropriate PPE.

13.5.2. Health surveillance may be required as outlined in Chapter 10.

13.6. Nickel recycling

13.6.1. Nickel can be reclaimed from nickel, copper and aluminium vapour-based alloys, which can either be salvaged from sources such as machinery and aircraft parts, or refined from offcuts and turnings from the manufacture of new alloy products.

13.6.2. After being manually inspected and sorted from non-nickel bearing material, scrap nickel should be degreased. Trichlorethylene, a chemical that is commonly used for this purpose, is hepato-toxic.

13.6.3. Scrap nickel is generally smelted in an electric arc furnace. Supplementary refining of molten nickel involves adding the melt to primary nickel and cold scrap in a reactor. Manganese or other suitable alloys are added to produce the desired composition. Molten nickel is then poured from the furnace or reactor into ingot moulds.

13.6.4. These processes expose the worker to nickel dust, general dust, metal fumes, airborne solvents, radiant heat, radiation sources such as depleted uranium, and noise.

13.6.5. Protection and prevention should include health surveillance for respiratory and sensitization effects, excessive solvent exposure and radiation exposure as appropriate.

13.7. Cadmium recycling

13.7.1. Cadmium can be recovered from several sources, including motor vehicles, household appliances and electrical components. “New” scrap largely originates from cadmium-contaminated by-products from other industries. Scrap should be pretreated by a degreasing process. When it is melted and the pure metal condensed in a retort, operators might be exposed to the by-products of oil and gas combustion, cadmium fumes, solvents, noise and dust, and to the hazards of manual handling. General measures of protection and prevention plus health surveillance and biological monitoring as outlined in Chapter 10 should be undertaken.

13.8. Magnesium recycling

13.8.1. “Old” magnesium scrap is generally obtained from aircraft and automobile parts and from sludge from primary magnesium smelters. “New” scrap is sourced from offcuts and rejects from sheet mills. Magnesium is highly flammable and must be stored and handled appropriately, with work areas washed and kept moist to minimize the spread of flammable dust. Operators should be aware of the flammable hazards of magnesium dust, and be properly trained and equipped to handle molten magnesium.

14. Information, training and competence

14.1. Information and training

14.1.1. All those who work in the production of non-ferrous metals should be provided with sufficient information to protect their health from hazardous factors or substances which may be present, in a form and language that they understand, and sufficient training to understand the information and to take the necessary protective measures.

14.1.2. The form and content of the information and training should be devised and implemented in consultation with workers and/or their representatives, should meet the requirements of the competent authority as a minimum, and it should include:

- (i) applicable laws, regulations and codes of practice;
- (ii) labels and chemical and material safety data sheets;
- (iii) general and specific guidance on preventive measures, in particular on the procedures necessary to maintain exposures as low as practicable, safe work practices and personal protection;
- (iv) potential acute and chronic health effects which may result from exposure to hazardous materials;
- (v) emergency and first-aid measures;
- (vi) information on the responsibilities of manufacturers, suppliers, employers and workers, as well as on the need for cooperation between them.

14.1.3. When necessary, employers should request advice and obtain expertise as regards risk assessments where there are particular difficulties because of multiple or combined exposures in the working environment, where health surveillance reveals abnormal findings concerning workers' health, or when alternative technologies or solutions to a difficult problem have been found.

14.1.4. Instruction, training and information should be provided by employers before commencing work and periodically thereafter. Wherever practicable this should include practical on-the-job training.

14.1.5. Employers' training programmes should be developed in consultation with workers and their representatives.

14.1.6. Training programmes and the provision of information should be at no financial cost to workers, and should be during working hours, if possible.

14.2. Competence and review

14.2.1. The extent of instructions and training should be appropriate to the duties, understanding and literacy of the workers, and be sufficiently detailed to ensure that they understand both the safety requirements and the reasons for these requirements. Trainees should not be assigned to work duties until they have assimilated thoroughly all relevant safe work practices.

14.2.2. Employers should ensure that persons responsible for the provision of information, education and training, and exposure monitoring and assessment, have received appropriate, and where required by the competent authority, approved training or qualifications.

14.2.3. The extent of the training and instruction received and required should be reviewed and updated whenever work practices or working systems are reviewed.

14.2.4. The review should include the examination of:

- (i) whether workers understand the most effective use of the engineering control measures provided;
- (ii) whether workers understand when protective equipment is required, and its limitations;
- (iii) whether workers are familiar with procedures in the event of an emergency;
- (iv) procedures for the exchange of information between shiftworkers.

15. Surveillance of the working environment

15.1. Monitoring the workplace

15.1.1. Monitoring of the workplace should include:

- (i) identification and evaluation of hazardous factors which may affect workers' safety and health;
- (ii) assessment of conditions of occupational hygiene and factors in the organization of work which may give rise to hazards or risks to the safety and health of workers;
- (iii) assessment, where appropriate, of exposure of workers to hazardous agents;
- (iv) assessment of control systems designed to eliminate or reduce exposure;
- (v) assessment of collective and personal protective equipment.

15.1.2. Where applicable, monitoring of non-ferrous metals workplaces should be carried out in accordance with the requirements of the competent authority.

15.1.3. Such monitoring should be carried out in liaison with other technical services of the undertaking and in cooperation with the workers concerned and their representatives and/or the safety and health committee.

15.1.4. Manufacturers and suppliers should make the results of workplace monitoring available to workers, their representatives and the competent authority.

15.1.5. These data should be used on a confidential basis and solely to provide guidance and advice on measures to improve the workplace environment and the health and safety of workers.

15.1.6. The monitoring of the workplace should entail such visits by the personnel who provide occupational health services as may be necessary to examine the factors which may affect the workers' health, the environmental health conditions at the workplace and the working conditions.

15.2. Measuring methods and strategy

15.2.1. Sampling equipment should be compatible with the analytical methods available and should have been validated in accordance with public national or international standards, where they exist.

15.2.2. Static monitoring should be used to determine the distribution of temperature and airborne material throughout the general atmosphere of the non-

ferrous metal working area and to identify problems and priorities. Measurements or samples should be taken: close to sources of emission; at various places in the working area to assess distribution; and in working areas which represent typical exposures.

15.2.3. In order to evaluate the risk of exposure to the individual worker, air samples should be collected in the worker's breathing zone by means of personal samplers. Sampling should be carried out while work is under way.

15.2.4. Where temperatures or concentrations of airborne material vary from one work operation or phase to another, measurements or personal sampling should be carried out in such a manner that the average, and in any case the maximum, level of exposure of each individual worker can be determined.

15.2.5. Personal sampling should be carried out at various times throughout the work shift, supplemented where necessary by short-term sampling.

15.2.6. Exposure profiles of particular jobs or occupational categories should be constructed from the sampling data of different operations and from the workers' exposure in these jobs.

15.2.7. When required, non-ferrous metal workplace sampling should be conducted in a systematic way according to a monitoring programme developed after consultation with workers and their representatives.

15.2.8. The monitoring strategy should aim to ensure that:

- (i) specific operations where exposures may occur are identified and levels of exposure are quantified;
- (ii) exposures do not exceed exposure limits set or approved by the competent authority;
- (iii) preventive measures are effective in their implementation for all applications and in all jobs;
- (iv) any changes in work practices have not led to increased exposures;
- (v) supplementary preventive measures are developed as necessary.

15.3. Record keeping

15.3.1. The results of workplace and personal monitoring should be collected in a standardized way.

15.3.2. The records should be retained by employers for at least 20 years, or for a longer time as determined by the competent authority.

15.3.3. Records should include all relevant data such as details of the site, the source or sources of emissions, information on the functioning of the process, and the availability and wearing of personal protective clothing and equipment.

15.3.4. Workers and their authorized representatives should have access to their own personal monitoring record, as well as to the workplace monitoring records.

15.4. Interpretation and application of monitoring data

15.4.1. The interpretation of the results of workplace monitoring in non-ferrous metals plants should include consideration of the working conditions at the time of the monitoring and whether or not they were typical.

15.4.2. The results should be compared with the exposure limits determined by the competent authority, as well as with the results of previous monitoring carried out during the same or similar operations, at the same workplace or under similar conditions of exposure.

15.4.3. The results of workplace monitoring should be considered as levels requiring action, when:

- (i) the exposure limits determined by the competent authority are exceeded;
- (ii) the concentrations of materials are greater than those measured previously during the same or similar operations, at the same workplace or under similar conditions of exposure.

15.4.4. When workplace monitoring results have been interpreted as excessive, the necessary corrective action should be taken in a timely manner in consultation with the workers and their representatives. Follow-up monitoring should be carried out when the necessary corrective and preventive measures have been implemented.

15.4.5. When the results of workplace monitoring have been considered consistently satisfactory, the need for future monitoring, if any, should be determined in consultation with the workers and their representatives, and the competent authority if required.

16. Workers' health surveillance

16.1. General provisions

16.1.1. The central purpose of workers' health surveillance should be the primary prevention of occupational and work-related injuries and diseases in the production of non-ferrous metals.

16.1.2. Health surveillance programmes for workers in the production of non-ferrous metals should be consistent with:

- (i) the aims of occupational health as defined by the Joint ILO/WHO Committee on Occupational Health at its 12th Session, 1995;
- (ii) the requirements of the Occupational Health Services Convention, 1985 (No. 161), and Recommendation, 1985 (No. 171);
- (iii) the *Technical and ethical guidelines for workers' health surveillance* adopted by the ILO in 1997.

16.1.3. The establishment of workers' health surveillance programmes should be based on sound scientific and technical knowledge of non-ferrous metals processes and be in accordance with the requirements of the competent authority. A linkage should be established between the surveillance of workers' health and the surveillance of occupational hazards present at the workplace.

16.1.4. The surveillance of workers' health should be appropriate to the occupational risks at the workplace. The assessment of the level and type of surveillance appropriate to potential exposure of workers to materials in the production of non-ferrous metals should be based on a thorough investigation of all work-related factors which may affect workers' health.

16.1.5. Workers' health surveillance programmes should be designed and implemented in consultation with workers and their representatives.

16.2. Medical examinations

16.2.1. As medical examinations are the most commonly used means of health assessment of individual workers, they should serve the following purposes:

- (i) the assessment of the health of workers in relation to hazards or risks caused by exposure to hazardous factors, giving special attention to those workers having specific needs for protection in relation to their health condition;
- (ii) detection of clinical and pre-clinical abnormalities at a point where intervention is beneficial to individual health;
- (iii) prevention of further deterioration in workers' health;

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- (iv) evaluation of the effectiveness of control values at the workplace;
 - (v) reinforcement of safe methods of work and health maintenance;
 - (vi) assessment of fitness for a particular type of work.

16.2.2. Pre-assignment medical examinations should:

- (i) collect information which serves as a baseline for future health surveillance;
- (ii) be adapted to the type of work, vocational fitness criteria and workplace hazards.

16.2.3. During employment, periodic medical examinations should take place at intervals prescribed by national laws and regulations, and be appropriate to the occupational risks of the enterprise.

16.2.4. Workers should have the right to request an assessment of health (i.e. a medical examination or other tests, as appropriate) if a disorder occurs which they believe to be due or related to work in the production of non-ferrous metals.

16.2.5. Where persons have been exposed to hazardous factors and, as a consequence, there is a significant risk to their health in the long term, suitable arrangements should be made for post-employment medical surveillance for the purpose of ensuring the early diagnosis and treatment of related diseases.

16.2.6. The competent authority should ensure that laws and regulations governing workers' health surveillance are properly applied.

16.2.7. The results and records of workers' health surveillance should be:

- (i) clearly explained by professional health personnel to the workers concerned or to the person of their choice;
- (ii) be kept confidential, only open to relevant medical staff, unless the worker has explicitly consented in writing to the release of all or part of such information.

16.2.8. Workers should have the right of access to their own personal health and medical files, including at the time of retirement and thereafter.

16.3. Occupational health services

16.3.1. The employer should establish an occupational health service for every non-ferrous metals plant.

16.3.2. The employer should be responsible for emergency medical care.

16.3.3. The organization, functions, staffing and equipment of occupational health services should conform to the requirements laid down in the Occupational Health Services Recommendation, 1959 (No. 112).

17. Emergency procedures and first aid

17.1. Emergency procedures

17.1.1. Arrangements should be made to deal at all times, and in accordance with the requirements of the competent authority, or as advised by risk assessment, with emergencies and accidents which might arise from the use of hazardous materials in the production of non-ferrous metals.

17.1.2. These arrangements, and the procedures to be followed, should be kept up to date.

17.1.3. Workers should be trained in the relevant procedures, including raising the alarm, calling for appropriate emergency assistance, using personal protective equipment, evacuation, and action to minimize the incident.

17.2. First aid

17.2.1. Adequate first-aid arrangements should be provided in accordance with any requirements laid down by the competent authority and having regard to the various types and sizes of non-ferrous metal production operations.

17.2.2. As far as is practicable, appropriate means and trained personnel to provide first aid should be readily available at all times during the use of hazardous materials in the production of non-ferrous metals.

17.2.3. As far as reasonably practicable, selected supervisory employees should undergo a training programme to enable them to qualify for a recognized first-aid certificate.

17.2.4. Where hazardous materials are used, first-aid personnel should be trained as regards:

- (i) the hazards associated with the materials and how to protect themselves from them;
- (ii) how to take effective action immediately;
- (iii) any relevant procedures associated with sending a casualty to hospital.

17.2.5. The first-aid equipment and facilities should be appropriate for dealing with the hazards to be encountered in the production of non-ferrous metals. Suitable facilities should be available for workers to use themselves. These should be strategically placed to allow for their immediate use in the event of an emergency.

17.2.6. There should be ready access at all times to first-aid equipment and to the facilities provided.

17.2.7. Properly equipped first-aid rooms should be provided in accordance with national laws or regulations.

17.3. Fire-fighting

17.3.1. Suitable fire-fighting equipment should be provided for the quantity and characteristics of the materials used in the production of non-ferrous metals. Adequate equipment should be available to cover the on-site transport and storage of non-ferrous metals and raw materials.

17.3.2. Fire-fighting equipment should be readily available and located in accordance with the requirements of the competent authority.

17.3.3. Fire-fighting and fire-protection equipment should be maintained in full working order, which should be ensured by regular inspection.

17.3.4. Suitable training, instruction and information should be given to workers about the hazards of fires involving chemicals, fuels or molten metal and the appropriate precautions to be taken. Where reliance is placed on trained fire-fighters, such arrangements should be emphasized and the action expected of workers clearly explained.

18. Investigating and reporting occupational accidents, occupational diseases and incidents

18.1. Investigating occupational accidents, occupational diseases and incidents

18.1.1. In order to assess the risks, and take any corrective steps necessary, the employer, in cooperation with workers and their representatives, should investigate immediately:

- (i) occupational accidents and incidents, whether or not they cause bodily injury;
- (ii) suspected and confirmed cases of occupational disease;
- (iii) situations where workers have removed themselves from danger;
- (iv) any other situation where there may be an unacceptable risk involving hazardous materials.

18.1.2. The investigation should include a review of the existing control measures.

18.2. Reporting occupational accidents, occupational diseases and incidents

18.2.1. Occupational accidents, occupational diseases and incidents arising from the production of non-ferrous metals should be reported to the competent authority in accordance with national laws and practice.

18.2.2. The competent authority may specify and periodically review which diseases are prescribed as being of occupational origin and which require reporting, in accordance with national laws and regulations.

19. Definitions

In this code, the following terms have the meaning assigned to them in the definition below:

- *Competent authority*: A minister, government department or other public authority with the power to issue regulations, orders or other instructions having the force of law.
- *Competent person*: A person with suitable training and sufficient knowledge, experience and skill for the safe performance of the specific work.
- *Dangerous occurrence*: Readily identifiable event, as defined under national laws and regulations, with potential to cause an injury or disease to persons at work or the general public.
- *Employer*: A legal person who produces non-ferrous metals with recognized responsibility, commitment and duties towards a worker in his or her employment by virtue of a mutually agreed relationship.
- *Engineering controls*: Use of technical measures such as enclosure, ventilation and workplace design to minimize exposure.
- *Exposure limit*: An exposure level specified or recommended by a competent authority to limit injury to health. The terms adopted by the competent authority vary from country to country and include: “administrative control levels”, “maximum allowable concentrations”, “permissible exposure limits”, “occupational exposure limits”, and “threshold limit values”.
- *Hazard*: The inherent potential to cause physical injury or damage to the health of people.
- *Hazard assessment*: A systematic evaluation of hazards.
- *Incident*: An unsafe occurrence arising out of or in the course of work where no personal injury is caused.
- *Notification*: A procedure, specified in national laws and regulations, for establishing the way in which the employer or others directly concerned submit information concerning occupational accidents, dangerous occurrences or incidents, or occupational diseases, as appropriate and as prescribed by the competent authority.
- *Occupational accident*: An unexpected occurrence, including acts of non-consensual violence, arising out of or in the course of work which results in fatal or non-fatal occupational injury.
- *Occupational disease*: Disease known, under prescribed conditions, to arise out of exposure to substances or dangerous conditions in processes, trades or occupations.

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- *Occupational health services*: Services entrusted with essentially preventive functions and responsible for advising the employer, the workers and their representatives in the undertaking on:
 - (i) the requirements for establishing and maintaining a safe and healthy working environment which will facilitate optimal physical and mental health in relation to work;
 - (ii) the adaptation of work to the capabilities of the workers in the light of their physical and mental health.
 - *Occupational health surveillance*: The ongoing and systematic collection, analysis, interpretation and dissemination of data for the purpose of prevention. Surveillance is essential to the planning, implementation and evaluation of occupational health programmes and to the control of work-related ill health and injuries and the protection and promotion of workers' health. Occupational health surveillance includes workers' health surveillance and working environment surveillance.
 - *Occupational safety and health management system*: Set of interrelated or interacting elements to establish occupational safety and health policy and objectives and to achieve those objectives.
 - *Recording*: A procedure, specified in national laws and regulations, for ensuring that the employer maintains information on:
 - (i) occupational accidents and diseases;
 - (ii) dangerous occurrences and incidents.
 - *Reporting*: A procedure, specified by the employer, in accordance with national laws and regulations and with the practice at the enterprise, for the submission by workers to their immediate supervisor, the competent person, or any other specified person or body, of information on:
 - (i) any occupational accident or injury to health which arises in the course of or in connection with work;
 - (ii) suspected cases of occupational diseases;
 - (iii) dangerous occurrences and incidents.
 - *Risk*: A combination of an occurrence of a hazardous event and the severity of injury or damage to the health of people caused by this event.
 - *Risk assessment*: The process for evaluating the risks to safety and health at work arising from hazards at work.
 - *Safety and health committee*: A committee set up to advise on safety and health matters. The composition of such a committee includes representatives of employers and workers.

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- *Screening criteria:* The values or requirements against which the significance of the identified hazard or effect can be measured. They should be based on sound scientific and technical information and may be developed by the enterprise and industry or tripartite bodies, or provided by the regulators.
 - *Statutory provisions:* Regulations and all provisions given force of law by the competent authority.
 - *Supervisor:* A person responsible for the day-to-day planning, organization and control of a production function.
 - *Surveillance of the working environment:* A generic term which includes the identification and evaluation of environmental factors which may affect workers' health. It covers assessments of sanitary and occupational hygiene conditions, factors in the organization of work which may pose hazards or risks to the health of workers, collective and personal protective equipment, exposure of workers to hazardous agents and control systems to eliminate or reduce them. From the standpoint of workers' health, the surveillance of the working environment may focus on, but not be limited to, ergonomics, accident and disease prevention, occupational hygiene in the workplace, work organization, and psychosocial factors in the workplace.
 - *Worker:* Any person who performs work, either regularly or temporarily, for an employer.
 - *Workers and their representatives:* Where this code refers to workers and their representatives, the intention is that, where representatives exist, they should be consulted as the means to achieve appropriate worker participation. In some instances it may be appropriate to involve all workers and all representatives.
 - *Workers' compensation:* Payment of compensation to workers or their families in the event of a temporary or permanent incapacity to work resulting from an injury or occupational disease sustained at or in connection with work.
 - *Workers' health surveillance:* A generic term which covers procedures and investigations to assess workers' health in order to detect and identify any abnormality. The results of surveillance should be used to protect and promote the health of the individual, collective health at the workplace, and the health of the exposed working population. Health assessment procedures may include, but are not limited to, medical examinations, biological monitoring, radiological examinations, questionnaires or a review of health records.
 - *Workers' representatives:* In accordance with the Workers' Representatives Convention, 1971 (No. 135), persons who are recognized as such by national law or practice, whether they are:
 - (i) trade union representatives, namely representatives designated or elected by trade unions or by members of such unions; or
 - (ii) elected representatives, namely representatives who are freely elected by the workers of the undertaking in accordance with the provisions of national laws or regulations or of collective agreements and whose

functions do not include activities which are recognized as the exclusive prerogative of trade unions in the country concerned.

- *Workers' safety and health representative*: A workers' representative elected or appointed in accordance with national laws, regulations and practice to represent workers' interests in OSH at the workplace.
- *Workplace*: Covers all places under the control of an employer where workers need to be or to go due to their work.
- *Work-related injuries, ill health and diseases*. Negative impacts on health arising from exposure to chemical, biological, physical, work-organizational and psychosocial factors at work.

Appendix A

Occupational exposure limits for hazardous substances, electric and magnetic fields, optical radiation, heat, noise and vibration

1. Purpose

1.1. The purpose of this appendix is to give a general introduction to exposure limits for the use of employers and others, and to indicate where more information can be obtained. Although some illustrative values are quoted, it is not the purpose of this appendix to list values, because these change continually as more technical information becomes available, and it is the responsibility of the competent authority to specify which exposure limits should be used and how.

2. General

2.1. An exposure limit (EL) is a level of exposure which is specified by a competent authority, or some other authoritative organization such as a professional body, as an indicator of the level to which workers can be exposed without serious injury. It is used as a general term and covers the various expressions employed in national lists, such as “maximum allowable concentration”, “threshold limit value”, “permissible level”, “limit value”, “average limit value”, “permissible limit”, “occupational exposure limit”, “industrial hygiene standards”, etc. The exact definition and intended application of ELs vary widely from one authority to another and the underlying definitions and assumptions and the requirements of the appropriate competent authority must be taken into account if they are used. For example, some authorities have promulgated ELs which are used as legally permitted “safe” levels of exposure and are intended to protect against injury, not against every health effect. Other authorities provide for limits which are intended as guidelines or recommendations in the control of potential workplace health hazards. An important example of the caution to be applied in using ELs is provided in the introduction to the annual publication *Threshold limit values (TLVs)* of the American Conference of Governmental Industrial Hygienists (ACGIH): TLVs “represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously”. Consequently, any EL represents a risk which is felt to be acceptable based on a particular criterion, and where such limits are promulgated there is usually an additional requirement to keep exposure as low as practicable, rather than simply below the EL.

2.2. It is also important to take into account the averaging period for which the limit is intended. Some limits are ceiling values to be continuously applied; others apply to average exposures over a period of up to several years. A short-period limit requires stricter control than a longer-period limit at the same exposure value. For example, a limit applying to a month might allow the exposure to range above the value for days at a time, provided there was a compensating period of low exposure which maintained the monthly average. If the same value were applied to 15-minute averages, the control would have to be good enough to keep every 15-minute average below the value.

2.3. ELs generally limit exposure of the individual, and measurements to be compared with the EL must therefore be taken close to the individual (“personal exposure”), unless the EL in question is clearly stated to be applicable to the general value

in the workplace environment. A measurement result sometimes depends on the measurement method, and quality control of measurements is often important; employers should consult the occupational health service on these issues.

2.4. Some authorities issue lists of values to be used in biological monitoring or in biological effect monitoring. As with ELs, different lists are derived from different assumptions and are intended to be used in different ways. They include lists of values which are believed to be safe, and values which are not necessarily safe but which represent an acceptable standard of control.

3. General sources

3.1. It is the responsibility of the competent authority to specify what ELs should be used, and the responsibility of the employer to obtain this information from the competent authority for any particular hazard and to compare the EL values with exposure levels in workplaces, to verify whether exposure is being properly controlled. A large number of international, national and other authorities have published lists of legal or recommended ELs of various sorts, but usually only for chemicals. The most wide-ranging is the ACGIH TLV list, updated annually, which includes recommended EL values for airborne chemicals; biological monitoring limits; ionizing, non-ionizing and optical radiation; thermal stress; noise; and vibration. The International Programme on Chemical Safety (IPCS) produces IPCS International Chemical Safety Cards, which are peer-reviewed assessment documents. International organizations, such as the International Organization for Standardization (ISO) and the International Atomic Energy Agency (IAEA), produce technical standards on the measurement and control of several ambient factors with the objective of their being transferred to regional or national legislation.

3.2. For all the ambient factors dealt with in this code of practice, detailed guidance on ELs and other aspects of assessment and control is provided by the ILO *Encyclopaedia of Occupational Health and Safety* (Geneva, 1998). Some references concerning ELs for particular ambient factors are given in the following sections.

4. Hazardous substances

4.1. ELs for solids and non-volatile liquids are usually in mg/m^3 , that is, milligrams of the chemical in a cubic metre of air. ELs for gases and vapours are usually in ppm, that is, parts of the substance in a million parts of air, by volume, and also in mg/m^3 at a specified temperature and pressure. There is a smaller number of lists of limits for biological monitoring.

4.2. Many authorities have issued lists of ELs for airborne chemicals, on various assumptions (see paragraph 2.1 of this appendix). The International Occupational Safety and Health Information Centre (CIS) of the ILO maintains a database of the limits from different parts of the world. For the time being, peer-reviewed IPCS International Chemical Safety Cards are available for around 1,300 chemical substances.

4.3. There are European standards for:

- (a) the performance of measurement methods for airborne chemicals: EN 482: *Workplace atmospheres – General requirements for the performance of procedures for the measurement of chemical agents* (1994);
- (b) comparison of the results with ELs: EN 689: *Workplace atmospheres – Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy* (1996).

4.4. Recommended values are given in *Threshold limit values for chemical substances and physical agents and biological exposure indices*, 1998 (United States, ACGIH, 1998) (revised annually).

4.5. Prominent national standards are:

- (a) EH 40/97: *Occupational exposure limits*, 1997 (United Kingdom, Health and Safety Executive (HSE), 1997) (revised annually);
- (b) Technical code of practice TRGS 900 (Technische Regeln für Gefahrstoffe): *Grenzwerte in der Luft am Arbeitsplatz (limit values relating to air in the workplace)* (Germany, 1998) (revised annually).

5. **Electric and magnetic fields**

5.1. There are as yet no internationally accepted sets of limits for electric and magnetic fields corresponding to the recommendations on ionizing radiation issued by the International Commission on Radiological Protection (ICRP), although some ELs have been recommended by the International Non-Ionizing Radiation Committee (INIRC) of the International Radiation Protection Association (IRPA), and by its successor, the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Some limits proposed by these and other organizations are in terms of the physical or physiological effects of the radiation and some in terms of the strengths of the fields. The relations between the units and quantities are complicated, and different quantities have been used in recommended ELs. Many of the recommendations depend on the frequency of the radiation. Units for time-varying quantities usually refer to the root-mean-square (rms) values.

5.2. Guidelines and recommendations can be found in the practical guide on *Protection of workers from power frequency electric and magnetic fields*, ILO Occupational Safety and Health Series, No. 69 (Geneva, 1994).

5.3. EN 50166: *Human exposure to electromagnetic fields* (1995).

6. **Optical radiation**

6.1. Exposure limits for optical radiation are to be established for the various kinds of radiation. *Threshold limit values* (ACGIH, 1997) recommends that:

- (a) ELs for UV radiation be in terms of the radiant flux density (or irradiance) of the radiation at the eye, in mW/cm^2 , weighted according to the wavelength of the radiation;
- (b) ELs for visible light be in terms of the radiance of the source, i. e. the energy output per unit area of the source into each solid angle, weighted according to the wavelength of the radiation;
- (c) ELs for IR radiation be in terms of the radiant flux density at the eye, in mW/cm^2 , and unweighted for wavelength. However, for IR heat lamps there is also a limit in terms of the source's radiance.

6.2. The *Guidelines on protection against non-ionizing radiation* (IRPA, 1991) include ELs for lasers to protect the eye and skin. They are generally in terms of the energy density reaching the eye or skin (that is, in J/m^2 , equal to the radiant flux density in W/m^2 multiplied by the exposure time in seconds). The ELs vary with wavelength, and for visible and IR wavelengths are relaxed slightly as exposure time increases. Guidance on

their use and further references on limits of exposure to laser radiation are given in the practical guide on *The use of lasers in the workplace*, ILO Occupational Safety and Health Series, No. 68 (Geneva, 1993). Control measures, however, are more easily specified in terms of the class of laser used than in terms of the ELs. The laser classification is specified in IEC 60 825-1: *Safety of laser products – Part 1: Equipment classification, requirements and users guide* (International Electrotechnical Commission, 1993).

7. Heat

7.1. A series of international standards, in particular of the International Organization for Standardization (ISO), is helpful in assessment and monitoring of the thermal environment. ISO 11399:1995 *Ergonomics of the thermal environment – Principles and application of relevant International Standards* is a useful guide to their application.

7.2. In hot environments, ISO 7243:1989 *Hot environments – Estimation of the heat stress on working man, based on the WGBT-index (wet bulb globe temperature)* gives a rapid method based on the wet bulb globe temperature (WGBT) index, which will be satisfactory under most conditions. It may provide insufficient protection for work in impervious clothing, in high radiant temperature, or a combination of high temperature and high air velocity. Under these more severe conditions, ISO 7933:1989 *Hot environments – Analytical determination and interpretation of thermal stress using calculation of required sweat rate* and ISO 9886:1992 *Ergonomics – Evaluation of thermal strain by physiological measurements* provide guidance for assessing individual response.

7.3. EN 563: *Safety of machinery – Temperatures of touchable surfaces – Ergonomics data to establish temperature limit values for hot surfaces* (1994).

7.4. ACGIH (1997) (see paragraph 4.4) gives details of work/rest regimes.

8. Noise

8.1. Noise is conventionally measured in terms of the pressure of the sound wave. Because the ear responds roughly to the logarithm of the pressure, rather than its linear value, noise intensity is measured in decibels (dB), which are related to the logarithm of the ratio of the pressure of the sound to the pressure of a standardized least detectable sound. Also, the ear is more responsive to some frequencies than others, so measurements and ELs are in terms of dB(A), which takes a frequency weighting into account. All authorities specify an EL in terms of dB(A) applicable to eight-hour exposures, with a formula to deal with other exposure periods, and in most cases a peak EL as well. Some authorities apply stricter standards to particular environments.

8.2. ISO 1999:1990 *Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment* gives estimates of the hearing loss which will result from various exposure levels.

8.3. ISO 4871:1996 *Acoustics – Declaration and verification of the noise emission values of machinery and equipment*.

8.4. ISO 9612:1997 *Acoustics – Guidelines for the measurement and assessment of exposure to noise in a working environment*.

8.5. ISO 7196:1995 *Acoustics – Frequency-weighting characteristics for infrasound measurements*.

8.6. ISO 11690:1996 *Acoustics – Recommended practice for the design of low-noise workplaces containing machinery. Part 1: Noise control strategies; Part 2: Noise control measures; Part 3: Sound propagation and noise prediction in workrooms.*

9. Vibration

9.1. ELs for vibration are usually in terms of the root-mean-square (rms) acceleration, frequency weighted to take human response into account. The standard is usually applied to eight-hour exposures, with a formula to account for shorter or longer periods.

9.2. For whole-body vibration, limits are applied to the longitudinal component (through the head and feet), to the two axes at right angles to this, and to a weighted combination of all three. ISO 2631-1:1997 *Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 1: General requirements* provides general requirements.

9.3. For hand-transmitted vibration, limits are applied to frequency-weighted acceleration along three orthogonal axes centred at the point of contact of the hand and the tool. ISO 5349:1986 *Mechanical vibration – Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration* is currently under revision.

Appendix B

Additional chemicals used in the non-ferrous metals industries

Formaldehyde

Short-term (acute) exposure through the inhalation of vapour can cause severe irritation of the nose, throat and windpipe. Formaldehyde solutions can cause primary irritation resulting in tingling, drying and reddening of skin. Eye contact results in irritation, tingling of the eye; concentrated solutions can cause severe eye injury.

Ingestion of formaldehyde causes irritation, severe pain in the mouth, throat, oesophagus and intestinal tract. Later symptoms can include dizziness, depression and coma.

Long-term (chronic) exposure through inhalation causes irritation of mucous membranes and the upper respiratory tract. Long-term skin contact causes skin allergy.

Hydrogen cyanide

Short-term (acute) inhalation or ingestion causes weakness, headache, giddiness, dizziness, confusion, anxiety, nausea and vomiting. High concentrations can cause death within minutes or hours. There may be a bitter, pungent, burning taste in the mouth.

Long-term (chronic) exposure causes a persistent runny nose, weakness, dizziness, giddiness, headache, nausea, abdominal pain, vomiting, throat irritation, changes in taste and smell, muscle cramps, weight loss, flushing of the face and enlargement of the thyroid gland.

Benzene

Short-term (acute) inhalation causes depression of the central nervous system, marked by drowsiness, dizziness, headache, nausea, loss of coordination, confusion and unconsciousness. Long-term exposure to benzene reduces the number of red and white blood cells and damages bone marrow. Benzene is carcinogenic.

Toluene

Short-term (acute) exposure by inhalation or ingestion causes central nervous system depression. Irritation of the nose, throat and respiratory tract are minor symptoms.

Sulphuric acid

Short-term (acute) exposure through inhalation can cause severe irritation or corrosive damage. Symptoms can be severe lung damage, coughing and shortness of breath. Sulphuric acid is corrosive and contact with the skin causes severe irritation and burns which may result in permanent scarring. Eye contact results in severe irritation, redness, swelling, pain and, possibly, permanent damage, including blindness. Ingestion causes burns to the mouth, throat, oesophagus and stomach. Symptoms include difficulty swallowing, intense thirst, nausea, vomiting, diarrhoea and, in severe cases, collapse and death.

Long-term (chronic) exposure can cause red, itchy, dry skin and dental erosion.

Ammonia

Short-term (acute) inhalation causes severe irritation of the respiratory tract. Skin contact results in burns, blistering and, possibly, permanent scarring of the skin. Eye contact causes irritation and, possibly, corrosive injury.

Carbon monoxide

Inhalation of carbon monoxide causes symptoms including headache, weakness, dizziness, nausea, fainting, increased heartbeat, irregular heartbeat, loss of consciousness and death.

Phenol

Short-term (acute) contact with skin, eye or mucous membranes leads to numbness or slight tingling, then burns, blisters, permanent skin damage and gangrene, damage to the mouth, throat and stomach, internal bleeding, vomiting, diarrhoea, decreased blood pressure. Shock, collapse, coma and death may result.

Chlorine

If inhaled, chlorine causes severe breathing difficulties and pulmonary oedema. It can aggravate respiratory diseases, such as bronchitis and asthma.

Cyclohexane

Short-term (acute) inhalation can cause headache, nausea, dizziness, drowsiness and confusion. In very high concentrations, unconsciousness and death can result. Ingestion of extremely large doses may cause nausea, vomiting, diarrhoea and headache.