Physical agents

Published on: 17/01/2012 Latest update: 03/06/2022

Introduction

The term “Physical Agents" is commonly used to describe a group of sources of energy which have the capability of causing injury or disease to workers. Examples of physical agents include noise, vibration, electromagnetic radiation, electricity and extremes of temperature.

This overview article introduces the various physical agents, and briefly discusses the risks to workers from the agents, how these risks may be controlled and identifies the European Directives that seek to protect workers across Europe from the agents. Links to detailed articles on the individual physical agents are provided.

European legislation

In Europe, the risks in the workplace from exposure to many physical agents have been controlled through European Directives. European Directives define minimum levels of worker protection that Member States are required to implement in national legislation. Member States may define higher levels of protection than specified in Directives, and usually have 3 years from the publication of the Directive to put in place national legislation.

Some agents are covered though the series of Directives that specifically relate to physical agents, others are dealt with by Directives outside that series, see Table 1.

Not all agents are covered by European Directives and where guidance on exposures is available these are normally defined in National or International Standards or other occupational safety and health guidelines.

Physical Agent	Directive	Summary at EU-OSHA	European Commission guidelines
Physical Agents (Noise)	2003/10/EC[1]	https://osha.europa.eu/en/legislation/directives/82	https://osha.europa.eu/en/legislation/guidelines/non-binding-guide-to-good-practice-for-the-application-of-directive-2003-10-ec-of-the-european-parliament-and-of-the-council-on-the-minimum-safety-and-health-requirements-regarding-the-exposure-of-workers-to-the-risks-arising-from-physical-agents-noise
Physical Agents (Vibration)	2002/44/EC[2]	https://osha.europa.eu/en/legislation/directives/19	https://osha.europa.eu/en/legislation/guidelines/non-binding-guide-to-good-practice-with-a-view-to-implementation-of-directive-2002-44-ec-on-the-minimum-health-and-safety-requirements-regarding-the-exposure-of-workers-to-the-risks-arising-from-physical-agents-vibrations
Physical Agents (Artificial Optical Radiation)	2006/25/EC[3]	https://osha.europa.eu/en/legislation/directives/directive-2006-25-ec-of-the-european-parliament-and-of-the-council-of-5-april-2006	https://osha.europa.eu/en/legislation/guidelines/non-binding-guide-to-good-practice-for-implementing-directive-2006-25-ec-201aartificial-optical-radiation2019
Physical Agents (Electromagnetic Fields)	2013/35/EU[4]	https://osha.europa.eu/en/legislation/directives/directive-2013-35-eu-electromagnetic-fields	https://osha.europa.eu/en/legislation/guidelines/non-binding-guide-good-practice-implementing-directive-201335eu
Ionizing Radiation	2013/59/EU RATOM[5]	https://osha.europa.eu/en/legislation/directives/directive-2013-59-euratom-protection-against-ionising-radiation	https://osha.europa.eu/en/legislation/guidelines/technical-recommendations-for-monitoring-individuals-occupationally-exposed-to-external-radiation

Physical Agent	Directive	Summary at EU-OSHA	European Commission guidelines
Electrical Equipment	2014/35/EC[6]		

Table 1. European Directives relating to physical agents

Source: Pitts, Kudász

Physical agents

Noise

Exposure to high levels ofnoise on a regular basis, or very high levels of impactive or explosive noise can cause permanent hearing loss or other damage to the ear such as tinnitus. Both hearing loss and tinnitus are irreparable conditions with a significant impact on day-to-day lives.

Noise in the workplace can also create safety risks, where workers are unable to hear warning sounds such as moving machinery noise and alarms. Such conditions can easily occur in noisy workplaces, especially where workers need to use hearing protection and where individual workers suffer from some hearing loss.

Noise should be eliminated at source where possible, or reduced to levels where risks are minimal. Daily exposure and peak noise action levels and limit values are given in the Physical Agents (Noise) Directives[1] to ensure that appropriate actions are taken at appropriate noise levels to ensure the protection of workers.

Personal hearing protection is used when other controls cannot adequately reduce exposures. Hearing protection must be selected so as to reduce noise exposures as far as possible without isolating the worker, which may compromise safety.

The European Directive on Machinery Safety[7] requires that noisy equipment for use in the workplace is supplied with noise emission information that will enable employers to select lower noise machinery. Noise emission values provide values for noise levels at operator positions and (for noisier machinery) sound power levels.

Vibration

Hand-arm vibration

Workers are exposed to hand-arm vibration when using vibrating hand-held, hand-guided or hand-fed power tools. Hand-arm vibration risk can be encountered in many industry groups, for workers using many types of powered hand-held machinery. However, hand-arm vibration is most often associated with activities such as the use of grinders in heavy steel work, chainsaws and other tools in forestry and arboriculture, road-breakers in construction and utilities and chipping hammers in stone working.

Exposure to hand-arm vibration for long periods on a regular basis can cause independent vascular, neurosensory and musculoskeletal disorders of the hand and arm. Collectively, these disorders are referred to as Hand-Arm Vibration Syndrome (HAVS). HAVS, which is permanent and largely irreversible, can have a significant impact on daily lives. Sufferers find it difficult to properly feel and manipulate items with their hand and fingers, so simple everyday tasks such as reading a newspaper, cutting up food and even dressing becomes difficult.

There is some evidence from the research literature to suggest that the use of vibrating hand tools can also lead to a risk of developing Carpal Tunnel Syndrome (CTS). However, not all research supports this[8] and some studies have suggested that the postural influence of using such tools rather than the vibration exposure is the primary cause.

Hand-arm vibration should be eliminated at source, where possible or reduced to levels where risks are minimal. Daily hand-arm vibration exposure action levels and limit values are given in the Physical Agents (Vibration) Directive[2] to ensure that appropriate actions are taken at appropriate exposure levels to ensure the protection of workers. Employers may also need to consider upper limb musculoskeletal disorder (MSD) risks alongside hand-arm vibration. Like HAVS, MSDs can be associated with the use of hand-held power tools; however they are caused by factors such as awkward postures, repetitive actions and the application of high forces.

If other vibration controls cannot adequately reduce exposure, the exposure time of each worker may need to be restricted to prevent the development of vibration injury.

Anti-vibration gloves with the European CE mark are available. However, anti-vibration gloves do not usually reduce vibration exposures and employers do not have the information required to allow them to make any assessment of the likely vibration exposure when wearing gloves. There are benefits from wearing gloves, as they keep the hands warm and help to maintain

good circulation; however these benefits can equally be achieved with normal work gloves.

The European Directive on Machinery Safety[7] requires that machinery equipment for use in the workplace is supplied with hand-arm vibration emission information that will enable employers to select lower vibration machines. Hand-arm vibration emission values also allow purchasers to estimate likely workplace exposures and thereby assess the likely risks to workers.

Whole-body vibration

Workers are exposed to whole-body vibration when sitting or standing on vibrating machinery. Usually hazardous exposures are associated with off-road vehicles in industries such as agriculture, forestry, mining, quarrying and with small-fast boats used off-shore. Vehicles such as fork-lift trucks, cranes and even road-vehicles such as lorries and coaches also have the capability of producing high levels of whole-body vibration.

Whole-body vibration shocks are believed to be an important part of the overall risk. For this reason the EU Physical Agents (Vibration) Directive[2] allows Member States to control whole-body vibration exposures either using a daily exposure based on root-mean-squared (r.m.s.) vibration values or a vibration dose value (VDV) exposure which is a measure that is more sensitive to vibration shocks.

Whole-body vibration exposures, especially in conjunction with poor postures or manual handling, are primarily associated with lower-back pain and injury although upper back and other musculoskeletal problems can be encountered.

Whole-body vibration should be eliminated at source where possible or reduced to levels where risks are minimal. Daily whole-body vibration exposure action levels and limit values are given in the Physical Agents (Vibration) Directive[2] to ensure that appropriate actions are taken at appropriate exposure levels to ensure the protection of workers.

Reduction of whole-body vibration exposure can often be achieved by selecting the right vehicle for the job, improving road surfaces, reducing speeds and modifying suspension systems. Suspension seats are often used to reduce the vibration exposures in industrial vehicles.

The European Directive on Machinery Safety[7] requires that mobile machinery for use in the workplace is supplied with whole-body vibration emission information that will help employers select lower vibration machines.

Optical radiation

Natural optical radiation

Exposure to natural optical radiation (sunlight) is a risk for outdoor workers. Over-exposure of the skin to the UV radiation in sunlight can cause skin cancers and eye damage. Occupations at particular risk include those that involve long-periods of outdoor work such as workers in:

- Construction, road maintenance and utilities
- Agriculture, horticulture and forestry
- Postal and delivery service
- Marine activities (for example: in-shore and off-shore sailing, fish-farming, fishing)
- Window cleaning
- Waste collection
- Leisure (for example: golf course workers, outdoor pool attendants, beach workers)

Workers should avoid prolonged exposure to sunlight to avoid getting skin reddening (erythema) which is a sign of skin damage as well as an early sign of sunburn. Simple ways to minimise the risks are to:

- take breaks in shaded places
- keep vulnerable areas of the body such as the back and neck covered using suitable UV protective clothing
- use sunscreen on exposed skin

It is important to take care, both in work and out of work. Don't try to get a tan; it may look good but it shows that the skin is already damaged.

Control of natural optical radiation is not included in EU Directives. However, general advice on protection from sunlight for outdoor workers is provided by occupational health authorities, for example HSE INDG337[9] and HSE INDG147[10].

Artificial optical radiation

Exposure to artificial optical radiation may arise from light emitted from all artificial sources, i.e. light in all its forms such as visible, ultraviolet, infra-red and lasers, but excluding sunlight. The effects of exposure to artificial optical radiation can be both acute and chronic, affecting mainly the skin and eyes.

Where the skin is affected, those exposed may suffer short-term effects of reddening (erythema), blistering and burns. Long-term exposures may cause skin ageing (elastosis) and skin cancer. For the eyes, damage may include inflammation of the cornea (photokeratitis), inflammation of the conjunctiva that lines the eyelids and eye socket (photoconjunctivitis), retinal damage, corneal burns, retinal burns and cataracts.

The majority of light sources (such as overhead and task lighting, computer screens and photocopiers) are safe when used properly (e.g. fluorescent lamps fitted with diffusers). However, some sources may present a risk that needs to be controlled (e.g. welding, plasma cutting, UV curing of inks and paints).

The exposure of workers should be controlled by selecting low-emission equipment, restricting access and using screens. Exposure limit values are given in the Physical Agents (artificial optical radiation) Directive[3] to ensure that appropriate actions are taken at appropriate exposure levels to ensure the protection of workers. Exposure limits are dependent upon wavelength, the part of the body at risk and the time exposed. The limits are defined in terms of irradiance (the radiated power per square metre incident on a surface, W/m^2), radiance (the radiated power incident on a surface within in a given solid angle, $W/m^2/sr$), or radiant exposure (the integral of the irradiance with time, i.e. the radiant energy per square meter incident on a surface, J/m^2).

If other controls cannot adequately control exposure, workers will need to wear protective clothing to cover exposed areas of skin and to protect the eyes. Normally this means wearing gloves, goggles or face shields. Eye protection should be suitable for the wavelength of radiation to which the worker is exposed.

Lasers

Lasers are a sub-group of artificial optical radiation that present specific risks to the worker. Injury to the eye can be caused by brief exposures to quite low-powered lasers and high powered lasers can also burn the skin. The diffuse reflection of higher powered laser beams from a surface can also be hazardous to the eye. Lasers are used in a wide range of applications including medicine and entertainment.

Exposure limit values are given in the Physical Agents (artificial optical radiation) Directive[3] to ensure that appropriate actions are taken at appropriate exposure levels to ensure the protection of workers. Exposure limits are dependent upon wavelength, the time exposed and the part of the body. The limits are defined in terms of irradiance (the radiated power per square metre incident on a surface, W/m^2) or radiant exposure (the integral of the irradiance with time, i.e. the radiant energy per square meter incident on a surface, J/m^2).

Risks from lasers can be avoided by careful control of the route that the beam takes, avoiding unintended reflections and the use of appropriate protective glasses. For higher powered lasers key switches and interlocks are required to ensure access by suitably trained personnel and avoid unintentional operation. Laser safety classifications are designed to assist in the process of identifying suitable controls for different types of laser product. Lasers are rated against 7 classes defined by EN 60825-19[11], see Table 2. For more advice on laser safety see: [12]

Source Adapted from EN 60825-1:2007 [11]

Table 2: EN 60825-1 laser classes

Class	Hazard	Warning statement*
Class 1	Safe under reasonably foreseeable conditions (Note: Class 1 lasers include high-power lasers that are fully enclosed, such that potentially hazardous radiation is not accessible during use).	-
Class 1M	Safe for the naked eye except if magnifying optics are used.	Do not view directly with optical instruments
Class 2	Safe for short exposures (less than 0.25s). The eye is protected by the blink reflex.	Do not stare into the beam
Class 2M	Safe for short exposures (less than 0.25s). The eye is protected by the blink reflex except if magnifying optics are used.	Do not stare into the beam or view directly with optical instruments
Class 3R	Safe if handled with care, may be dangerous if mishandled. Risk is limited by the blink reflex and natural response to heating of the cornea for infrared radiation.	Avoid direct eye exposure
Class 3B	Direct viewing is hazardous. Protective eyewear is necessary if the beam is accessible. Safety interlocks are required to prevent access to hazardous laser radiation.	Avoid exposure to beam
Class 4	Can burn the skin and cause permanent eye damage. Class 4 lasers can also present a fire hazard. Safety interlocks with manual reset are required to prevent access to hazardous laser radiation.	Avoid eye or skin exposure to direct or scattered radiation

* The warning statements accompany the title: "laser radiation" and laser product type statement on laser product labels in the format:

LASER RADIATION
Warning statement
CLASS *x* LASER PRODUCT

Additional labelling may also be required dependent upon the laser class and beam accessibility.

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Electromagnetic fields

Electromagnetic fields (EMFs) arise whenever electrical energy is used. Although most EMF sources at work will produce field strengths that can be considered harmless, hazardous EMFs arise from work processes such as welding, radiofrequency heating and drying, high-field magnetic resonance imaging (MRI) scanners and from radio, TV and telecommunications broadcasting masts. Exposure of workers to high levels of EMFs can give rise to a variety of health effects that depend on the frequency of the electromagnetic radiation. At low frequencies the central nervous system of the body can be affected whilst at high frequencies, heating effects can occur. These acute health effects are extremely rare and do not occur in most day-to-day work situations.

The Physical Agents (electromagnetic radiation) Directive[4] was published in 2004, with the objective to ensure appropriate protection of workers from electromagnetic fields. However, implementation of this directive was postponed following concerns expressed by EU Member States. The provisions of the revised Directive had to be met by Member States' legislation by 1/July/2016.

Ionising radiation

Ionising radiation are either electromagnetic rays (X-rays or gamma rays) or particles (alpha and beta particles). It occurs naturally (e.g. from the radioactive decay of natural radioactive substances such as radon gas and its decay products) but can also be produced artificially. In the workplace, ionising radiation has many applications in medicine, research, engineering, construction, and nuclear power generation.

In the workplace,ionising radiation presents health risks to workers. Workers with long-term exposure to low-levels of ionising radiation are at risk of developing cancers and DNA mutations. High levels of radiation exposure cause radiation sickness and burns.

Exposure limit values are given in the ionising radiation EURATOM Directive[5] to ensure that appropriate actions are taken at appropriate exposure levels to ensure the protection of workers. In most European countries the limit for effective dose of occupational workers is set at 20mSv in any single year. Substantially lower dose limits are defined for apprentices, pregnant workers and members of the public affected by work activities.

Protection of workers and others from work activities involving ionising radiation are controlled through systems of:

- reporting and authorisation of hazardous activities,
- limitation and monitoring of received doses
- classification and delineation of work areas
- information to and training of workers
- medical surveillance of exposed workers

Thermal risks

People working in uncomfortably hot and cold environments are more likely to behave unsafely because their ability to make decisions and/or perform manual tasks deteriorates. When the body's means of controlling its internal temperature starts to fail heat stress occurs.

As well as controlling the air temperature, consideration of factors such as work rate, humidity and clothing worn while working may help to minimise the risks from thermal discomfort and of developing heat stress.

Control of thermal risks in the workplace is not included in any specific individual EU Directives, although such risks are covered by the general provisions of the 'Framework Directive' (89/391/EEC) and further material on their assessment and management is available in a series of ISO Standards. These standards encompass thermal comfort as well as risks to health associated with hot and cold environments. Specific information on clothing forprotection against thermal hazards is also available, and general advice on the protection of workers from thermal risks is provided by occupational health authorities, for example HSE's GEIS1[13].

Electricity

Electricity is part of everyday life both at home and at work, but electricity can kill or severely injure people and cause damage to property. Both alternating current (AC) and Direct Current (DC) electrical supplies can cause injuries such as: electric shock, electrical burns and thermal burns as well creating a loss of muscle control which may be a safety hazard.

Even non-fatal shocks can cause severe and permanent injury. For example, shocks from faulty equipment may lead to falls from ladders, scaffolds or other work platforms. Those using or working with electricity may not be the only ones at risk; poor electrical installations and faulty electrical appliances can lead to fires, which may also cause death or injury to others. Most of these accidents can be avoided by careful planning and straightforward precautions.

Protection of workers from electrical hazards is primarily covered by the electrical equipment Directive[6]. Control of risks starts with ensuring the design, installation, modification and repair of electrical facilities are carried out by those with suitable training and competence. Engineering controls, such as interlocks and circuit breakers are required to ensure access is suitably controlled and in case of faults, systems fail safe. However, these controls need to be used in conjunction with simple routine checks for signs of damage or contamination with water.

Summary

The term 'Physical Agents' can be applied to a number of agents that cause a range of adverse health and safety effects on the worker. The agents may present risks to workers in most, if not all, industry categories. For many agents, legal duties have been placed on employers to control workplace exposure to the agents through European Directives.

The health and safety risks from physical agents are diverse, but these risks can be controlled. The basic control principles that can generally be applied to the agents are: eliminating or reducing emissions at source, reducing transmitted energy using barriers, isolators or absorbers, managing the durations of exposures and the use of protective clothing. In addition to these control measures, information, instruction and training for machine users and health surveillance are also important components of successful programmes to manage the risks from physical agents.

References

[1] Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise), Seventeenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32003L0010:EN:NOT

[2] Directive 2002/44/EC of the European Parliament and of the Council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32002L0044

[3] Directive 2006/25/EC of the European Parliament and of the Council of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation) (19th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), OJ L 114, 27.4. 2006. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0025

[4] Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC, OJ L 179/1, 29.6.2013. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013L0035

[5] Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, OJ L 13/1 17.1.2014. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013L0059

See all references

Further reading

Non-binding guide to good practice for the application of Directive 2003/10/EC of the European Parliament and of the Council on the minimum safety and health requirements regarding the exposure of workers to the risks arising from physical agents (Noise), 2008. Available at: : http://bookshop.europa.eu/is-bin/INTERSHOP.enfinity/WFS/EU-Bookshop-Site/en_GB/-/EUR/ViewPublication-Start?PublicationKey=KE8108222

Non-binding guide to good practice with a view to implementation of directive 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibrations), 2008. Available at: http://bookshop.europa.eu/is-bin/INTERSHOP.enfinity/WFS/EU-Bookshop-Site/en_GB/-/EUR/ViewPublication-Start?PublicationKey=KE7007108

Non-binding guide to good practice for implementing Directive 2006/25/EC 'artificial optical radiation', 2011. Available at: http://bookshop.europa.eu/en/non-binding-guide-to-good-practice-for-implementing-directive-2006-25-ec-pbKE3010384/
Technical recommendations for monitoring individuals occupationally exposed to external radiation, 2009. Available at: http://bookshop.europa.eu/is-bin/INTERSHOP.enfinity/WFS/EU-Bookshop-Site/en_GB/-/EUR/ViewPublication-Start?PublicationKey=KOXA09004&CatalogCategoryID=Ke4KABstjN4AAAEj8pAY4e5L

EU-OSHA - European Agency for Safety and Health at Work, *Workplace Exposure to vibration in Europe: An expert review*, 2008. Available at: https://osha.europa.eu/en/publications/reports/8108322_vibration_exposure/view

EU-OSHA - European Agency for Safety and Health at Work "Report - Prevention of risks from occupational noise in practice", 2005. Available at: https://osha.europa.eu/en/publications/reports/6905812/view

EU-OSHA - European Agency for Safety and Health at Work, "Report - Reducing the risks from occupational noise", 2005. Available at: https://osha.europa.eu/en/publications/reports/6805535/view

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