SHEET N° 10

Cadmium

CARCINOGENS AT WORK: Know to Prevent

Information about the substance and where it can be found

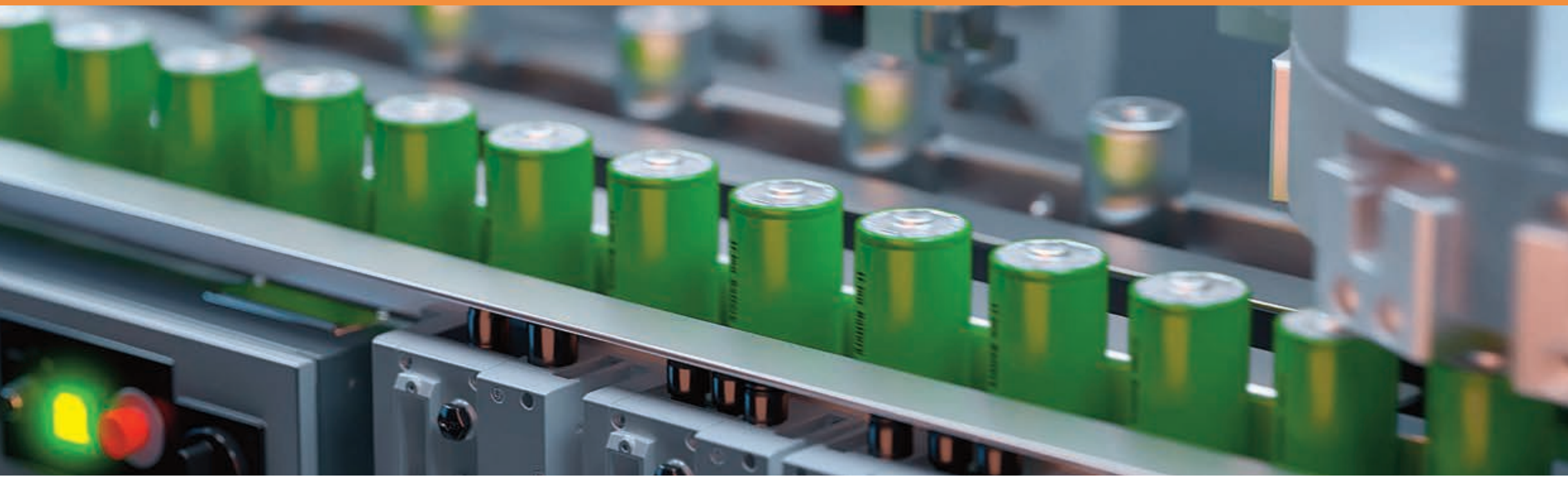
Cadmium is a silver-coloured, soft, ductile and malleable metal, which occurs naturally in the earth's crust in low concentrations, usually associated with other minerals such as zinc, lead and copper. It is soluble in dilute nitric acid, ammonium nitrate and hot sulphuric acid, and insoluble in water (NTP, 2021). However, solubility varies widely among the large number of cadmium compounds (DLEP, 2018). Cadmium is non-combustible, but oxidises slowly in the presence of moisture, and when heated to high temperatures, it burns, emitting corrosive and toxic fumes or vapours such as cadmium oxide. On the other hand, it is highly resistant to corrosion and has a wide variety of industrial uses, making it one of the commonest pollutants in the environment. As a result, legislative measures have been taken in many countries to reduce their use and consequent dispersion into the environment.

Thus, the uses of cadmium and its compounds have been regulated by *Commission Regulation (EC) No 552/2009 of 22 June 2009, Commission Regulation (EU) No 494/2011 of 22 May 2011; and Commission Regulation (EU) No 835/2012 of 18 September 2012* amending **annex XVII** to **Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)** as regards restrictions on cadmium and its compounds. Thus, its uses are restricted to colouring of plastics and paints, stabilisation of polymers and vinyl chloride copolymers, cadmium plating of metals, jewellery manufacturing and as brazing filler metals. Exceptionally, they will be used in sectors where they are technically indispensable, such as: aeronautics, aerospace, nuclear, mining, electronics, construction and building works, among others.

Thus, the main authorised uses for cadmium metal are: the manufacture of nickel-cadmiun (Ni-Cd) batteries and accumulators; the manufacture of cadmium oxide powder, using it as a catalyst for polymerisation reactions; in zinc, lead and copper refining and smelting processes; in soldering activities; in anti-corrosion coating of metals (steel, cast iron, copper alloys, aluminium, etc.); the manufacture of various types of alloys (low melting point); as an electroplating agent (oxide, chloride, cyanide); as an inter-

TABLE OF CONTENTS

- Information about the substance and where it can be found
- Health effects
- Where the exposure can take place
- Exposure assessment
- Controlling exposure
- Health surveillance
- Other preventive measures
- References



mediate in the synthesis of cadmium compounds and some fungicides (INRS, 2022); (Infocarquim, 2022).

On the other hand, the sectors authorised for the use of *inorganic cadmium compounds* include: the use as raw materials to prepare other cadmium compounds, in particular salts of organic acids used as stabilisers for plastics (oxide, chloride, nitrate); the manufacture of pigments for paints, plastics, glass, ceramics, enamels and in textile finishing; as components of many electrical materials: batteries (CdO), solar or photoelectric cells, rectifiers, contactors, semiconductors (oxide, hydroxide, sulphate, sulphide, selenide), among others (INRS, 2022).

Health effects

The International Agency for Research on Cancer (IARC, 2012) has classified cadmium as a human carcinogen (Group 1), based on animal studies involving long-term exposure to respirable cadmium showing lung tumours and epidemiological meta-studies suggesting associations between cadmium exposure in workers and lung, kidney and prostate tumours (ECHA/RAC, 2021).

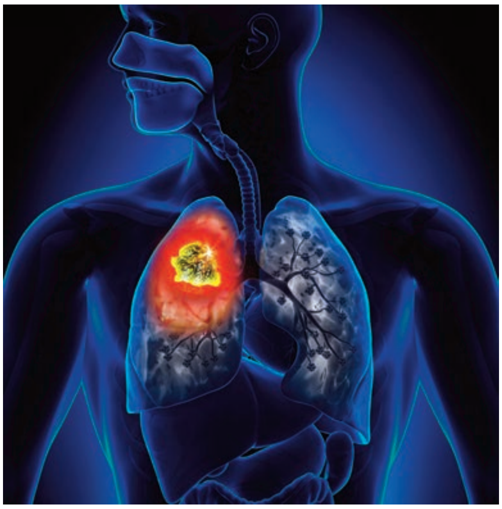
Similarly, in the European Union cadmium and some cadmium salts are classified as **category 1B carcinogens** according to Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP Regulation) (Table 1). Mechanisms involved in carcinogenesis include: induction of oxidative stress (generation of reactive oxygen species, most likely through inhibition of antioxidant defence systems), oxidative DNA damage, inhibition of DNA repair and down-regulation of cell proliferation. (ECHA/RAC, 2021).

In occupational exposures, cadmium's main route of entry into the body is via inhalation, and sometimes, depending on personal hygiene, the digestive route may be significant.

Table 1
Harmonised hazard classification of cadmium according to Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging of substances and mixtures (CLP)

Cadmium (Cd). CAS No. 7440-43-9			
Classification			
CLP classification		**Hazard statement**	
Carcinogenicity. Carc.1B		H350: May cause cancer	
Germ cell mutagenicity. Muta.2B.		H341: Suspected of causing genetic defects	
Acute toxicity. Acute Tox. 2		H330: Fatal if inhaled.	
Reproductive toxicity. Repr. 2.		H361fd: Suspected of damaging fertility or the unborn child.	
Hazardous to the aquatic environment. Aquatic Acute 1.		H250: Catches fire spontaneously if exposed to air.	
Hazardous to the aquatic environment. Aquatic Chronic 1.		H410: Very toxic to aquatic life with long lasting effects.	
Specific target organ toxicity — repeated exposure. STOT RE 1.		H372: Causes damage to organs.	
Labelling. Hazard pictograms and signal word.			
Danger			
			

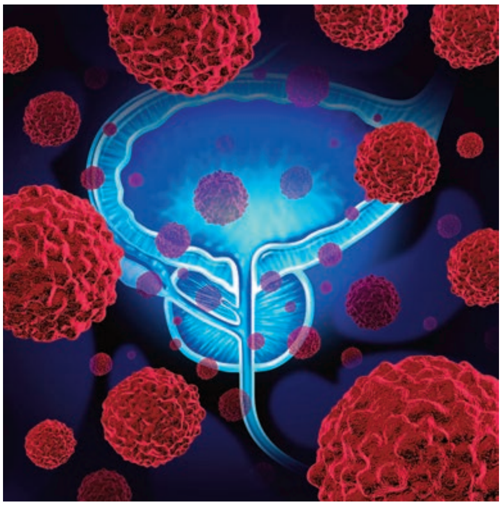
The IARC (iarc.who.int) is an autonomous agency of the World Health Organization of the United Nations. It seeks to promote international collaboration in cancer research. It runs studies that are widely recognised for their quality and independence.



More specifically, between 2 and 50% of this agent is absorbed via the respiratory tract, depending on the particle size (dusts or fumes), the solubility of the compound (water soluble or insoluble), the deposition pattern in the respiratory tract and the ventilation rate (SCOEL, 2017).

In contrast, gastrointestinal absorption of cadmium in the environment is estimated to be less than 5%, a figure that varies according to diet and individual iron and/or calcium status. Similarly, tobacco must be considered as an important source of cadmium exposure (DLEP, 2018).

After absorption by any of these routes, it is transported to the liver, where it induces synthesis of a low molecular weight protein called *metallothionein*, which binds to cadmium, forming the *cadmium-metallothionein* complex; it is slowly released and transported through the bloodstream until it is deposited in the proximal renal tubule.



The half-life of cadmium in the body can be several decades. This is because it accumulates in the body, mainly in the kidney and bones (ECHA/RAC, 2021).

The main routes of cadmium excretion are urine and faeces. 0.007% of the body content is excreted daily in urine and 0.03% in faeces. The urinary elimination half-life is up to 40 years. Only a small fraction of cadmium from the blood compartment and a small fraction from the liver via the biliary tract is excreted in the faeces. This would explain the progressive evolution of the pathological manifestations, even after cessation of exposure.

The **effects on human health** vary depending on the type of exposition. Acute toxicity can cause digestive damage or respiratory disorders, while *chronic exposure* is responsible for kidney damage, respiratory, cardiovascular, bone and dental problems (INRS, 2022). Moreover, cadmium may affect the birth weight of babies (ECHA/RAC, 2021).

Acute health effects

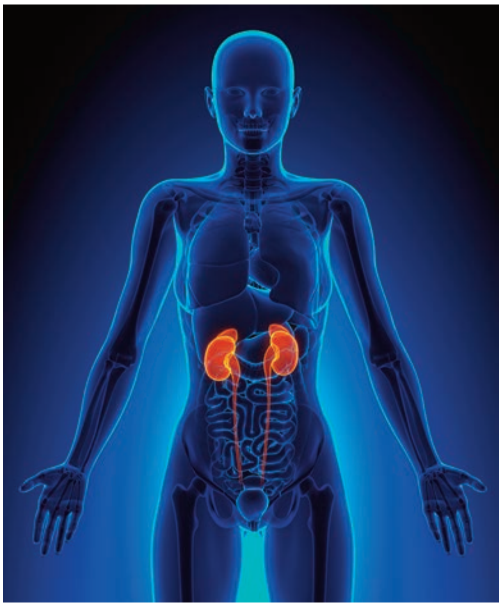
- Acute cadmium poisoning via the **digestive tract** may be followed by severe gastrointestinal disturbances such as nausea, vomiting, abdominal pain and diarrhoea, and may lead, at high doses, to renal failure.

- However, acute poisoning by inhalation, may initially present with an asymptomatic period, followed by signs of respiratory tract irritation (cough, dyspnoea, chest pain), digestive signs (nausea, vomiting), accompanied by chills, fever, headache, etc., and may rapidly develop into severe acute pulmonary oedema, which can lead to the death of the poisoned person.

Chronic health effects

Chronic poisoning, both occupational and in the general environment, is associated with respiratory and cardiovascular disorders, renal dysfunction, calcium metabolism disorders and neurotoxicity.

- In turn, it is common in jobs where there is a risk of exposure due to inhalation of cadmium fumes or respirable cadmium dusts or its compounds, for there to be **respiratory disturbances** caused by pulmonary involvement occur, accompanied by a series of manifestations following patterns compatible with COPD, sometimes leading to total respiratory insufficiency.



- **Bone-related** injuries occur through impairment of tubular calcium and phosphate absorption, which may lead to demineralisation of bones, resulting in joint pain, spontaneous bone fractures (especially in the ribs), and, in some cases of prolonged exposure, to osteomalacia and osteoporosis (ECHA/RAC, 2021).
- Many reviews and meta-analyses have shown associations between cadmium in blood or urine and **atherosclerosis and cardiovascular disease** (ECHA/RAC, 2021).
- There are also studies concluding an association between maternal exposure to cadmium and a **decrease in neonatal birth weight** (ECHA/RAC, 2021).
- However, the **kidney** stands out as the **target organ** following exposure to this agent. Renal injury is characterised by cadmium accumulation in the cortex and proximal tubule cells leading to decreased glomerular filtration rate and eventual renal failure. Renal signs are often the first manifestation of nephrotoxicity in subjects exposed at work to cadmium and, more specifically, the first sign of toxicity is renal tubular lesion followed by glomerular injury, often leading to increased urinary excretion of low molecular weight proteins (proteinuria) (WHO, 1992); (AESAN, 2021).

Besides the aforementioned effects, cadmium is a potent lung carcinogen in rats, and human experience indicates a risk of cancer in humans after prolonged exposure to cadmium.

Although a threshold based on mode of action is likely to exist, it is difficult to define due to limited *in vivo* data, so it is recommended that all cadmium exposure be minimised. Therefore, although limit values have been set, it is recommended that exposure be minimised (ECHA/RAC, 2021).

Therefore, it may have **carcinogenic effects**, with the most frequent cancers developed by the working population due to exposure at work being lung and prostate cancer (in the male population) and, to a lesser extent, kidney and liver cancer (INRS, 2022).

Royal Decree 1299/2006, of 10 November, approving the list of occupational diseases in the Social Security system and establishes criteria for their notification and registration, in appendix I, group 6, lists the occupational diseases associated with exposure to cadmium, specifically malignant neoplasia of the bronchus, lung and prostate.

Where the exposure can take place

Exposure to cadmium or its compounds can occur both in the general environment and at workplaces; thus, exposure can occur in the general population and in the working population.

The general population can be exposed to cadmium through multiple sources, including emissions from industrial and mining activities and contamination of various environmental media, that is, air, water and soil, often involving subsequent contamination of food. Thus, the main sources of cadmium exposure in the general population include diet and tobacco (ASTDR, 2012).

However, the risk of exposure to cadmium is much higher at work than in the general environment and is believed to be one of the main sources of exposure. Exposure at work sometimes leads to prolonged exposure to these agents and thus to adverse health effects for workers, in contrast to exposures among the general population, where no health damage has been recognised, except in certain situations where contamination is present in very high proportions.

In particular, it is estimated that around 10,000 workers in the EU are potentially exposed to cadmium and its compounds.

Exposure at work occurs mainly through inhaling dust and fume from cadmium compounds generated in work processes, although it can sometimes be caused by ingestion of dust due to poor hygienic practices. Thus, workers in many industries face potential exposure to cadmium and/or cadmium compounds and may accumulate higher or lower levels of cadmium depending on the type of work performed and the workplace.

These exposures usually occur due to metal working and refining operations or from ambient air in industrial plants where batteries, coatings or plastics are manufactured (The facts Cadmium. Roadmap on carcinogens).

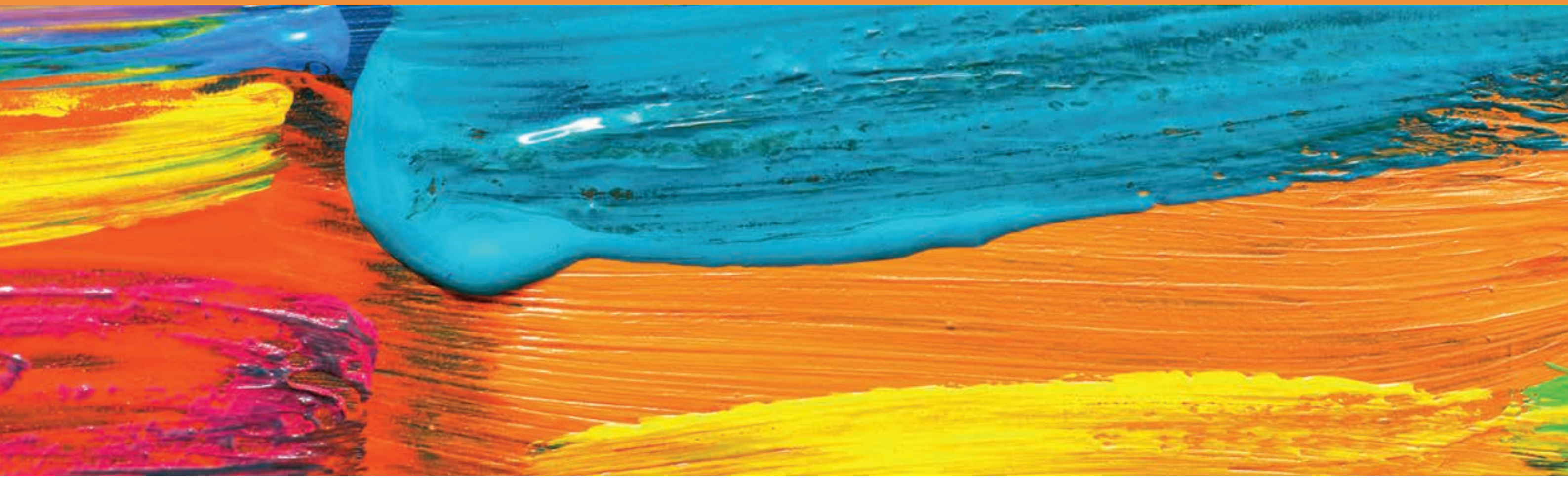
Exposure may be higher in jobs where there is exposure to cadmium dust or fumes, when cadmium-containing compounds or surfaces are heated, or when welding or cutting operations are performed with cadmium-containing materials.

Potential exposure is highest among workers involved in cadmium production and refining, manufacturing of nickel-cadmium (Ni-Cd) batteries, electroplating, pigment manufacturing and welding operations. Exposed workers are mainly found in construction, metal product manufacturing (especially batteries), non-ferrous base metal industries and plastic product manufacturing.

A *non-exhaustive list of industries and activities* in which the main exposures to cadmium and its compounds occur, as well as specific operations or tasks that usually involve such a risk, can be found below (Adapted from IARC Monograph 100-C, 2012); (NTP, 2021).

- **Battery production:** this is the main application of the cadmium produced. Mainly Ni-Cd batteries are manufactured, although silver-cadmium batteries are also used in aeronautical applications.

In general, smokers have on average twice the body burden of non-smokers. In the non-smoking population, food accounts for approximately 90% of cadmium exposure, with the main foodstuffs contributing to cadmium exposure being cereals and vegetables (EFSA, 2009). Moreover, exposure can occur through inhaling cadmium in ambient air and drinking water, although this is usually very low (accounting for less than 10% of total exposure) and tends to occur mainly in industrial areas close to where cadmium is released.



- **Manufacture of cadmium pigments** for paints, enamels, plastics, paper, glass, ceramics, rubber, pyrotechnics, and textile finishing.
- **Application by spraying** of cadmium-containing **paints and varnishes**.
- **Galvanic coatings** for increased corrosion resistance. Cadmium-plated steel parts have been used in numerous technical applications in the aircraft and automotive industry, in the manufacture of springs and nuts and bolts of all types. Cadmium-plated parts have also been used to manufacture electrical and electronic components, such as connectors and switches.
- Production of semi- and superconductors, solar cells, stabilisers, sensors, fluorescent lamps.
- Cadmium preparation by processing zinc, lead and copper.
- **Welding and oxy-fuel cutting** operations of cadmium-alloyed parts.
- Furnace work in iron or steel foundries.
- Production of various types of (low melting) alloys. In particular, cadmium with bismuth, lead and tin forms alloys used in the manufacture of fuses for automatic fire sprinklers or for moulding protective shields for patients undergoing radiological treatment, among many other technical applications. It is also used in the manufacture of a variety of welds. Ag-Cd alloys are used for brazing. The filler rods are alloys of Ag, Cu, Zn and Cd.
- Production, processing and handling of cadmium powder compounds.
- Enamelling and engraving operations, laser cutting, printing.
- Glassware. Glass melting and casting.
- Pesticide manufacture and use.
- Manufacture of nuclear reactor control rods.
- Production of plastics.
- Manufacture of jewellery.
- Manufacture of dental amalgams.
- Processing of cadmium-containing waste. Hazardous waste treatment in public sanitation activities.

The application of cadmium selenide and cadmium telluride nanocrystals to the synthesis of ultra-thin photovoltaic films is currently under development. Nanomaterials used in biology, medicine, engineering and consumer products also contain cadmium (Werlin et al., 2011).

Exposure assessment

Royal Decree 665/1997 sets a limit value of 0.001 mg/m^3 for Cd and its inorganic compounds. However, this limit value may be difficult to achieve in the short term in some sectors of activity. Therefore, a transitional period (until 11 July 2027) is established during which a limit value of 0.002 mg/m^3 for the respirable fraction applies, in conjunction with a biological monitoring system with a biological limit value lower than or equal to 0.002 mg Cd/g urine creatinine (table 2).

The document "Límites de Exposición Profesional para Agentes Químicos en España", drawn up by the INSST, contains the limit values for cadmium and its compounds, according to Royal Decree 395/2022. BLV (Biological limit value) are also set out for two biological indicators related to exposure to this agent, being 2 µg/g creatinine for cadmium in urine and 5 µg/l for cadmium in blood (table 3).

Thus, it should be noted that the BLV represent the most likely levels of biological indicators in healthy workers subjected to an overall exposure to chemical agents, which is equivalent, in terms of absorbed dose, to an exposure exclusively by inhalation of the order of the 8 hour-OEL.

Given the hazardous nature of these types of chemical agents, they must be identified at an early stage in the risk assessment process. This assessment shall also include possible risks of unforeseen exposure to such agents due to accidents, incidents or emergencies. The risk assessment will provide information about the preventative measures to be implemented to reduce exposure to a level as low as technically possible.

Regulatory references

Royal Decree 395/2022, amending *Royal Decree 665/1997 of 12 May 1997 on the protection of workers from the risks related to exposure to carcinogens* at work, which transposes into Spanish law Council Directive 2019/983/EC of 5 June 2019 amending Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work, included in its Appendix III, on values for protecting workers from the risks related to exposure to carcinogens or mutagens at work, cadmium and its inorganic compounds as carcinogens.

Table 2 Occupational exposure limit values. RD 665/ 1997				
Name of agent	EC No[1]	CAS No[2]	8 hour-OEL[3]	Transitional measures
Cadmium and its inorganic compounds	-	-	0,001 $mg/m^{3(4)}$	Limit value 0.002 mg/m^3 until 11 July 2027. Respirable fraction. It is applied in conjunction with a biological monitoring system with a biological limit value less than or equal to 0.002 mg Cd/g urine creatinine.

Table 3 Occupational exposure limit (OEL). Source: Document "Límites de exposición profesional para agentes químicos en España 2022"				
CHEMICAL AGENT (year of inclusion or update)	BIOLOGICAL INDICATOR (BI)	LIMIT VALUES (BLV)	SAMPLING MOMENT	Notes
Cadmium and its inorganic compounds (2017)	Cadmium in Urine	2 µg/g creatinine	Non-critical[5]	F
	Blood Cadmium	5 µg/l	Non-critical[5]	F

1 The EC number is the EU official number of the substance as defined in section 1.1.1.2 of Part 1 of appendix VI to Regulation (EC) No 1272/2008.
2 CAS No Chemical Abstracts Service registration number.
3 Measured or calculated in relation to a time-weighted average with a reference period of eight hours.
4 mg/m^3= milligrams per cubic metre of air at 20°C and 101.3 KPa (760 mm of mercury pressure)
5 Indicators with non-critical sampling times have very long elimination half-lives, accumulating in the body for years and some for a lifetime. Once the steady state has been reached, which depends on each biological indicator (weeks, months), sampling can be done at any time. It is essential to consult the specific documentation on the subject.
F Background. The indicator is generally present in detectable amounts in non-occupationally exposed individuals. These background levels are considered in the BLV.

The quantitative assessment of inhalation exposure to cadmium shall be based on measuring the concentration of the chemical agent in the worker's breathing zone, weighting the result according to the reference period (normally 8 hours) and comparing it with the known reference criterion, in this case the 8 hour-OEL.

Along with the design of the sampling strategy, the first step in cadmium sampling for further analysis in the laboratory is the choice of the most appropriate method for the object of measurement, bearing in mind the specific conditions of the working environment and the materials or other substances that may be present and that may cause interference or error in the measurement result.

INSST has validated two methods for sampling and analysis:

- MTA/MA-025/A16: Determinación de metales y sus compuestos iónicos en aire. Método de captación en filtro/espectrofotometría de absorción atómica con llama.
- MTA/MA-065/A16: Determinación de metales y sus compuestos iónicos en aire. Método de captación de filtro/espectrometría de emisión atómica por plasma acoplado inductivamente con detector óptico (ICP-AES).

Other bodies also have validated methods such as the *"Deutsche Gesetzliche Unfallversicherung"* (DGUV), the "Method for determining cadmium and its inorganic compounds in workplace air using ICP mass spectrometry after acid digestion", whereby sampling can be performed at a fixed or personal point using nitrocellulose membrane filters.

Moreover, the National Institute for Occupational Safety and Health (NIOSH) includes in its NMAM (NIOSH Manual of Analytical Methods) a method for sampling and analysing various chemical elements, including cadmium, in workplace air by ICP mass spectrometry following the nitric/perchloric acid digestion procedure.

In all these cases, the sample is collected by passing a known volume of air through a sampler containing a suitable retention element, with the aid of a sampling pump, to collect the sample in the appropriate filter for later analysis in the laboratory.

Representativeness of the samples

Whenever a quantitative assessment of inhalation exposure to a hazardous chemical agent, a sampling strategy must be adopted to ensure the representativeness of the data obtained. The standard UNE-EN 689:2019+AC:2019 *Workplace exposure - Measurement of exposure by inhalation to chemical agents - Strategy for testing compliance with occupational exposure limit values*, proposes a possible strategy for comparing daily exposure with the occupational exposure limit values.

These sampling and analytical methods have been developed to determine time-weighted average concentrations of metals in air, in personal sampling and at fixed locations. Therefore, they can be used to make comparison measurements with the occupational exposure limit values and periodic measurements. It could also be used for initial assessment measurements of the time-weighted average concentration.

In conjunction with verification of compliance with the environmental limit value, **biological monitoring** of exposure to cadmium and its compounds, either using blood cadmium or urine as a biological indicator, is of great importance, since it offers a number of advantages by including all possible sources of occupational and environmental exposure (gastrointestinal exposure in the workplace, tobacco use and dietary exposure). Furthermore, since cadmium is a cumulative toxic, the cadmium measurement in urine is a good indicator of the body burden integrating all sources of exposure and is a suitable parameter to prevent kidney damage (DLEP, 2018). Measurement of **cadmium in urine** reflects body burden and predicts health risk, while measurement of **cadmium in blood** can provide complementary information to detect recent exposures and assess the impact of preventative measures to control exposure (SCOEL, 2017).

Thus, it should be noted that the German Foundation for Scientific Research (Deutsche Forschungsgemeinschaft - DFG) published *"The MAK collection for Occupational Health and Safety"*, which lists the following methods for biological control of cadmium exposure:

- Antimony, Lead, Cadmium, Platinum, Mercury, Tellurium, Thallium, Bismuth, Tungsten, Tin. Quadrupole ICP-MS. Determination in urine. 1998.
- Cadmium. Determination in blood. 1981.

Thus, for this agent in particular, biological monitoring is applied in conjunction with environmental assessment, which is very useful, since it allows the effectiveness of personal protective equipment (PPE) to be verified, on certain occasions, to assess whether there is a route of exposure other than inhalation, detecting possible absorption via the dermal or digestive tract; or to detect exposure of non-occupational origin. Where the dermal route may be significant for the total body content, the use of biological monitoring is advisable to quantify the overall absorbed amount of the contaminant.

Controlling exposure

For most carcinogens, there are no safe exposures, so in these cases it is necessary to take specific measures to minimise the risk as much as possible. Thus, the company must ensure that the risk posed by a chemical agent that is a hazard to the health and safety of workers at work is **eliminated or minimised**. For this purpose, the use of cadmium and its compounds should preferably be avoided by replacing it by another agent or by a chemical process which, according to its conditions of use, is non-hazardous or less hazardous.

Where the nature of the activity does not permit the elimination of the risk by substitution, the company shall ensure that the risk is minimised by applying preventative and protective measures consistent with the risk assessment and applied in order **of priority** according to their effectiveness.

Thus, where substitution is not possible, the possibility of working in a closed system should be explored; where this is also not possible, it should be ensured that the level of exposure of workers is reduced to as low a level as is technically possible, and finally, where the above measures are not sufficient, personal protective equipment (PPE) must be used.

1. Substitution of the chemical agent

According to art. 4 of Royal Decree 665/1997, as well as point 1.f) of art. 15 of the Act 31 of 8th november 1995 on prevention of occupational risks, whenever technically feasible, the obligatory and priority measure to **eliminate the risk** of exposure to carcinogenic or mutagenic agents must be the substitution of these agents by a substance, mixture or process which, under normal usage conditions, is not dangerous or is less dangerous to the health or safety of workers. In any case, the new risks that may be introduced by substitution must always be assessed.

This measure is the most difficult to implement, especially when a production process is already in place, and many variables must be taken into account, but it must be planned and implemented whenever feasible, even if it is more costly, and it is necessary to keep up to date with technological advances in each sector.

Prioritisation of preventive measures for carcinogens:

1. Substitution
2. Closed system
3. Reduction of exposure to as low a level as is technically possible.
4. Personal protective equipment

An example of substitution is that of cadmium as a component of silver alloys, which is used for brazing. Due to its toxicity, in December 2011, EU legislation restricted it in several applications, including the electronics industry.

Its use in silver brazing alloys made it possible to reduce the melting temperature of the alloy and to improve some of its technical characteristics. Moreover, by substituting part of the silver, the costs of these alloys were reduced.

As alternatives, other alloys can be used for various applications and sectors, some of them also based on silver, but others cannot. Copper/silver/phosphorus, copper/silver/zinc or copper/phosphorus alloys can be used as alternatives to precious metal, iron, stainless steel and copper assemblies. Tin-containing alloys are also available for these purposes. However, it is recommended to check the suitability of the alternative alloy type for the specific intended application.

Another example of substitution can be seen in the use of nickel-cadmium (NiCd) batteries in medical equipment, such as portable defibrillators. Although European Union legislation still allows such equipment to use lithium batteries, manufacturers of new medical equipment have turned to lithium-based alternatives, and portable monitors and defibrillators used in emergencies are now available in versions equipped with lithium-ion batteries. These batteries can store the energy needed for their applications, charge quickly and are easy to transport due to their lighter weight compared to other batteries (SUBSPORT, 2012).

In cases where, after initial consideration of substitution, it is deemed not to be technically feasible according to the state of knowledge and the degree of applicability of the best available techniques in the particular sector and operation, other measures may be taken to minimise exposure to cadmium and/or its compounds; these are described below.

The INSST is responsible for drawing up non-binding Technical Guides to facilitate the application of the Royal Decrees implementing the Law on the Prevention of Workplace Risks. In particular, it can be consulted on its website at www.insst.es in the section "Documentación > Material normativo > Guías técnicas > Específicas", the Technical Guide for assessing and preventing risks related to exposure to carcinogenic or mutagenic agents at work.

Appendix 3 of this Technical Guideline offers guidance on how to deal with the process of carcinogen or mutagen substitution.

2. Closed system

Where it is not technically feasible to replace the carcinogen or mutagen, the inhalation of dust, fumes or mists must be avoided, and any operation must be performed in a closed system.

Thus, the aim is to prevent the dispersion of the agent into the air breathed by the worker by putting the process within a closed system with air renewal and adequate air treatment prior to discharge to ensure that the agents do not harm the environment or public health.

The handling of carcinogens or mutagens in closed and sealed systems, preferably under negative pressure, is the first technological option to prevent and reduce exposure. These systems not only eliminate exposure, but also prevent exposure to process intermediates. However, the risk to the safety of workers in the event of failure or breakdown of system components, which could lead to leakage, is not eliminated. To minimise failures, the equipment or components constituting the enclosure system shall be of proven quality and reliability and, given that it is equipment to be used with products posing a known hazard, shall require a preventative and, where possible, predictive maintenance programme to ensure the durability of the initial performance of the equipment in terms of reliability and safety. In doing so, the manufacturer's instructions contained in the instruction manual and, in the absence of or in addition to the instruction manual, good professional practice, must be followed.

Particular attention must be paid to leakage at critical points (valves, sampling points, etc.) and to the proper functioning of the facilities that ensure the depression in the system.

3. Reduction of exposure to as low a level as is technically possible

Where the application of a closed system is not technically possible, exposure shall be reduced to as low a level as is technically possible, with the aim of minimising the likelihood of adverse effects on the health of workers.

This obligation implies that it is not sufficient to achieve exposure levels below the established occupational exposure limit, but rather that it is necessary to go beyond it by applying all available technical and organizational measures.

Royal Decree 665/1997 establishes the obligation to adopt all necessary measures as set out in article 5.5. In general, these requirements are along the same lines as what should already be applied to conform to **Royal Decree 374/2001, on the protection of the health and safety of workers against risks related to chemical agents at work**, adding the express mention of installing devices that detect and alert in the event of situations that could generate abnormally high exposures.

Measures to reduce exposure to as low a level as technically feasible include limiting the quantities of the carcinogen or mutagen in the workplace, as well as designating work processes and technical measures to prevent or minimise the formation of carcinogens or mutagens.

Moreover, these measures include limiting the number of workers exposed or likely to be exposed as far as possible, evacuating carcinogens or mutagens at source by local exhaust ventilation or, where this is not technically

For health and safety signs in workplaces, the requirements of Royal Decree 485/1997 of 14 April 1997 on minimum requirements for health and safety signs at work must be complied with.

More information can be found in the Technical Guide on health and safety signage at work, prepared by the INSST to clarify the technical aspects set out in the Royal Decree.

possible, by general ventilation, in conditions which do not pose a risk to public health and the environment, demarcating risk areas with appropriate health and safety signage, using the most appropriate measuring methods, in particular for the immediate detection of abnormal exposures due to unforeseen events or accidents, and by applying the most appropriate procedures and working methods, among others.

One of the measures used in production areas where there may be a risk from cadmium exposure is the construction of a spatial separation between contaminated and clean areas, in the form of two locker rooms connected through a laundry room or in the form of a sluice system connected to the work area and used to put on and taking off work and protective clothing.

4. Personal protective equipment (PPE)

Personal protective equipment should not be used as the only preventative measure, but should be the **last preventive option**, and all possible previous technical measures should be applied first.

The results of the risk assessment will be the basis for determining the need for personal protective equipment (PPE) and for selecting the most appropriate equipment. Moreover, when selecting equipment, the anatomy of the workers who will be using it should be taken into account and, in the case of respiratory protective equipment, it is highly recommended that a fit test be performed on each individual.

PPE that may be necessary to protect against the hygiene risks related to exposure to cadmium and/or its compounds include:

- **Respiratory protection:** masks or half-masks fitted with type P3 filters.
- **Skin protection:** work clothes, chemical protective gloves, for example, nitrile rubber and polychloroprene.
- **Eye protection:** safety glasses.

Regulatory references

To select, use and maintain personal protective equipment, the requirements set out in *Royal Decree 773/1997 on minimum health and safety provisions concerning the use by workers of personal protective equipment* must be complied with.

More information can be found in the Technical Guide for the use of personal protective equipment by workers, which was drawn up by the INSST to clarify the technical aspects set out in the Royal Decree.

Finally, it should be noted that the cleaning and maintenance procedures for these PPE are as important as their correct selection and use. Thus, Manufacturers' recommendations must be strictly followed, and workers must be trained to know and apply them correctly. A suitable storage place for PPE must be provided.

Health surveillance

According to article 8 of Royal Decree 665/1997, **adequate and specific surveillance** of the health of workers must be guaranteed in relation to the risks of exposure to carcinogenic or mutagenic agents, and must be performed by competent health personnel, as determined by the health authorities in the guidelines and protocols that are drawn up, according to article 37.3 of Royal Decree 39/1997 of 17th January, by virtue of which the Regulations for Prevention services are approved.

In general, exposure to carcinogens or mutagens is characterised by long-term effects or diseases with long latency periods such as cancer. Thus, Royal Decree 665/1997 establishes a right for workers who have been exposed to these agents to the extension of health surveillance beyond the end of the exposure or of the employment relationship.

For the health surveillance programme to be specific to the risks arising from chemical agents present in the workplace, the company must provide the basic health unit (BHS) responsible for performing it with information about these risks, through the risk assessment, safety data sheets, etc.

Currently, there is no specific health surveillance protocol for workers exposed to cadmium and its compounds. However, in 2019, the **Public Health Commission of the Inter- territorial Council of the National Health System** approved the *"Basic and general guide for the orientation of health surveillance activities for the prevention of occupational risks"*, as a support tool for those responsible for designing, implementing, applying and managing surveillance of workers' health.

Regulatory references on health surveillance

Health surveillance activities shall be performed according to the conditions and characteristics set out in:

- Article 8 of Royal Decree 665/1997.
- Article 22 of the Act 31/1995.
- Royal Decree 843/2011, of 17 June, setting out the basic criteria for organising resource to conduct the prevention services' health activities.

This health surveillance must be performed (Royal Decree 665/1997, art. 8):

- Before the beginning of the exposure.
- At regular intervals, as often as medical expertise dictates.
- When it is necessary because a disorder has been detected in one of the company s workers with similar exposure, which may be due to exposure to carcinogenic or mutagenic agents.

Therefore, in the absence of specific guidelines and protocols for action, the prevention service responsible for health surveillance, based on the risk assessment and the health effects of cadmium and/or its compounds, shall draw up a protocol and set out in writing the method and criteria used for the health surveillance.

In any case, workers must be consulted during the clinical examination to establish whether they suffer from any discomfort that may be related to exposure to these agents and for possible signs or symptoms indicative of possible exposure to high cadmium concentrations at work. Workers exposed to this substance must be informed of the potential hazards to fertility and pregnancy.

Moreover, as a complementary part of this health surveillance, **biological monitoring** should also be carried out to detect organic abnormalities at an early stage or potentially dangerous levels of exposure. In most cases, they are an integral part of the medical examination. Such investigation shall require the informed consent of the worker. In these cases, it is recommended that the biological limit values (VLBs®) be used that are listed in the INSST document "Límites de Exposición Profesional para Agentes Químicos en España".

Other preventive measures

In work involving the risk of exposure to cadmium and/or its compounds, another series of preventative measures established in Royal Decree 665/1997 must be complied with, such as:

- **Personal hygiene measures** (art. 6), such as: prohibiting eating, smoking and drinking in work areas where such a risk exists; providing workers with appropriate protective clothing or other suitable special clothing; providing places for separate storage of work or protective clothing and street clothing; providing appropriate and adequate toilets and washrooms for workers' use; providing a designated place for the proper storage of protective equipment, ensuring that it is cleaned and checked for proper functioning.

Regulatory references

Royal Decree 1154/2020, amending *Royal Decree 665/1997, on the protection of workers from the risks related to exposure to carcinogens at work*, specifies in article 6 that workers identified in the risk assessment as exposed shall have, during working hours, the time they need for personal hygiene, with a maximum of 10 minutes before lunch and another 10 minutes before leaving work. This time may under no circums tances accumulate or be used for other purposes.

The employer is responsible for laundering decontaminating work clothes, and workers are strictly forbidden to take them home for this purpose.

- **Measures to be taken in the event of accidental and non-regular exposures** (art. 7).
- **Obligations with regard to documentation** (article 9).
- **Information for the competent authority** (article 10).
- **Consultation, information and training** (arts. 11 and 12).

References

- AESAN (2021). Informe del Comité Científico de la Agencia Española de Seguridad Alimentaria y Nutrición en relación a la evaluación del riesgo de la exposición de la población española a cadmio a través de la dieta.
- ATSDR (2015) ToxFAQsTM: Cadmium (Cadmium)| ToxFAQ | ATSDR
- ECHA. European Chemicals Agency. https://echa.europa.eu/es/substance-information/-/substance-info/100.028.320
- ECHA. Committee for Risk Assessment RAC. Opinion on scientific evaluation of occupational exposure limits for Cadmium and its inorganic compounds. ECHA/RAC/A77-O-0000006982-64-01/F. 18 March 2021.
- EFSA, 2009. Cadmium in food. Scientific Opinion of the Panel on Con-
- IARC. 2012. Arsenic, Metals, Fibres, and Dusts. In IARC Monographs on the Identification of Carcinogenic Hazards to Humans volume 100C.
- IARC. 1993. Beryllium, cadmium, mercury, and exposures in the glass manufacturing Industry. In IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 58.
- INRS. 2022. Cadmium (FT 60). Généralités. Fiches Toxicologiques - INRS. @ INRSfrance.
- INSST, 2022, Límites de exposición profesional para agentes químicos en España 2022.

- INSST. DLEP, 2018. Documentación Toxicológica para el establecimiento del límite de exposición profesional del cadmio y sus compuestos. Cadmio y compuestos inorgánicos.
- INSST. Infocarquim. Cadmio (pirofórico).
- ISTAS, 2006. Sistema de información sobre exposición ocupacional a cancerígenos en España en el año 2004.
- WHO (1992). World Health Organization. Renal effects and Low Molecular Weight Proteinuria. Environmental Health Criteria 134: Cadmium. World Health Organization. Geneva, pp: 136-146.
- SCOEL/OPIN/336, 2017. Cadmium and its inorganic compounds.
- SUBSPORT, 2012, Specific Substances Alternatives Assessment. https://www.subsportplus.eu/
- NTP NIEHS. NIH. GOV, 2021. Cadmium and Cadmium compounds http://ntp.niehs.nih.gov/go/roc
- Werlin, R., Priester, J., Mielke, R. et al. (2011) Biomagnification of cadmium selenide quantum dots in a simple experimental microbial food chain. Nature Nanotech, 6, pp: 65-71.

Author:
Instituto Nacional de Seguridad y Salud en el Trabajo (INSST), O.A., M.P.

datos abiertos

Catalogue of publications of the General State Administration:
http://cpage.mpr.gob.es

INSST publications catalogue:
http://www.insst.es/catalogo-de-publicaciones

-C.10.2.23

NIPO (en línea): 118-23-040-5