DGUV
Deutsche Gesetzliche Unfallversicherung
Spitzenverband

Description of exposure

Exposure to mercury during the manufacture of lamps

This description of exposure was produced by the German Social Accident Insurance Institution for the energy textile electrical and media products sectors (BG ETEM).

General

Section 6 (1) 3 of the German Ordinance on hazardous substances (GefStoffV) [1] requires companies to determine the nature and scale of exposure of their employees. This can be achieved by workplace measurements or other, equivalent assessment methods.

Descriptions of exposure constitute a suitable method of assessing the exposure to mercury arising during the manufacture of lamps containing mercury. The descriptions are based upon measurements of airborne hazardous substances at workplaces.

This description of exposure can be used in accordance with Sections 6 and 7 of the GefStoffV, Section 3 of the Ordinance on industrial safety and health (BetrSichV) [2] and Section 5 of the Occupational safety and health act (ArbSchG) [3] during the performance of risk assessments and the specification of measures based upon them. It provides support during assessment of the inhalative exposure to mercury. Other hazards, such as those arising from skin contact or physical and chemical effects, must be considered separately. The use of substances and/or methods presenting a lower risk (TRGS 600 technical rules governing substitution) [4], observance of the ranking of protective measures, and the provision of instruction to employees etc. continue to be mandatory.

1 Scope

Electrical and electronic equipment placed on the market for the first time is subject to substance prohibitions, for example for mercury, under EU Directive No 2011/65/EU on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS Directive) [5]. Exemptions include the use of mercury in lamps. For example, the maximum permissible mercury content of a compact fluorescent lamp (CFL) with a rating of up to 30 W is 2.5 mg. CFLs with a mercury content substantially below these limits (e.g. 1.5 mg) are already available on the market. The maximum permissible mercury content of standard straight fluorescent tubes is between 3.5 and 7 mg, depending upon the type. High-pressure mercury vapour lamps contain up to 30 mg of mercury and have not been placed on the market since April 2015 (RoHS Directive 2011/65/EU, Annex III) [5].

Depending upon the lamp type, the mercury is dosed into the lamp during manufacture in the form either of metallic mercury (in liquid form or as a pellet formed by combining the mercury with a solid carrier material such as iron powder), or of amalgam pellet/rods. Mercury exposure must be anticipated in a number of working areas during the manufacture of lamps containing the substance.

This description of exposure applies to the manufacture of lamps containing mercury and describes exposure to mercury and its inorganic compounds. It does not apply to the manufacture of mercury pellets and amalgam pellets/rods.

The recycling of lamps containing mercury is described in a separate description of exposure. Recommendations for risk assessment (EGUs) by the German Social Accident Insurance Institutions have been issued for the collection of lamps containing mercury and for the dismantling of flat-screen TVs/monitors backlit by lamps containing mercury.

2 Definitions

The terms below used in this description of exposure are defined as follows:

Mercury vapour lamps are gas-discharge lamps that use the excitation of mercury atoms to generate light. They include compact fluorescent lamps (CFLs; also referred to as energy-saving lamps), fluorescent tubes, special types of fluorescent tube, high-pressure mercury vapour lamps, and cold cathode fluorescent lamps (CCFLs) used for the backlighting of flat-screen TVs/monitors.

Amalgam is an alloy of mercury and various other metals. It is incorporated into the lamps in the form of pellets, rods or tiny spheres. When the lamp is switched on, mercury vapour is released from the amalgam inside it. Should the lamp be broken whilst it is on or otherwise in the warm state, mercury vapour may be released. When the lamp is cold, the mercury is bound.

Mercury pellets are used in order to introduce mercury in solid form into the lamp. This is achieved by pressing liquid mercury together with iron powder in a defined mixture ratio to form a solid body. The process takes place during **pellet production**. The mercury pellets are fitted into the lamps in a subsequent production step in the production plant. Should the lamp be broken, mercury vapour may be released.

A **module** is a self-contained item comprising two or more individual parts. Modules are items that cannot be dismantled further.

3 Work processes/tasks

The production processes differ considerably according to the type of lamp being manufactured. The production process generally comprises the following sub-steps. Following preassembly of the required modules, e.g. the cap and electronic components, the individual modules are assembled to form the finished lamp. Depending upon the lamp type, the mercury is added during this process in liquid form, as a mercury pellet, or in the form of amalgam pellets/rods. During assembly, the lamp is activated according to its design, and a function test is performed. It is then assembled further. Depending upon the production process, lamps that are broken or non-functioning may be shredded and recycled. Exposure to mercury must be anticipated during dosing and installation of the modules containing mercury, and also whenever lamps break.

4 Exposure to hazardous substances

Under EU Regulation 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP Regulation) [6], mercury is classified as a hazardous substance (see Table 1).

Table 1: Classification and marking of mercury under the CLP Regulation

Hazard class	Hazard category	Pictogram	H phrase
Acute toxicity, inhalation	cat. 2		H330, Fatal if inhaled
Reproductive toxicity	cat. 1B		H360D, May cause harm to the unborn child
Specific target organ toxicity (repeated exposure)	cat. 1		H372, Causes damage to organs through prolonged or repeated exposure
Acute and chronic aquatic toxicity	cat. 1		H400, Very toxic to aquatic life H410, Very toxic to aquatic life with long lasting effects

Mercury must also be marked with the signal word "Danger"

The TRGS 900 technical rules for hazardous substances (occupational exposure limits, OELs) [7] state an OEL of 0.02 mg/m³ for mercury and its inorganic compounds. A level of eight times this value (0.16 mg/m³) must not be exceeded over a brief period (15-minute mean, peak limit Category II).

The TRGS 903 technical rules for hazardous substances (biological limits) [8] specify a biological limit of 25 µg of mercury per gramme of creatinine.

The primary uptake route for mercury in the vapour phase is the respiratory tract. The uptake of liquid or gaseous elemental mercury through intact skin is generally negligible. Where elemental mercury enters the digestive tract, it is for the most part not absorbed.

4.1 Results of workplace measurements

The interpretations are based upon mercury exposure measurements obtained during the manufacture of lamps. A total of 17 measurements were performed in six companies for this purpose from 2012 to 2014. Owing to the low number of relevant companies in Germany and the corresponding low number of measured values, this description of exposure does not however permit differentiation and statistical interpretation by working area. Instead, a distinction was drawn according to the form in which mercury was incorporated into the lamp:

- Incorporation of amalgam pellets or rods
- Incorporation of mercury pellets
- Dosing of liquid mercury.

The measurements were performed with reference to the TRGS 402 technical rules (identification and assessment of hazards associated with tasks involving hazardous substances: inhalative exposure) [9]. They entailed personal measurements performed by means of the methods described in the IFA folder [10]. For the hazardous substance of mercury, Tables 2 to 4 show the number of measurements obtained, the number of companies, the occupational exposure limit (OEL), the minimum and maximum measured values and the median. The measured values relate to a working shift. Only measurements obtained by equipment worn on the person were considered

Table 2 shows the results of measurements obtained during the manufacture of lamps employing amalgam pellets and rods. In the production installations studied, the workers performed checking and control tasks and placed broken lamp debris in waste bins provided for the purpose. Amalgam rods are also inserted manually into the glass body during the production of special lamps..

Table 2: Measurement results for mercury during the manufacture of lamps containing amalgam

Hazardous substance	Number of measured values	Number of com-panies	OEL (mg/m³)	Number of measured values < LOD[1)]	Minimum measured value (mg/m³)	Median (mg/m³)	Maximaler Messwert (mg/m³)
Mercury	5	3	0.02	1	0.001	0.001	0.005

1) Limit of determination (0.0002 mg/m³)

Table 3 shows the results of measurements obtained during the manufacture of lamps containing mercury pellets. The workers performed checks and adjustment work and rectified faults on the production plant, and regularly refilled the dosing unit with mercury pellets. Broken lamp debris was also collected in disposal containers.

Table 3: Measurement results for mercury during the manufacture of lamps containing mercury pellets

Hazardous substance	Number of measured values	Number of com-panies	OEL (mg/m³)	Number of measured values < LOD[1)]	Minimum measured value (mg/m³)	Median (mg/m³)	Maximum measured (mg/m³)
Mercury	5	1	0.02	1	0.0004	0.0005	0.0006

1) Limit of determination (0.0002 mg/m³)

Table 4 shows the results of measurement during the manufacture of lamps containing liquid mercury. Such lamps are generally special lamps, for example for the disinfection of water by means of ultraviolet (UV) light. Besides the filling of dosing units and lamp bodies with liquid mercury and

subsequent tasks such as the welding of contacts, the workers also performed checks and adjustment tasks. Faults arising on the production plant were rectified, and broken lamp debris was placed in waste bins.

In one case, the production conditions led to increased broken lamp debris arising in a work area and not being removed until later, resulting in an elevated measured mercury concentration of 0.017 mg/m³. This measured value was not considered in the statistical analysis (Table 4).

Table 4: Measurement results for mercury during the manufacture of lamps containing liquid mercury

Hazardous substance f	Number of measured values	Number of com-panies	OEL (mg/m³)	Number of measured values < LOD[1)]	Minimum measured value (mg/m³)	Median (mg/m³)	Maximum measured value (mg/m³)
Mercury	7	4	0.02	2	0.002	0.003	0.010

1) Bestimmungsgrenze (0,0002 mg/m³)

The OEL was observed during all tasks studied. Owing to differences in the process however, differences were observed in the level of mercury exposure. Exposure was highest where liquid mercury was used. High breakage rates in the production process also increase the mercury exposure.

5 Protective measures

5.1 General requirements

General protective measures in accordance with the GefStoffV must be taken at workplaces in lamp manufacturing, and the general principles concerning work hygiene set out in the TRGS 500 technical rules (protective measures) [11] must be observed.

Technical protective measures take priority over organizational and personal protective measures. Ideally, technical measures should prevent any release of hazardous substances into the working areas of workers and should reduce contact with the hazardous substances to a minimum.

5.2 Ventilation measures

Where the work processes are such that hazardous substances cannot reliably be prevented from entering the working areas of workers, they must be collected (e.g. by vacuuming) at the point at which they arise or are emitted, and routed away in a way that presents no danger to human beings or the environment.

5.3 Room ventilation measures

An engineered room ventilation and air exhaust system is always required when vacuuming equipment is fitted to plants or when the hazardous substances cannot be collected adequately at

the point of creation or emission. Ventilation equipment has the function of balancing airflows in the room and of supplying sufficient fresh air to the working area. The vacuuming equipment on plants and the room ventilation measures must be coordinated.

Ventilation systems must be planned and designed for the airflows required for collection of the hazardous substances (collection airflow) and for room ventilation (external and recirculating airflows). They must be dimensioned for the anticipated substance and thermal loads.

Information on ventilation equipment can be found in DGUV Rule 109-002 (workplace ventilation – engineered ventilation measures) [12].

5.4 Special technical measures

Lamp breakage must be reduced to a minimum and ideally avoided altogether. Should lamp breakage nevertheless occur, broken lamp debris must be stored temporarily in sealable containers. The contents of these containers must be removed each day from the working areas and disposed of properly.

Liquid mercury must be handled in a fume hood (for example during portioning for the dosing plant). All vessels containing liquid mercury must be sealed following use or when not required.

5.5 Measures to be taken in the event of unintentional release

Should liquid mercury be released despite the above measures, mercury droplets can be collected by means of a zinc sheet treated with hydrochloric acid, and shaken off into a collecting vessel (beneath which a safety vessel should be placed). The zinc sheet must be kept available for reuse at a continually vacuumed point, or disposed of together with the mercury residues. Smaller quantities can be collected by means of standard mercury tongs or bound by means of special adsorption materials, and disposed of [13].

The working area must then be ventilated, and soiled objects and the floor cleaned. Appropriate personal protective equipment must be worn during these tasks.

5.6 Organizational measures

As part of his organizational measures, the employer must ensure that the following measures in particular are implemented:

- Selection/creation and operation of suitable workplaces, including sanitation and break areas
- Selection, provision and cleaning of work clothing
- Cleaning of work areas and the work environment
- Measures for personal hygiene
- Provision of instruction to workers concerning hazards and protective measures with reference to the safety and health procedures (TRGS 555 concerning safety and health procedures and the provision of information to workers) [14]; instruction must be provided to workers before commencement of employment and thereafter at least once a year
- Restriction of employment for young people in accordance with the German Child labour act (JArbSchG) and the Ordinance on the protection of pregnant and nursing women at the workplace (MuSchRiV).

- Individual working areas may be entered only by the workers working in them. Warning signs to this effect (access restrictions) must be affixed).
- An escape and rescue plan must be produced where necessitated by the location, size and form of use of the workplace.

5.7 Personal protective equipment

Suitable personal protective equipment must be provided by the employer when, despite technical and organizational protective measures, the occupational exposure limit or biological limit for mercury are not observed. This may be the case for example during maintenance or troubleshooting.

6 Information on application

Following changes to the process and otherwise at regular intervals of not more than one year, the user of this description of exposure must review the validity of the assumptions upon which it is based, and document the results of the review. This includes ascertaining that this description of exposure is still valid. The review must be performed in the context of the risk assessment in accordance with Section 6 of the GefStoffV.

The description of exposure provides the company with practical information on protective measures and the levels of exposure to mercury for the working areas under examination.

Provided the process parameters and protective measures are observed, it can be assumed that the requirement of Section 7 (4) of the GefStoffV for exposure to be minimized is satisfied.

During the complete risk assessment, performance of a hazardous substance measurement is recommended for documenting of the exposure to mercury at permanent workplaces for the purposes of future diagnosis.

Other requirements of the GefStoffV, particularly Sections 6 (covering the gathering of information) and 7 (covering the obligation to observe the ranking of protective measures) continue to apply during application of this description of exposure.

7 Review

This description of exposure was produced in July 2016 by the BG ETEM. It is reviewed at regular intervals. Changes where necessary will be published.

8 Bibliography

[1] Verordnung zum Schutz vor Gefahrstoffen (Gefahrstoffverordnung – GefStoffV), 26 November 2010 (BGBl. I p. 1643), last amended by Article 148 of the ordinance, 29 March 2017 (BGBl. I p. 626).

[2] Verordnung über Sicherheit und Gesundheitsschutz bei der Verwendung von Arbeitsmitteln (Betriebssicherheitsverordnung – BetrSichV), 3 February 2015 (BGBl. I p. 49), last amended by Article 147 of the ordinance, 29 March 2017 (BGBl. I p. 626).

[3] Gesetz über die Durchführung von Maßnahmen des Arbeitsschutzes zur Verbesserung der Sicherheit und des Gesundheitsschutzes der Beschäftigten bei der Arbeit (Arbeitsschutzgesetz – ArbSchG), 7 August 1996 (BGBl. I, pp. 1246 ff.), last amended by Article 427 of the ordinance, 31 August 2015 (BGBl. I p. 1474).

[4] Technische Regel für Gefahrstoffe 600 "Substitution (TRGS 600)". Date of issue: August 2008. GMBl. Nos 46/47, 22 September 2008, pp. 970-989.

[5] Directive 2011/65/EU (Restriction of the Use of Hazardous Substances, RoHS), transposed in Germany by the Verordnung zur Beschränkung der Verwendung gefährlicher Stoffe in Elektro- und Elektronikgeräten (Elektro- und Elektronikgeräte-Stoff-Verordnung – ElektroStoffV), 19 April 2013 (BGBl. I p. 1111), last amended by Article 1 of the ordinance, 4 July 2016 (BGBl. I No 33 p. 1581).

[6] CLP Regulation: Regulation (EC) No 1272/2008 of the European Parliament and of the Council on classification, labelling and packaging of substances and mixtures of 16 December 2008, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006.

[7] Technische Regel für Gefahrstoffe 900 "Arbeitsplatzgrenzwerte (TRGS 900)". Date of issue: January 2006, last amended and extended: GMBl. 2017 pp. 368-370 [No 20], 8 June 2017.

[8] Technische Regel für Gefahrstoffe 903 "Biologische Grenzwerte (BGW) (TRGS 903)". Date of issue: Feburary 2013, last amended and extended: GMBl 2017 pp. 370-371 [No 20], 8 June 2017.

[9] Technische Regel für Gefahrstoffe 402 "Ermitteln und Beurteilen der Gefährdungen bei Tätigkeiten mit Gefahrstoffen: Inhalative Exposition (TRGS 402)". Date of issue: January 2010, last amended and extended: GMBl 2016 pp. 843-846, 21 October 2016 [No 43].

[10] IFA-Arbeitsmappe Messung von Gefahrstoffen. Published by: Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA), Sankt Augustin. Erich Schmidt, Berlin 2011 – loose-leaf

[11] Technische Regel für Gefahrstoffe 500 "Schutzmaßnahmen (TRGS 500)". Date of issue: January 2008, extended: May 2008.

[12] DGUV Regel 109-002 "Arbeitsplatzlüftung – Lufttechnische Maßnahmen" (April 2004). Published by: Hauptverband der gewerblichen Berufsgenossenschaften (HVBG), Fachausschuss Einwirkungen und arbeitsbedingte Gesundheitsgefahren, 2004.

[13] GESTIS Substance Database: http://www.dguv.de/ifa/gestis-database

[14] Technische Regel für Gefahrstoffe 555 "Betriebsanweisung und Information der Beschäftigten (TRGS 555)", date of issue: February 2017, GMBl 2017 pp. 275-281, 20 April 2017