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Occupational exposure to the inhalable and respirable dust fractions

Authors: See list of authors on Page 302

Published by: Deutsche Gesetzliche Unfallversicherung e. V. (DGUV)
Glinkastr. 40
10117 Berlin
Phone: +49 30 13001-0
Fax: +49 30 13001-9876
Internet: www.dguv.de
E-mail: info@dguv.de

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Abstract

Occupational exposure to inhalable and respirable dust fractions

Dusts are present at virtually all workplaces. Excessive inhalative exposure to dusts may lead to serious diseases of the respiratory tract. It is therefore imperative that workplaces associated with elevated dust exposure be identified, and suitable measures taken to protect workers.

This IFA Report provides a summary overview of occupational exposure to dust within the scope of the German general dust exposure limit (ASGW). The general dust exposure limit applies for assessment of the total exposure to low-solubility and insoluble dusts (including biopersistent granular dusts for which no substance-specific toxicity is known) for the respirable and inhalable fractions. Harmful effects upon health caused by the specific substances of which the dusts are comprised or contained within them as admixtures must be evaluated separately, and lie outside the scope of this report. The same applies to fibrous and ultrafine dusts. This report serves as a reference work for the incidence and occurrence, properties and associated health hazards of the dusts concerned. In addition, it contains information on setting the general dust exposure limit and on regulations to be observed where respirable or inhalable dust occur at workplaces.

Exposure data relating to workplace measurements from the Measurement system for exposure assessment of the German Social Accident Insurance Institutions (MGU) form a key part of the report's content. Over 35,000 items of exposure data each for respirable and inhalable dust, obtained during the period from 2005 to 2016 and documented in the IFA's MEGA database of measured data relating to exposure to hazardous substances at the workplace, were evaluated statistically and described. The results of the measurements are broken down in this report by sector and working area. The statistical collectives are further differentiated by measurement strategy, namely distinction between measurements performed on the person and those performed by stationary sampling systems erected in the working areas. In some areas, further differentiation of the statistical collectives was possible according to whether measurements performed on the person were accompanied by collection (exhaust) of the dust in the working area.

The exposure data are supplemented by descriptions of the working method, exposed activities or protective measures. This information is used to produce a register of working areas for preventive activity and retrospective analyses.

Kurzfassung

Arbeitsbedingte Exposition gegenüber der einatembaren und der alveolengängigen Staubfraktion

Stäube sind an fast allen Arbeitsplätzen gegenwärtig. Übermäßige inhalative Belastungen durch Stäube können zu schwerwiegenden Atemwegserkrankungen führen. Daher ist es geboten, Arbeitsplätze mit erhöhten Staubexpositionen zu identifizieren und geeignete Maßnahmen zum Schutz der Beschäftigten zu ergreifen.

Mit diesem IFA Report wird eine zusammenfassende Übersicht zu arbeitsbedingten Expositionen von Stäuben im Geltungsbereich des Allgemeinen Staubgrenzwerts (ASGW) vorgelegt. Der ASGW gilt zur Beurteilung der Gesamtexposition gegenüber schwerlöslichen und unlöslichen Stäuben (auch: granuläre biobeständige Stäube ohne bekannte stoffspezifische Toxizität – GBS) für die alveolengängige Fraktion (A-Staub) und die einatembare Fraktion (E-Staub). Stoffspezifische gesundheitsschädigende Wirkungen, die von Stoffen ausgehen, aus denen die Stäube bestehen oder in ihnen als Beimengungen enthalten sind, müssen gesondert bewertet werden und sind nicht Gegenstand dieses Berichts, ebenso wenig wie Faserstäube und ultrafeine Stäube. Der Report dient diesbezüglich als Nachschlagewerk zum Vorkommen und Auftreten sowie zu Eigenschaften und Gesundheitsgefahren. Er beinhaltet darüber hinaus auch Informationen zur Ableitung des ASGW und zu Vorschriften, die beim Auftreten von A- oder E-Staub an Arbeitsplätzen zu beachten sind.

Als Schwerpunkt enthält er Expositionsdaten zu Arbeitsplatzmessungen aus dem „Messsystem Gefährdungsermittlung der Unfallversicherungsträger“ (MGU). Jeweils über 35 000 Expositionsdaten zu A- und E-Staub aus dem Datenzeitraum 2005 bis 2016, die in der IFA Expositionsdatenbank „Messdaten zur Exposition gegenüber Gefahrstoffen am Arbeitsplatz“ (MEGA) dokumentiert sind, wurden statistisch ausgewertet und beschrieben. Die Messergebnisse werden in diesem Report nach Branchen und Arbeitsbereichen aufgeschlüsselt. Weitere Differenzierungen der statistischen Kollektive betreffen die Messstrategie – die Unterscheidung zwischen Messungen „an der Person“ und Messungen mit „stationär“ aufgestellten Probenahmesystemen in den Arbeitsbereichen. In einigen Bereichen konnten die statistischen Kollektive zusätzlich dahingehend differenziert werden, ob bei Messungen an der Person eine Erfassung (Absaugung) im Arbeitsbereich vorlag oder nicht.

Die Expositionsdaten werden durch Erläuterungen zum Arbeitsverfahren, zu exponierten Tätigkeiten oder zu Schutzmaßnahmen ergänzt. Hierdurch wird ein Arbeitsbereichskataster für die Prävention und für retrospektive Betrachtungen zur Verfügung gestellt.

Résumé

Exposition professionnelle à la fraction inhalable et alvéolaire de la poussière

Des poussières sont présentes sur la quasi-totalité des lieux de travail. Une exposition excessive par inhalation de poussières peut provoquer de graves maladies respiratoires. Il y a donc lieu d'identifier les lieux de travail soumis à une forte exposition de poussière, et de prendre les mesures adéquates pour protéger les employés.

Le présent rapport de l'IFA fournit un aperçu synthétique de l'exposition professionnelle aux poussières dans le domaine d'application de la Valeur limite générale pour la poussière (ASGW) allemande. L'ASGW est utilisée pour évaluer l'exposition totale aux poussières peu solubles et insolubles (ou encore : poussières biopersistantes granulaires sans toxicité connue – GBS) pour la fraction alvéolaire (poussière A) et la fraction inhalable (poussière E). Les effets nocifs pour la santé provenant des substances spécifiques dont sont constituées les poussières, ou qui sont contenues dans un mélange de substances, doivent être évalués séparément et ne font pas l'objet du présent rapport, pas plus que les poussières de fibres ou les poussières ultrafines.

Le présent rapport constitue à cet égard un ouvrage de référence sur la présence et l'apparition des poussières ainsi que sur leurs propriétés et dangers pour la santé. Il contient en outre des informations sur l'application de l'ASGW et sur les réglementations à respecter en cas d'apparition de poussière A ou de poussière E sur le lieu de travail.

L'accent est mis particulièrement sur les données d'exposition sur les lieux de travail provenant du « Système de mesure pour l'évaluation des expositions » des organismes allemands d'assurance accidents (MGU). Plus de 35 000 données d'exposition, tant sur la poussière A que sur la poussière E, collectées entre 2005 et 2016 et documentées dans la base de données d'exposition de l'IFA intitulée « Données de mesure sur l'exposition à des substances dangereuses sur le lieu de travail » (MEGA) ont été évaluées et décrites statistiquement. Dans le présent rapport, les résultats des mesures sont ventilés par secteur d'activité et par domaine de travail. D'autres différenciations des collectifs statistiques concernent la stratégie de mesurage – la distinction entre les mesures effectuées « sur la personne » et les mesures effectuées à l'aide de systèmes d'échantillonnage « fixes » dans les zones de travail. Dans certains domaines, les collectifs statistiques ont pu être encore différenciés selon qu'on était ou non en présence d'un enregistrement (par aspiration) dans la zone de travail lors des mesures sur la personne.

Les données d'exposition sont complétées par des précisions sur les méthodes de travail sur les activités exposées ou sur les mesures de protection. Il en résulte un registre des domaines de travail, qui pourra être utilisé pour la prévention ou pour des analyses rétrospectives.

Resumen

Exposición en el contexto laboral respecto a la fracción de polvo inhalable y respirable.

El polvo está presente en prácticamente todos los entornos laborales. Una carga excesiva de polvo inhalado puede causar enfermedades graves del aparato respiratorio. Por tanto, es necesario identificar aquellos puestos de trabajo con una exposición elevada al polvo y tomar medidas adecuadas para proteger a los empleados.

Con este informe de la IFA presentamos una visión resumida de la exposición al polvo en el contexto laboral en el ámbito de aplicación del valor límite de polvo total (ASGW). Dicho valor límite se aplica en la evaluación de la exposición total a tipos de polvo difícilmente solubles e insolubles (también tipos de polvo granulares biopersistentes sin una toxicidad conocida a consecuencia de una sustancia concreta) para la fracción de polvo respirable y para la fracción de polvo inhalable. Los efectos perniciosos para la salud de las sustancias concretas de las que se compone el polvo o que están contenidas en él como aditivos deben evaluarse por separado, y no constituyen el objeto de este informe, al igual que tampoco se tratan en él los polvos de fibras ni los polvos ultrafinos. A este respecto, el informe hace las veces de obra de consulta sobre su aparición e incidencia así como sobre características y riesgos para la salud. Además, también incluye informaciones sobre la determinación del ámbito de aplicación del valor límite de polvo total y sobre la normativa que debe tenerse en cuenta respecto a la existencia de polvo respirable y polvo inhalable en el puesto de trabajo.

Como punto central del informe se incluyen en él datos de exposición sobre las mediciones realizadas en el puesto de trabajo con el sistema de medición para el cálculo de riesgo establecido por las aseguradoras de accidentes (MGU). Se han evaluado estadísticamente y se han descrito más de 35.000 datos de exposición sobre polvo respirable y otros tantos sobre polvo inhalable correspondientes al periodo comprendido entre 2005 y 2016, documentados en la base de datos de exposición de la IFA “Datos de medición sobre la exposición a sustancias peligrosas en el puesto de trabajo” (MEGA). Los resultados de las mediciones se clasifican en este informe por sectores y ámbitos de trabajo. También se efectúan otras diferenciaciones de los colectivos estadísticos en función de la estrategia de medición, es decir, la diferenciación entre mediciones “sobre la persona” y mediciones con sistemas de obtención de muestras situados de manera “estacionaria” en los ámbitos de trabajo. En algunos ámbitos, los colectivos estadísticos pudieron además diferenciarse en función de si, en el caso de las mediciones sobre la persona, la constatación (aspiración) se había producido o no en el ámbito de trabajo.

Los datos de exposición se complementan con explicaciones sobre el proceso de trabajo, sobre las actividades expuestas o sobre las medidas de protección. De este modo se configura un catastro del ámbito laboral sobre prevención con observaciones retrospectivas.

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1 Substance information

1.1 Incidence

Dusts are very fine solid particles, differing in their size and origin, and can remain suspended in gases – especially air – for a certain period of time [1]. The German TRGS 900 technical rules for hazardous substances [2] define dusts as a dispersed distribution of solid substances in air, caused by mechanical processes or by raising. They are ubiquitous both in the natural environment and in work areas. Only "clean rooms", which are supplied with purified air by means of complex ventilation and filtration systems, can be kept almost entirely free of dust.

Dust can be generated by a range of processes. Natural sources of dust include combustion processes, volcanic eruptions and erosion by wind and weather. Dust already deposited can be raised and mobilized again by air movements. Examples of biogenic dusts are mould spores, the excrement of house dust mites and pollen. Anthropogenic dusts are produced in some cases intentionally in certain industrial processes, such as milling or the production of powdered feedstocks for use in the chemical industry. Most anthropogenic dusts however are produced incidentally during the mechanical processing of solids (comminution processes, surface treatment, abrasion), or by thermal processes such as welding or hot metal working. Some dusts may be both natural and artificial in origin.

Dusts are classified as either inorganic or organic according to their composition (for examples, see Annex 1). Examples of inorganic dusts are rock dust or metal dusts produced during mechanical or thermal processing. Examples of organic dusts are wood dust and grain flour.

1.2 Properties

Dusts encompass a very wide range of densities (for examples, refer again to Annex 1). Ore and heavy metal dusts for example may have densities of approximately 4 g/cm³ (non-ferrous metal ores, non-ferrous metal carbonates and sulphates), > 7 g/cm³ (iron), or > 15 g/cm³ (platinum, gold). Silicate, light metal carbonate and sulphate dusts have densities of approximately 2 to 3 g/cm³. Light metals, soot and rock dusts have densities of 1.5 to approximately 3 g/cm³; organic dusts, such as grain flour, paper, plastics and coal, have densities of < 1 to approximately 2 g/m³.

Dust particles range in diameter from < 1 nm to several hundred µm. Individual particles are not present in a defined size, but exhibit a size distribution. They take the form of broadly spherical particles, platelets, or in some cases fibres. Biopersistent fibres do not fall within the scope of the German general dust limit value (GDLV), either individually or when combined to form particle agglomerates.

The size of the dust particles has a decisive influence upon whether they can be inhaled and where in the respiratory tract they are deposited. Particles with a diameter of predominantly < 5 µm pass from the tracheae, through the bronchia and bronchioli, to the alveoli, which form the ends of the branches of the lung passages. These particles are termed the respirable fraction. Conversely, the inhalable fraction comprises the entire dust inhaled through the mouth and nose (diameters of up to approximately 150 µm). The process of filtration in the human respiratory tract is simulated by the sampling systems for respirable and inhalable dust (see Section 3.1.1).

1.3 Health hazards

This IFA Report deals exclusively with data for exposure to poorly soluble and insoluble dusts with no known substance-specific toxicity, within the scope of the GDLV. A general mechanism of action – supported by scientific findings – is assumed for these dusts, irrespective of their chemical composition. Their particles are degraded in the lungs only very slowly, if at all, and their chemical constituents exhibit little or no bioavailability; they consequently do not interact chemically with structures of the organism. Their harmful properties derive solely from an effect emanating from their properties as particles as such. They accumulate in the lungs as a consequence of prolonged, excessive inhalation exposure. This may result in a disease developing progressively in human beings over a period of years or even decades which is evident in the form of coughing, impaired lung function, chronic bronchitis and even the appearance of fibrosis (hardening and scarring) and pulmonary emphysema (hyperinflation). The development of pulmonary tumours has also been observed in animal experiments. This has not yet been clearly proven for humans, but is probable.

Extensive findings exist concerning the mechanism of action of the health hazard associated with inhalation exposure of the lungs to insoluble dusts. The findings have been obtained for the most part from experiments on animals, but are considered relevant to humans. The pathophysiological processes that arise in the lung when it is exposed to dust are described in simplified form below.

- Particles deposited in the lungs are removed by a range of mechanisms. Mucociliary clearance removes particles deposited in the bronchia and bronchioli through coordinated movements of the cilia. Should dust reach the alveoli, the deposited particles are taken up (phagocytized) by alveolar macrophages, which are scavenger cells (phagocytes). The alveolar macrophages loaded with the dust then migrate to the bronchia, a process also termed alveolar or macrophage-mediated clearance. Finally, the particles are removed from the lungs by mucociliary clearance and swallowed or coughed up. Instead of being transported away however, particles may enter the support tissue (pulmonary interstitium) between the alveoli, where they are also digested (phagocytized) by macrophages.

- At higher pulmonary exposures, the mobility of the macrophages decreases with increasing dust load (upwards of 6% of their volume), which significantly increases the elimination half-life. In addition, an influx of other phagocytes of different types (granulocytes, lymphocytes) from the bloodstream occurs.

- When chronically elevated exposures cause the cleaning capacity to be exceeded, numerous processes begin which can be interpreted as indicators of lung overload and can have adverse effects upon health. Inflammatory mediators, the inflammatory cells (leukocytes), are attracted and growth factors are released. Certain inflammatory factors stimulate the production of collagen, thereby promoting the formation of fibroses. The inflammatory reaction can be detected by examination of the composition of the bronchial fluid (bronchoalveolar lavage, BAL) (increased cell counts, increased protein content, higher concentrations of the lactate dehydrogenase and b-glucuronidase enzymes, and cytokines and growth factors).

- At a macrophage load of around 60%, alveolar clearance ceases entirely. The macrophages may also die off (apoptosis), in which case the phagocytized particles are released again and the inflammatory processes are further intensified. The retardation and possible complete cessation of macrophage-mediated clearance is also termed overload.

- The dust-laden macrophages attempt to destroy the foreign bodies by the intense release of reactive oxygen species (ROSs). ROSs are highly reactive. They can act on neighbouring cells of the lung tissue, causing internal DNA damage to the latter which in turn causes the cells to mutate and develop further into tumours under the influence of the growth factors.

The prevailing view is that permanent damage to the lung must be anticipated when inflammatory reactions occur or when clearance is impaired when loading of the macrophages reaches 6% of their volume. The GDLV was based upon these toxicological endpoints.

2 General dust limit value (GDLV)

2.1 Deriving of the GDLV

The GDLV was derived for poorly soluble and insoluble dusts with no known substance-specific toxicity. These include dusts with a bioavailability similar to or lower than that of calcium sulphate (gypsum), such as titanium dioxide, industrial soot (carbon black) or toner particles ("model toner"[1] for experiments on rats in which substance-specific effects are reduced to a minimum). Conversely, substance-specific atmospheric limit values are laid down for dusts of specific toxicity the effect of which derives from toxic properties of the substances of which the particles are composed or which are contained in the particles as admixtures. The same applies to biopersistent fibres.

2.1.1 GDLV for respirable dust

The GDLV for the respirable dust fraction was lowered in 2014 from 3 mg/m³ to 1.25 mg/m³ at a mean dust density of 2.5 g/cm³, based on new findings obtained from animal experiments [2]. This limit provides protection against inflammatory reactions in the lung, and thus also against the disease consequently progressing in a manner potentially leading to chronic respiratory symptoms, pulmonary fibrosis and emphysema and probably also lung cancer.

The setting of the GDLV for respirable dust by the Committee for Hazardous Substances [3] is explained in detail in the rationale of the German Research Foundation for the MAK[2] maximum workplace concentration value [4]. An NOAEL[3] or a robust dose-response relationship to the incidence of a critical effect (health endpoint) is normally required in order for a health-based limit value to be derived. Since relevant human data were not available, the results of animal experiments involving chronic inhalation exposure of rats to toner and TiO_2 particles (particle size in the range of respirable dust) were used. The basis for derivation of the value was the occurrence of inflammatory proliferative changes in the rat lung, serving as the most sensitive relevant endpoint: when this is avoided, further harmful effects are not anticipated. The NOAEC[4] determined from the animal experiments is the highest particle concentration at which no findings were observed in this respect. Owing to anatomical and physiological differences, this NOAEC must be applied to the situation in human beings by application of extrapolation models employing species-specific extrapolation factors, in order for a "human equivalent concentration" (HEC) to be determined. The HEC is the (atmospheric) concentration of a dust that is assumed to have the same adverse effect as an equivalent concentration in the animal experiments. A GDLV is derived from this HEC. If this GDLV is observed, no adverse effects upon workers' health need be anticipated.

The MAK rationale describes two methods for deriving the limit value. These yield HEC particle concentrations at similar levels. Both derivation methods are based on the assumption that at a given particle dose per square metre of lung surface area, i.e. the same macrophage loading volume, humans and rats are equally susceptible to particle-induced inflammation. The MPPD-V2.0 model (MPPD: multiple path particle dosimetry model), with which the deposition of the test dusts in the lungs can be estimated for a given particle concentration, was used for both calculations. The MPPD model employs the following input variables: density and particle size distribution of the substance (mass median aerodynamic diameter (MMAD) with geometric standard deviation) and functional residual capacity of the lung, volume of the upper respiratory tract, and tidal volume and respiratory frequency of the species under consideration. A further important influencing factor for the derivation is the half-life of particle elimination (clearance), which differs significantly between rats and humans. Half-lives of 60 days for rats and 400 days for humans are assumed for the purpose of the calculations.

The first derivation method extrapolates the particle dose per square metre of lung surface at the NOAEC from rat to human being, taking into account the particle clearance rate and the duration of exposure (length of the study vs. length of working life). From this result, the HEC is then calculated. The HEC is 0.11 mg/m³ for toner and 0.25 mg/m³ for titanium dioxide, in both cases at a density of 1 g/cm³.

The second derivation method is based on data from a number of studies involving different insoluble dusts in rats. These show that the onset of impaired clearance –

1 Model toner: reduced aerodynamic diameter to increase the respirable fraction; no further accumulations of material on the surface of the toner as would otherwise be normal.

2 MAK: Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area

3 NOAEL: no observed adverse effect level; the highest dose (exposure concentration) at which no adverse (toxic) effects are observed

4 NOAEC: no observed adverse effect concentration

an overload – occurs at a loading volume of the macrophages upwards of approximately 6%. This value is also assumed for humans. During extrapolation from rat to human being, a particle concentration must be determined which, under chronic exposure, also results in a loading of the alveolar macrophages (corresponding in number and volume to that in the human lung) of 6%. This extrapolation yields an HEC of 0.5 mg/m³ (respirable dust) at a density of 1 g/cm³.

From these HEC values of between 0.11 mg/m³ and 0.5 mg/m³, determined with reference to a number of studies and procedures, the MAK Commission derives an MAK value of 0.3 mg/m³ at a density of 1 g/cm³. By contrast, the German Committee for Hazardous Substances (AGS) takes the upper end of the HEC value range as a basis, specifying 1.25 mg/m³ at a dust density typical for workplaces of 2.5 g/cm³ (corresponding to 0.5 mg/m³ at a density of 1 g/cm³) as the GDLV for respirable dust.

The GDLV for respirable dust can be converted for exposures to dusts with densities deviating from the above value. In such cases, the aggregate/agglomerate density should – if known – be used in place of the material density, as it yields a better description of the effect's dependency upon the dose.

The GDLV for respirable dust does not apply to ultrafine particles, as a higher potency is assumed for these particles.

2.1.2 GDLV for inhalable dust

The GDLV for the inhalable dust fraction of 10 mg/m³, representing a mean shift-based value at an average dust density of 2.5 g/cm³, is based on an older limit recommended by the German Research Foundation (DFG) [5]. It was obtained by conversion of the MAK value, which was determined in the form of an annual mean value of 4 mg/m³.

This value was determined mainly from human data from the German Democratic Republic (GDR) and from the DFG study of chronic bronchitis. The critical endpoint in both cases was the impairment of pulmonary function. A dust concentration without adverse effect can be derived neither from these studies, nor from other available epidemiological studies.

Evaluation of the results of occupational medical check-ups conducted in the GDR between 1982 and 1990 shows that workers with per-shift exposures above 10 mg/m³ had a significantly higher prevalence of obstructive lung diseases than non-exposed workers. For particle concentrations of 3.8 mg/m³ and above, the DFG study permits a statistical deduction of an increase in the prevalence of chronic bronchial reactions of 5% above the background prevalence. This derivation is supported by other studies (conducted for example in foundries and agriculture) in which the onset of impairments of the pulmonary parameters was observed at particle concentrations of between 4 and 5.9 mg/m³ and of 5 mg/m³. The MAK Commission concludes from this that if a limit value for inhalable dust of 4 mg/m³ is observed, the risk of work-related respiratory disorders is only slightly higher, if at all, than the background prevalence.

2.2 Historical development of the GDLV

The table below shows how the GDLV has developed in Germany over the years. These values were published in the TRGA 900 and TRGS 900 technical rules. Up to 2000, the GDLV took the form of an annual mean value. In 2001, the setting of a new value was accompanied by a switch to mean shift-based values. The development of dust limit values in the GDR is described in the BGIA Report: Exposure to quartz at the workplace [6].

Table 1:
Historical development of the GDLV

Description	Limit value in mg/m³	Violation factor	Year
Inert dusts	15 8 F		1968 [7] 1973 [8]
GDLV	6 F		1983 [9]
GDLV for activities/areas of activity in accordance with Clause 2.4 (8) and (9) in conjunction with (10) of TRGS 900*	6 R	4	2001 [10]
GDLV, other	3 R****	4	2001 [10]
GDLV for substances in accordance with Clause 2.4 (7) of TRGS 900**	10 I	4	2001 [10]
GDLV, other	10 I	4	2004 [10]
GDLV	3 R 10 E	2 (II) 2 (II)	2006 [10] 2006 [10]
GDLV, transitional arrangement until 31 December 2018***	3 R****	2 (II)	2014 [10]
GDLV, other	1,25 R**** 10 I	 2 (II)	2014 [10] 2014 [10]
F = fine dust; R = respirable fraction; I = inhalable fraction			

* The areas exempted included:
- Work in the construction, minerals and earths industries, and in areas and activities which were assigned to these industries by analogy:
  - Dismantling, demolition and chiselling-off work
  - Grinding, cutting and milling work
  - Dry working and processing of cut stone (natural and concrete stone) with use of hand-held tools
  - Surface treatment of concrete
  - Mechanized fettling
  - Earthworks and compaction work; vehicle traffic on construction sites
  - Construction work below ground
  - Construction site cleaning work
  - Mobile recycling systems for construction materials
  - Legacy equipment used for the processing of natural stone (crushing, sizing, sorting plants), including loading
- Legacy equipment used in extraction and processing in the architectural and heavy ceramics and sand-lime brick industry
- Legacy equipment used in shaping (pressing) in the sand-lime brick industry
- Legacy equipment for bagging and packing of highly dusty goods in the building materials and chemical industries and in comparable areas of activity
- Coaling area in power plants
- The following areas of activity in the steel industry:
  - BOF steel plant (converter process, secondary metallurgy)
  - EAF steel plant (furnace process, secondary metallurgy)
  - Sintering plants
- Further activities or areas of activity not listed above in which the limit value of 3 mg/m³ was demonstrably also not observed despite the state of the art having been implemented

** For diboron trioxide (boron trioxide), tantalum, molybdenum and insoluble molybdenum compounds

*** For activities for which it can be shown that compliance with the occupational exposure limit (OEL) of 1.25 mg/m³ for the respirable dust fraction is not possible. The transitional arrangement can be used if the boundary conditions formulated in Clause 2.4.2 of TRGS 900 [XX] are met.

**** The health-based GDLV for the respirable fraction published in 2001 of 3 mg/m³ was set by the AGS on the basis of a typical dust density at workplaces of 2.5 g/cm³. The deliberations in the AGS were based on the limit value of 1.5 mg/m³ proposed by the MAK Commission in 1997 and the formula c = density × 1.2 [mg/m³] determined from animal experiments. The rationale for the limit value contained a reference to the fact that respirable workplace dusts of lower density (< 2.5 g/cm³) result in a correspondingly lower health-based atmospheric concentration. A higher atmospheric limit value for respirable dusts with a density of > 2.5 g/cm³ was not recommended at that time.

2.3 Application and scope of the GDLV

The GDLV is intended to prevent impairment of the respiratory organs as a result of general exposure to dust. It serves as the occupational exposure limit (OEL) for poorly soluble or insoluble dusts that are not regulated elsewhere.

The GDLV does not constitute a health-based limit value for ultrafine dusts or for dusts with specific toxicity, e.g. with mutagenic, carcinogenic (Category 1A, 1B), fibrogenic or sensitizing effects. For these dusts, the GDLV is to be applied as a general upper limit for determining protective measures in accordance with Annex I Clause 2.3 (2) of the German Ordinance on hazardous substances (GefStoffV) in cases where no substance-specific OEL according to TRGS 900 or risk-based assessment benchmarks according to TRGS 910 concerning the risk-based concept of measures for tasks involving carcinogenic hazardous substances [11] apply.

The GDLV does not apply to soluble substances, paint aerosols or coarsely dispersed particle fractions. Dusts containing manufactured nanomaterials are subject to the Notice on Hazardous Substances for manufactured nanomaterials [12]. The GDLV is not applicable to workplaces below ground within the scope of the German Ordinance on the protection of health in mining (GesBergV), which are subject to a monitored and documented dose-based protection concept, insofar as equivalent health protection is achieved by this means.

For assessment of the dust concentrations arising in the atmosphere in the work area, the inhalable and respirable dust fractions of the GDLV must normally be determined and assessed in accordance with the TRGS 402 technical rules concerning the determining and assessment of hazards during tasks involving hazardous substances (inhalation exposure) [13]. The higher substance index is to be used for the workplace assessment. The substance indices for the GDLV do not apply during calculation of the assessment indices of substance mixtures in accordance with TRGS 402, Clause 5.2.1 (2).

In practice, the dust fractions may also contain components for which substance-specific assessment benchmarks (TRGS 402) are specified. Where the dust fractions contain such substances, they must be identified and assessed separately. The OEL of 1.25 mg/m^3 for respirable dust is based on an average density of 2.5 g/cm^3. Should materials of particularly low density (such as plastics or paper) or particularly high density (such as metals) be used at a workplace, the material density can be used for conversion. The OEL for inhalable dust is set as a mean shift-based value of 10 mg/m^3. Technical reasoning does not support density-based conversion for inhalable dust.

Where no other findings are available, the entire measured dust fraction must be regarded as insoluble. Where cases arise in practice in which the solubility of the dusts occurring is of particular importance (e.g. sugar, potassium salt, gypsum), the employer may, during the risk assessment, specify a procedure for taking the soluble fraction into account during determining and assessment. The procedures described in the IFA Folder [14] may serve as guidance here.

For workplaces with constant conditions in accordance with Annex 5, Clause 1 (1) of TRGS 402 or with occasional exposure in accordance with Annex 5, Clause 3 of TRGS 402, a dose-based monitoring concept over a representative measurement period of not more than one month may also be specified in the risk assessment for respirable dust. In such cases, the individual mean shift-based values are measured over the selected measurement period and documented. The average of the measured mean shift-based values must not exceed the OEL for respirable dust over the measurement period. No individual mean shift-based value may exceed 3 mg/m^3 for the respirable fraction.

2.4 Examples of substances falling within the scope of the GDLV

No substance-specific GDLV is set for the substances below, since at this point in time, the AGS has no knowledge of their effect upon the respiratory organs beyond the non-specific effect. This list serves as an overview of example substances and is not exhaustive:

1. Aluminium
2. Aluminium hydroxide
3. Aluminium oxide (non-fibrous; except aluminium oxide fumes)
4. Barium sulfate
5. Graphite
6. Coal dust
7. Plastic dusts, e.g. polyvinyl chloride, Bakelite, polyethylene terephthalate (PET)
8. Magnesium oxide (excluding magnesium oxide fumes)
9. Silicon carbide (fibre-free)
10. Talcum
11. Tantalum

2.5 Provisions

Provisions governing activities involving dusts can be found in a number of legal sources.

2.5.1 German Ordinance on hazardous substances (GefStoffV)

In the GefStoffV, dusts (including fumes) are defined as dispersed distributions of solid substances in the air produced in particular by mechanical, thermal or chemical processes or by raising. The dusts (including nanomaterials) in the breathing zone of workers that can be taken up through the respiratory tract are described as the inhalable fraction. The inhalable dusts (including nanomaterials) capable of reaching the alveoli and bronchioli are described as the respirable fraction.

Sections 3 (concerning risk assessment and basic duties) and 4 (concerning protective measures) of the GefStoffV must be observed for dusts in the same way as for all hazardous substances. In addition, particular provisions governing activities involving exposure to respirable and inhalable dusts can be found in Annex I, Clause 2. Where dusts are created or may potentially be released during activities involving hazardous substances, the employer must determine and assess the dust-raising properties of these substances and specify the necessary protective measures as part of the risk assessment. For details of the protective measures, see Annex I, Clause 2.

2.5.2 TRGS 500 technical rules concerning protective measures

The TRGS 500 technical rules support the measures stated in the GefStoffV for activities in which dusts may occur.

3 Measurement methods

3.1 Sampling methods

3.1.1 Respirable and inhalable dust, definition and sampling systems

Until 1993, the respirable dust fraction was treated as fine dust. This is defined in accordance with the Johannesburg Convention of 1959. Theoretically, this particle spectrum corresponds to a dust collective obtained downstream of a dust removal system with the separation function of a sedimentation separator. The penetration levels of such a pre-separator as stated in the Johannesburg Convention for certain aerodynamic diameters are compiled in Table 2 and illustrated in Figure 1.

Table 2:
Penetration of pre-separators according to the Johannesburg Convention and EN 481

Johannesburg Convention (1959)		EN 481 (1993)	
Aerodynamic diameter of dust particles with a density of 1 g/cm³, in µm	Penetration level, in %	Aerodynamic diameter of dust particles with a density of 1 g/cm³, in µm	Penetration, in %
1.5	95	1	97.1
3.5	75	3	73.9
5.0	50	4	50.0
7.1	0	16	0

Since 1994, European EN 481 standard [15] has served as the basis for definition of the respirable fraction in TRGS 900. The two conventions are not identical; the deviations are however relatively minor for the dust particle distributions occurring in practice. The sampling equipment used prior to 1994 for the measurement of fine dust may continue to be used, since the separation functions of their pre-separators deviate only marginally from the desired function stated in EN 481 [15]. The definitions of EN 481 for the inhalable and respirable fractions have also been reproduced with identical content in ISO 7708, which was adopted as a German standard in 1996 [16].

Until 1993, the inhalable dust fraction was described as the total dust. The devices for measuring the total dust share the common criterion of a velocity of 1.25 m/s at the intake of the collection head. The inhalable dust fraction is also defined by way of EN 481 and ISO 7708. Since the dust measuring devices for total dust also meet the requirements of EN 481 for inhalable dust, they remain in use.

The sampling devices used previously are summarized in Table 3.

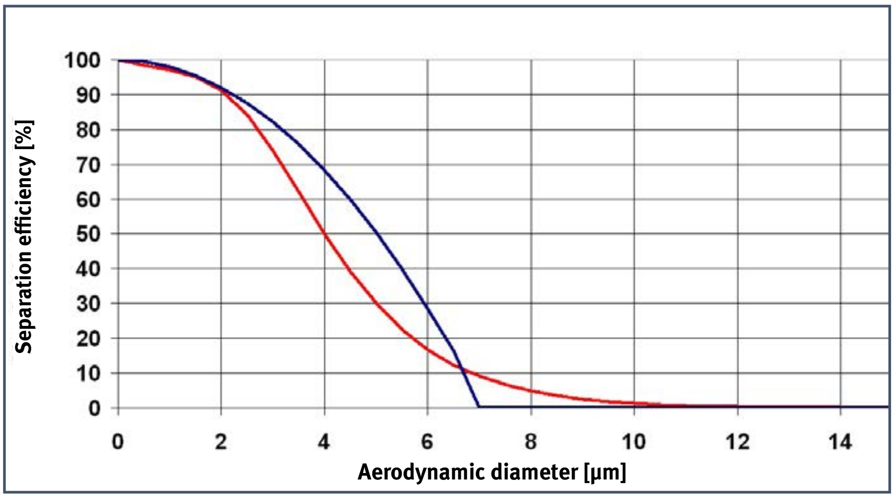

Figure 1:
Separation function for the respirable dust fraction in accordance with the Johannesburg Convention ("fine dust", blue line) and EN 481 ("respirable dust", red line)

Table 3:
Sampling systems for the respirable and inhalable dust fractions with statement of the volumetric flowrate

Sampling system	Volumetric flow rate in m^3/h	For determining respirable dust	For determining inhalable dust
Personal*			
FSP-BIA, with use of the Casella cyclone	0.12	×	
FSP-10, with 10 l cyclone and SG 10 pump	0.60	×	
GSP-3,5, intake cone with 7 mm opening	0.21		×
GSP-10, intake cone with 13 mm opening	0.60		×
Static			
MPG II with sedimentation pre-separator In accordance with the Johannesburg Convention	2.8	×	
PM 4 F cyclone pre-separator	4.0	×	
PM 4 G, with annular intake	4.0		×
VC 25 F, pre-separation by impaction	22.5	×	
VC 25 I, as for VC 25F, with additional impactor, particularly suitable for measurements in wet areas	22.5	×	
VC 25 G, with annular intake	22.5		×

* In addition to sampling systems for collection of a specific dust fraction, sampling devices for simultaneous collection of the inhalable and respirable fractions have also been developed in recent years. The PGP-EA (3.5 l/min), PGP-EA (10 l/min) and Respicon TM (3.11 l/min) are among the sampling systems available. As yet, the PGP-EA sampling systems have been approved only for welding fume measurements.

3.1.2 Personal and static measurements

In general, measurements performed on the person yield dust concentrations deviating from those in which the sampling equipment is mounted statically. In many cases, personal sampling yields higher concentrations than static sampling. This is particularly the case when the static sampler can be positioned only adjacent to or behind the worker. If however the static sampling device is situated directly adjacent to a machine emitting dust and the worker carries out other activities in the vicinity in addition to operation of the machine, the dust concentration determined by static sampling will generally be higher. Whether static sampling is suitable for determining the exposure of workers in certain areas of activity can be ascertained for example by comparative measurements. In general, measurements for determining dust concentrations should preferably be carried out on the person. A detailed discussion of the measurement strategy and assessment of the measurement results on which this report is based can be found in Section 4.1.

3.2 Analysis methods

3.2.1 Gravimetric determination of the dust concentration (weighing)

Membrane filters are typically used to determine the respirable dust concentration, glass fibre filters to determine the inhalable dust concentration. The use of glass fibre filters is recommended for inhalable dust collection, since unlike respirable dust, inhalable dust does not adhere well to membrane filters, and preference should therefore be given to depth filters. If metals are also to be determined in the inhalable dust however, membrane filters are used.

The dust concentrations are measured by differential weighing of the filters in the empty and loaded states. The dust concentration is calculated from the measured dust mass with reference to the sampling volume. During weighing of membrane filters, allowance must be made for the change in mass of the filters caused by the relative humidity of the air in the laboratory (correction by calculation or by the use of dummy filters in the laboratory or in sampling). A detailed description of the method can be found in the collection of DFG analysis methods [17].

During determining of wood dust concentrations (in the inhalable dust), determining of the incinerable fraction should also be possible[18]. Determining the soluble fraction of dusts is inherently difficult, since the processes taking place in the lung cannot be reproduced in an analytical laboratory. However, a conservative estimate can be obtained with use of a conventional method [19, 20].

3.2.2 Typical follow-up analyses for silicogenic components

Based on these loaded filters and the known volumetric flowrate of the sampling air, the concentration of quartz in the respirable dust is often determined in addition to the fine dust concentration. The established methods of infrared spectroscopy and X-ray diffraction analysis are available for this purpose.

In addition to quartz, X-ray analysis also recognizes detectable cristobalite components directly, since the peak position of the main interference of the cristobalite is close to one of the interferences evaluated for the determining of quartz. Determining the cristobalite respirable dust concentration is analogous to the X-ray method described for quartz. The use of IR spectroscopy to determine cristobalite is more difficult, since the relevant extinction band of cristobalite overlaps one of the extinction bands of quartz. For the determining of tridymite (largely insignificant in occupational safety and health), a radiographic method similar to that for determining quartz can be used. Since tridymite is a polytype, a calibration sample from the work area concerned should be used.

3.3 Limits of detection and influence of the dust concentration

The limits of detection and quantitation for determining the respirable and inhalable dust concentrations are summarized in Tables 4 and 5. One particular aspect must be taken into account during determining of the respirable dust concentration. In accordance with ISO 15767 [21], results of dust concentration analyses may be reported as soon as they lie above the limit of detection, provided it is stated that they lie below the limit of quantitation. This provision enables sufficiently low concentrations to be attained for observance of the limit value to be monitored under reasonable sampling conditions. Since this applies to quartz and cristobalite and to the amorphous silicas in the respirable fraction, a corresponding procedure is followed here. The limit of quantitation is used for determining the inhalable dust concentration.

Table 4:
Limits of detection for determining the respirable dust concentration, in mg/m³

Sampling device *(Volumetric flow in m³/h)*						
Duration of sampling	VC-25F *(22.5)*	PM 4F *(4.0)*	MPG II *(2.8)*	FSP-2 *(0.12)*	FSP-10 *(0.6)*	Respicon *(0.19)*
15 min	1.4	0.60	0.86	10	2.0	6.4
1 h	0.36	0.15	0.21	2.5	0.50	1.6
2 h	0.18	0.075	0.11	1.3	0.25	0.80
4 h	0.089	0.038	0.054	0.63	0.13	0.40
6 h	0.059	0.025	0.036	0.42	0.083	0.27
8 h	0.044	0.019	0.027	0.31	0.063	0.20

Table 5:
Limits of detection for determining the inhalable dust concentration, in mg/m³

Sampling device *(Volumetric flow in m³/h)*					
Duration of sampling	VC-25 G *(22.5)*	PM 4 G *(4.0)*	GSP-3.5 *(0.21)*	GSP-10 *(0.6)*	Respicon *(0.19)*
15 min	1.6	1.8	17	6.0	58.0
1 h	0.40	0.45	4.3	1.5	15.0
2 h	0.20	0.23	2.1	0.75	7.20
4 h	0.10	0.11	1.1	0.38	3.60
6 h	0.067	0.075	0.71	0.25	2.40
8 h	0.050	0.056	0.54	0.19	1.80

4 Available data and evaluation strategy

The measured values for respirable and inhalable dust stated in this report were determined for specific sectors and areas of activity with use of the German Social Accident Insurance Institutions' MGU measurement system for exposure assessment, which satisfies the quality assurance requirements of EN ISO 9001, and are archived in the IFA's MEGA database of measured data relating to exposure to hazardous substances at the workplace [22 to 27].

As a rule, the MGU measurements are carried out during preventive activity conducted in accordance with German Social Code (SGB) VII, Section 19 (2) 5: *"In order to monitor the measures for the prevention of [...], occupational diseases, work-related health hazards [...], the labour inspectors are in particular authorised to examine [...] procedures and work processes and to determine in particular the presence and concentration of hazardous substances and preparations"* (unofficial translation). The companies and workplaces at which sampling was performed were therefore selected on an ad-hoc basis rather than at random. The concentrations determined reflect normal procedures in the companies in which sampling was performed during the period in question.

The measurements were carried out in accordance with the measurement strategy set out in the TRGS 402 technical rules, with use of the measurement methods stated in Section 3. The measurements were taken in around 9,700 companies; gravimetric analysis was performed at the IFA. The procedures followed in the test laboratories satisfy EN ISO 17025, General requirements for the competence of testing and calibration laboratories.

The exposure data documented in MEGA were evaluated statistically against a range of selection criteria and strategies by means of the MEGA^{Pro} evaluation software application developed by the IFA.

Exposure data from 2005 to 2016 were evaluated for the purpose of the report. The detailed selection criteria for the statistical evaluations are documented in Section 5.1. Data were available from 37,253 analyses of respirable dust and 36,158 analyses of inhalable dust. For the evaluated data, the sampling performed was representative for the documented duration of exposure. Division of sampling into two groups by duration, namely ≥ 2 hours and < 2 hours, enables the sampling results obtained to be referenced on the one hand to the shift and on the other to the activity. Differentiation was further made between static measurements and those conducted on the person, and where applicable, according to whether or not local dust collection equipment was present. Table 6 provides an overview of the measured values for respirable and inhalable dust determined in the MGU according to the selection criteria.

The data collectives were selected for groups of areas of activity in different groups of sectors or cross-sector groups of areas of activity. The index of codes used for the sectors is based on the German Federal Statistical Office's classification of economic activities with statement of the company and similar descriptions [27]. This enabled data collectives to be grouped into comparable sectors and areas of activity.

In accordance with the TRGS 900 technical rules, a limit value of 1.25 mg/m³ is used in this report for respirable dust and of 10 mg/m³ for inhalable dust [2]. The values were not corrected for density. Soluble fractions were not determined.

Table 6:
Number of measured values for respirable and inhalable dust determined in the MGU according to the selection criteria

General description	Number of measured values	
	Inhalable dust	Respirable dust
Total	36158	37253
Form of sampling		
Personal	17505 (48.4%)	17459 (46.9%)
Static		
Old code	14071 (38.9%)	14472 (38.8%)
Person-specific for exposure assessment	2908 (8.0%)	3154 (8.5%)
Background exposure for exposure assessment	1606 (4.4%)	1823 (4.9%)
Number of data > limit value	3049 (8.4%)	5520 (14.8%)
Duration of sampling		
≥ 2 hours	30995 (85.7%)	31563 (84.7%)
< 2 hours	5163 (14.3%)	5690 (15.3%)
Local exhaust ventilation		
Without Local exhaust ventilation	10958 (30.3%)	11981 (32.2%)
With Local exhaust ventilation	18006 (49.8%)	17847 (47.9%)
Not stated	6439 (17.8%)	6617 (17.8%)

4.1 Comments on the measurement strategy and assessment of the measurement results

The measurement strategy followed in the MGU is consistent with the TRGS 402 technical rules concerning the determining and assessing of hazards during activities involving hazardous substances (inhalation exposure). In accordance with this TRGS and the objective of the MGU of obtaining and documenting valid exposure data, the area of activity, exposure conditions and measurement strategy are described in detail.

4.1.1 Form of sampling

Personal measurements are performed by means of sampling systems worn on the person. The measurement results obtained in this way are ideally suited to individual exposure assessment.

Measurements conducted by means of static sampling systems are also used in the MGU. Some static measurements are taken at the level of the breathing zone and in direct proximity to the worker; others are taken at the point of higher risk directly at the emission source. The measurement strategies, such as the distance between the sampling system and the source of emissions or the exposed individual, may differ widely for static measurements depending on the sector and the area of activity concerned. These static measurements cannot therefore be used for estimation of an individual's exposure without further information on the distance between the sampling system and the emission source and the exposed person.

4.1.2 Duration of sampling

Averaging of measurements over the entire duration of exposure during a shift is a particularly suitable means of determining the mean shift-based value. Where the duration of sampling is shorter than the full shift, the minimum number of measurements required distributed over the full shift is based on Table 2 in Annex 3 of TRGS 402. Where the sampling duration is ≥ 2 hours, a sample number of ≥ 1 must be selected.

Measured values with sampling durations of ≥ 2 hours, as is the general practice in the MGU, can be considered comparable to the exposure during an entire shift, and compared to the OEL.

Measured values with sampling durations of < 2 hours may have been obtained in order to determine the exposure during the activity under analysis; conversely, particularly in the case of dust measurements, high dust concentrations may have caused the sampling pump to switch off prematurely and measurement to have been terminated. Both limitation of sampling to the timing of the activity and shutting down of the pump owing to very high dust concentrations may contribute to the measurement results generally being higher for measurements with shorter sampling durations than those for measurements with sampling durations of ≥ 2 hours.

4.1.3 Local exhaust ventilation

Local exhaust ventilation (LEV) such as exhaust systems may influence the concentration of hazardous substances in work areas. Where the measurement results indicate that dust collection equipment was present ("LEV = yes"), the dust released by the work process or activity is collected and discharged by means of an exhaust system in the vicinity of the emission source. The MGU contains no information on the effectiveness of the dust collection equipment at the workplaces under analysis. Where measurement results indicate no dust collection ("LEV = no"), the dust released by the working process was not collected.

If the activity or work process is expected to give rise to little or no dust, dust collection equipment is often not necessary at the workplaces concerned. Conversely, areas of activity associated with the generation of high dust levels are equipped with dust collection equipment wherever possible. Since dust collection equipment is normally installed only at workplaces at which high levels of dust are generated, measured values for which the presence of dust collection equipment is documented may be higher than those obtained at workplaces without dust collection equipment that are practically dust-free or low-dust [28].

5 Description of the groups of sectors and areas of activity and the statistical evaluations

Statistical evaluations were performed for workplace measurements of the hazardous substances of respirable and inhalable dust in the period in which the data were collected, i.e. from January 2005 to December 2016. The exposure data to be evaluated were determined in the MGU. The measured values were grouped into data collectives either by groups of sectors and areas of activity or by cross-sector groups of areas of activity, and differentiated according to the duration and form of sampling.

The OELs of 1.25 mg/m³ for the respirable dust fraction and 10 mg/m³ for the inhalable dust fraction were used as assessment benchmarks (limit value, LV).

In data collectives from personal measurements exhibiting violations of the limit value in the 95th percentile and containing more than 40 measured values, the measurements were further differentiated according to whether or not dust collection equipment was present, where this appeared beneficial with respect to the group of sectors/group of areas of activity concerned.

5.1 Selection criteria for the statistical evaluations

- Hazardous substances: inhalable dust fraction (inhalable dust) and respirable dust fraction (respirable dust)
- Period in which the data were collected: January 2005 to December 2016
- Air samples relevant to exposure
- Workplace measurements
- Sampling systems for respirable and inhalable dust (standard methods in the MGU and measurement methods under trial for certain sample holders for inhalable dust)
- Sampling representative of exposure duration
- Normal operational situations (normal state, assembly, dismantling and start-up procedures, preparations, set-up work) and unfavourable but realistic conditions

5.2 Evaluation strategy

- Differentiation according to form of sampling
  - Personal
  - Static

- Differentiation according to duration of sampling
  - ≥ 2 hours
  - < 2 hours

- Where data collectives containing over 40 measurements on the person exhibit violations of the limit value in the 95th percentile, differentiation of the measurements where appropriate according to:
  - Dust collection equipment present: yes
  - Dust collection equipment present: no

- Statistical evaluations are carried out either:
  - For groups of areas of activity in different groups of sectors, or
  - Cross-sector groups of areas of activity

- Where results of analyses lie below the respective analytical limit of detection (LOD), the value of half the LOD is included in the statistics.

- Data collectives containing fewer than five items of measurement data are not evaluated and not presented.

- For data collectives containing five to nine measured values, the minimum and maximum values (measured values above the respective LOD) are shown for measured values exhibiting violations of the limit value.

- Data collectives from the group of other areas of activity, i.e. areas of activity which cannot be assigned to any specific group, are not shown.

5.3 Tables of results, abbreviations and footnotes

General note: in data collectives containing few measured values (number of measured values < 40), even isolated extreme values may have a strong influence upon the 90th and 95th percentiles.

5.3.1 Standardized tables of results

The numbering of tables of results in Chapters 6 to 19 follows that of the respective subsection. Where differentiation was made according to the presence of dust collection equipment, the results are shown in an additional table (Table a).

Table 7:
Standardized table of results for presentation of dust exposure data in the following chapters

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11
								Concentrations (mg/m^3)		
Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	50th percentile	90th percentile	95th percentile
Dust fraction										

Column 1: Duration of sampling
Sampling duration of the measurements (≥2 hours; < 2 hours)

Column 2: Form of sampling
Form of sampling used for the measurements (personal/static)

Column 3: Number of measured values
Number of measured values with respect to respirable or inhalable dust

Column 4: Number of companies
Number of companies with respect to respirable or inhalable dust

Column 5: Values < limit of detection (number and %)
Number and percentage of values below the limit of detection of the relevant measurement method

Column 6: Highest limit of detection* (mg/m^3)
Highest limit of detection in the body of data

Columns 7/8: ≤ LV (%)/> LV (%)
Percentage of the measured values below/above the respective limit value with respect to the respirable or inhalable dust. Further measured values are not assessable with respect to the limit value. Limit values of 1.25 mg/m^3 for respirable dust and 10 mg/m^3 for inhalable dust in accordance with TRGS 900 are used for assessment in this report [2].

Column 9: 50th percentile (mg/m^3)
50% of the available concentration values lie below this value, the remaining 50% above it. If the distribution value lies below the highest LOD in the body of data, the value is marked with a plus sign (+).

Column 10: 90th percentile (mg/m^3)
90% of the concentration values measured lie below this value, the remaining 10% above it. If the distribution value lies below the highest LOD in the body of data, the value is marked with a plus sign (+).

Column 11: 95th percentile (mg/m^3)
95% of the available concentration values lie below this value, the remaining 5% above it. If the distribution value lies below the highest LOD in the body of data, the value is marked with a plus sign (+).

Dust fraction:
The dust fractions (respirable and inhalable dust) and below them, the statistical results

5.3.2 Abbreviations and footnotes in tables

The following abbreviations and footnotes are used in the tables of results:

Table 8:
Abbreviations and footnotes in the tables of results in the following chapters

Abbreviation	Explanation
LOD	Analytical limit of detection
Value < LOD	Number and percentage of measured values lying below the LOD in the body of data
Highest LOD	Highest LOD in the body of data: at lower sample air volumes, the LOD is higher than the limit of detection of the standard method stated in the introduction. The sample air volume is the product of the sampling duration and the volumetric flow rate
n/a	No data available
LV	Limit value used as assessment benchmark
*	Where results of analyses lie below the respective LOD, the value of half the LOD is included in the statistics
**	Data from fewer than five companies may not be representative of an entire sector or area of activity
***	The body of data contains between five and ten measured values. Where limit values are exceeded, the minimum and maximum measured values are stated
+	The distribution value lies below the highest LOD in the body of data
$	The percentage of values below/above the specified LV is stated. Further measured values are not assessable with respect to the limit value
!	The number of measured values below the LOD is greater than the number of measured values represented by this cumulative frequency value. No concentration is stated for this cumulative frequency value

6 Extraction and processing of minerals, earths and raw materials

6.1 Extraction and processing of limestone and dolomite

Sector
Limestone, extraction and processing
Limestone, extraction
Gypsum, chalk, extraction
Dolomite, extraction

Limestone and dolomite are extracted from the rock mass primarily by quarry blasting, transported by dump trucks or belt conveyors, and processed in several stages in crushing and sizing plants to form products ranging in particle size from blocks to rock flour. The result of the multiple comminution and screening stages is a range of grain fractions, which are stored separately in outdoor areas and in silos. As a rule, the greater the level of comminution of the mineral raw material, the greater the likelihood of dust being released.

The dry method is generally used for processing in quarry operations. In order to prevent dust pollution, many installations are therefore fully encapsulated, and equipped with complex dust exhaust facilities, for example at transfer points between conveyors and at conveyor discharge points, and on crushers and screening machines. Scope for the use of water for dust control is however often limited: examples are jetting at the crusher intake, sprinkling of stockpiles, and at transfer points during loading for transport.

Workplaces involving dust exposure may be encountered:
- At the extraction stage during drilling work for production of the blast charge, and on conveying and loading equipment (excavators, wheel loaders, heavy goods vehicles)
- During material processing in open and encapsulated installations
- During loading of the finished products

Personal measurements (on equipment operators, plant fitters, test laboratory personnel) in the period from 2005 to 2016 reveal dust exposures for the entire sector that are predominantly below the GDLV. By contrast, static measurements, which are often taken in work areas in which material is mechanically stressed (crushers, screening plants) but that are not permanently manned, exhibit higher concentrations, above the OEL.

Table 6.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	20	12	5 (25%)	0.71	80	20	2.3	12.4	16
≥ 2 h	Static	15	11	1 (6.7%)	0.71	66.7	33.3	2.55	28.5	36.925
Respirable dust										
≥ 2 h	Personal	20	14	7 (35%)	0.25	90	10	0.29	1.04	2.6
≥ 2 h	Static	16	12	4 (25%)	0.25	81.3	18.8	0.42	2.258	4.2

6.2 Mining

Sector
Lignite extraction and processing
Coal extraction and processing
Potash and rock salt extraction and processing
Ore extraction and processing
Mineral extraction and processing, other

The body of data covers the extraction, conveying and processing of raw materials in underground and surface mining operations. The evaluation also covers secondary tasks at control stations and in quality control and packing of the products, although these are usually bulk products stored in stockpiles.

Underground and open-cast mining operations employ the extraction and processing methods referred to in the preceding chapters. The comminution and sizing technology used in open-cast mines is often the same as that in the natural stone industry, which is carried out outdoors or in encapsulated facilities. In underground mining operations, processing plants dominate which are operated in closed rooms – often themselves underground owing to the noise emissions – under special ventilation conditions. Progressive extraction requires robust mobile technology; this also applies to dust removal. While dry methods predominate below ground (with the exception of drilling tasks with dosed water spraying) and in the extraction of unconsolidated rock, both dry and wet methods are used during the processing of solid rock above ground.

Below ground in particular, higher dust exposures may therefore occur during extraction and processing activities, such as comminution. This frequently affects plant operating personnel, such as operators of drilling and milling equipment and machine fitters; by contrast, pressurized and air-conditioned cabs are the state of the art for the drivers of mining vehicles. Respirable and inhalable dust exposures generally lie below the GDLV. Stationary plants are usually controlled from air-conditioned control rooms.

Table 6.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	36	12	4 (11.1%)	0.71	88.9	11.1	2.32	10.094	24.686
≥ 2 h	Static	29	11	2 (6.9%)	0.25	93.1	6.9	0.88	5.698	11.309
Respirable dust										
≥ 2 h	Personal	37	13	11 (29.7%)	0.25	91.9	8.1	0.31	1.017	1.798
≥ 2 h	Static	33	13	10 (30.3%)	0.25	87.9	12.1	0.3	1.42	4.38

6.3 Extraction and processing of gravel and sand

Sector
Gravel and ballast works
Sand, extraction and processing
Gravel and sand (excluding pumice and silica sand), extraction
Silica sand, extraction
Gravel and sand, processing
Gravel and sand, extraction

Gravels and sands extracted from the deposits by either wet or dry processes are prepared in screening, washing, crushing, sorting, sizing and possibly drying installations to form products of various particle size fractions, and stored in silos or on open stockpiles. Special sands are also packed in sacks or flexible intermediate bulk containers (FIBCs) after drying.

In modern gravel and sand works, processes have now largely been automated. Workers' activities essentially involve checking, monitoring and maintenance tasks to ensure the continuity of operation. Only in the rarest of cases is it possible for parts of plants in raw materials preparation to be sealed off in order to prevent the transfer of dust, since the installations concerned are interlinked and not spatially separate. The measurements were carried out in both open and encapsulated systems. The individual areas of activity in which dust exposure occurred are shown in the tables below.

Dust is exhausted according to the state of the art in a wide range of areas of activity in the gravel and sand industry. The permissible workplace concentration at the 90th percentile is now generally observed, with the exception of the respirable dust exposure in certain areas of activity listed below.

6.3.1 Extraction: conveying, transport

The trend in the measured values since 1972 (refer to the Quartz Report, 2005) shows a considerable decrease in the dust exposure during conveying and transport in the gravel and sand industry. This decrease is due largely to automation of operating processes and dust control in vehicle cabs. Compliance with the GDLV is ensured at the 90th percentile.

Table 6.3.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	41	27	4 (11.1%)	0.71	88.9	11.1	2.32	10.094	24.686
≥ 2 h	Static	29	11	2 (6.9%)	0.25	93.1	6.9	0.88	5.698	11.309
Respirable dust										
≥ 2 h	Personal	37	13	11 (29.7%)	0.25	91.9	8.1	0.31	1.017	1.798
≥ 2 h	Static	33	13	10 (30.3%)	0.25	87.9	12.1	0.3	1.42	4.38

6.3.2 Preparation: sizing (screening)

For the processing step of sizing, the exposure to respirable dust – in terms of the 90th percentile – has been reduced considerably since publication of the 2005 Quartz Report. In this area of activity, measurements were taken primarily in dry screening installations; the release of dust in such installations is greater than in those for the corresponding wet processes. Personal measurement results indicate that the GDLV is met.

6.3.3 Preparation: mixing, drying

Measures must be taken to ensure adequate dust removal, particularly during tasks involving the drying of sand and mixing of different particle fractions. Compliance with the GDLV is not assured at the 90th percentile when tasks are performed during running operation. It should be noted that workers do not need to be present in the vicinity of these plants for longer periods, as the plants are operated fully automatically.

Table 6.3.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	23	18	4 (17.4%)	0.71	91.3	8.7	1.03	3.556	9.476
≥ 2 h	Static	20	15	3 (15%)	0.25	90	10	1.73	10	17.6
Respirable dust										
≥ 2 h	Personal	22	18	8 (36.4%)	0.25	95.5	4.5	0.26	0.654	0.904
≥ 2 h	Static	21	15	4 (19%)	0.18	85.7	14.3	0.225	1.82	2.09

Table 6.3.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	29	18	3 (18%)	0.71	86.2	13.8	1.745	13.51	20.09
≥ 2 h	Static	27	16	1 (3.7%)	0.71	96.3	3.7	1.355	7,289	9.544
Respirable dust										
≥ 2 h	Personal	34	22	10 (29.4%)	0.25	82.4	17.6	0.43	1.742	2.754
≥ 2 h	Static	25	15	5 (20%)	0.18	92	8	0.34	1.005	1.26
< 2 h	Static	7***	2**	0	n/a	28.6	71.4	=- Values: 0.17 to 6.15		

6.3.4 Preparation: comminution (crushing/grinding)

Comminution (crushing, grinding) is also associated with high exposure to respirable dust, as had already been shown by the evaluation in the 2005 Quartz Report. A large part of the measurements concern the production of crushed gravel, for example by the use of cone crushers. It should be noted that workers do not need to be present in the vicinity of crushers for longer periods, as they are operated fully automatically.

This is ruled out in any case for noise protection reasons. Dust exposure determined statically therefore provides indications of local elevated exposure, which must be taken into account by plant fitters and by personnel performing inspection rounds.

Dust problems arise on a considerable scale when crushing or grinding plant is housed within unitary preparation plants rather than being encapsulated separately. Dust exhaust systems with the required effectiveness can rarely be implemented in such cases.

Table 6.3.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	21	15	4 (19%)	0.71	90.5	9.5	1.695	8.012	15.805
≥ 2 h	Static	28	20	0	n/a	85.7	14.3	2.78	11.24	16.82
Respirable dust										
≥ 2 h	Personal	21	15	6 (28.6%)	0.25	85.7	14.3	0.405	2.27	2.457
≥ 2 h	Static	28	21	1 (3.6%)	0.21	71.4	28.6	0.46	1.66	2.13
< 2 h	Static	12	3**	0	n/a	8.3	91.7	4.56	10.454	10.98

Figure 1: Crushing plant in a gravel works

6.3.5 Filling, packing

The arrangements for dust exhaust correspond to the state of the art at workplaces on filling (bagging) and packing machines. Compliance with a workplace concentration at the 90th percentile is nevertheless not always assured if manual or semi-automated filling activities involve plant technology in which, for example, displaced air containing fine fractions is released in the breathing zone of the worker and regular cleaning work is required.

Table 6.3.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	30	17	6 (20%)	0.71	90	10	2,02	9	12.8
≥ 2 h	Static	31	17	3 (9.7%)	0.71	100	0	0.935	3.357	4.88
Respirable dust										
≥ 2 h	Personal	31	17	5 (16.1%)	0.25	83.9	16.1	0.51	1.626	1.917
≥ 2 h	Static	29	17	8 (27.6%)	0.25	96.6	3.4	0.335	0.855	0.911

6.4 Extraction and processing of natural stone and other raw materials

Sector
Minerals and earths (e.g. natural stone, raw clay), extraction
Natural stone (excluding limestone), gypsum, chalk, slate, extraction
Slate, extraction
Minerals and earths (other), extraction
Fluorite, feldspar, barite, silica, extraction
Natural stone, general processing
Minerals, other, processing
Natural stone, extraction

The rock freed from the rock mass by blasting or excavation is prepared in several stages in crushing and sizing plant to form the end products of crushed rock, chippings and rock flour. The material is first pre-crushed in a primary crusher and the coarse fractions are separated off. The various particle fractions are produced in the subsequent secondary crushing and screening stages and are then stored either on outdoor stockpiles or in silos. The level of dust generated generally increases with progressive comminution of the mineral raw material.

Workplaces involving dust exposure may be encountered:

- At the extraction stage during drilling work for production of the blast charge, and on conveying and loading equipment (excavators, wheel loaders, heavy goods vehicles)
- During material processing in open and encapsulated installations
- During loading of the finished products

With the exception of the extraction process, work performed in quarries is now virtually completely automated. Within the preparation plant, working tasks essentially involve checks, monitoring and maintenance tasks to ensure the continuity of operation. High levels of exposure particularly occur when personnel enter enclosed preparation plant for longer periods to perform checks and clear faults. Persons may enter such plant only with respiratory protection, and the time spent within them should be kept to an absolute minimum. Crusher operators at the control station or in a cabin may also be exposed to high concentrations of dust if the ventilation at these points is inadequate.

The trend in the measured values since 1972 (refer to the 2005 Quartz Report) shows that the use and improvement of dust removal measures at workplaces has resulted in the dust exposure being significantly reduced. Only for tasks in preparation are the measured data not consistent with the trend. This is attributable to the fact that for environmental reasons, preparation plants are now increasingly encapsulated. Despite the dust removal measures taken, high dust concentrations therefore arise within the plants. Permanently manned workplaces are however not found in these areas. Dust exposure levels determined statically thus provide indications of local increases in exposure, which must be considered for example by plant fitters and personnel performing inspection rounds at certain points of the plants.

Figure 2: Natural stone drilling rig with closed cab

6.4.1 Extraction

This body of data encompasses activities in quarries that are associated with extraction, such as the use of drilling gear to produce the blast holes for extraction blasting, secondary drilling, and operation of the extraction and conveying plant such as excavators, wheel loaders and heavy trucks. Natural stone businesses frequently process a part of their rock resources to produce paving and wall stones, or raw blocks from which construction elements may in turn be produced.

This summary includes the results of measurements taken during manual stone-splitting with pneumatic chisels, mechanized stone-splitting and other work such as sawing, drilling, milling, chiselling or grinding. Elevated dust exposure occurs in particular during these activities, as a result of which compliance with the permissible workplace concentration at the 90th percentile for the respirable dust fraction is not always ensured. Vehicle drivers are subject to considerably lower exposures, as they work in the closed cabs of loading or conveying equipment, which are usually equipped with facilities for dust control.

Pneumatic hand tools used during drilling, secondary blasting and splitting operations may present problems, since dust removal equipment at mobile workplaces, such as on site in the quarry, can track the work only with difficulty. Dust removal facilities on mobile hydraulic drills for the production of blast holes are state of the art; dust exposure can thus at least be limited.

Table 6.4.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	85	49	25 (29.4%)	0.74	96.5	3.5	0.985	4.645	9.055
≥ 2 h	Static	19	12	2 (10.5%)	0.71	94.7	5.3	1.72	5.601	5.965
Respirable dust										
≥ 2 h	Personal	87	49	37 (42.5%)	0.25	88.5	11.5	0.275	1.41	1.716
≥ 2 h	Static	30	14	7 (23.3%)	0.25	83.3	16.7	0.35	1.39	1.435

Figure 3: Use of a pneumatic hammer to split natural stone

6.4.2 Preparation

Preparation includes comminution of the mineral raw materials in crushing and milling plant, sizing to the desired particle fractions, and where required, washing and drying of the material.

The dry method is generally used for processing in quarry operations. In order to prevent dust pollution, many installations are therefore fully encapsulated, and equipped with complex dust exhaust facilities, for example at transfer points between conveyors and at conveyor discharge points, and on crushers and screening machines. Scope for the use of water to control dust is often limited, for example for jetting at the crusher intake, sprinkling of stockpiles, and at transfer points during loading for transport.

Comminution (crushing, milling) has been associated with high exposure to respirable and inhalable dust for many years. The GDLVs are often exceeded. Longer periods need not be spent in the vicinity of crushing and milling plants, since they are operated fully automatically; presence in these areas is also prohibited owing to the noise exposure. Dust exposure determined statically therefore provides indications of local elevated exposures, affecting plant fitters and personnel performing inspection rounds, for example. Persons may enter such plant only with respiratory protection, and the time spent within them should be kept to an absolute minimum.

Table 6.4.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	84	49	1 (1.2%)	0.46	76.2	23.8	3.55	33.88	57.74
≥ 2 h	Static	87	51	7 (8%)	0.71	80.5	19.5	2.085	19.09	22.98
< 2 h	Static	6 ***	2 **	0	n/a	50	50	=-Values: 0.75 to 46.4		
Respirable dust										
≥ 2 h	Personal	81	49	13 (16%)	1.22	71.6	28.4	+ 0.77	2.836	6.109
< 2 h	Static	78	45	22 (28.2%)	0.79	75.6	24.4	+ 0.46	2.262	3.203
< 2 h	Static	16	5	1 (6.3%)	0.36	18.8	81.3	2.65	5.09	7.464

6.4.3 Filling, storing, packing, weighing out

During the preparation of natural stone, rock flour is produced as a by-product of fine screening and filtration. Where it is not loaded directly from the silo into silo wagons, the rock flour is bagged in sacks or FIBCs. The bagging and packing installations are comparable to similar installations in the cement and lime industry and present similar issues of dust control when operated manually or semi-automatically. The area of activity encompasses placing the finished products in storage in silos or on stockpiles, and weighing them out and loading them onto vehicles. Personnel responsible for operating silo loading installations, which often form part of the preparation installations and beneath which goods vehicles pass, may be exposed to dust outside the enclosed control cabin, for example during inspection rounds within the installation in the vicinity of the loading point and in the silo portal. Conversely, use of a wheel loader for the loading of stockpiles involves considerably lower dust exposure for its operator, who remains within the enclosed cab of the loader, which generally features measures for dust control.

Figure 4: Inspection round in the ballast transfer area

The substantial difference between the 50th and 90th percentile values is due to the wide variation in the technical design of loading equipment (loading conveyor, loading nozzle, free-fall loading, with or without dust exhaust or spraying with water). Low measured values are associated with loading methods featuring effective dust exhaust or water spraying; high values are encountered with loading methods featuring less effective dust control.

Table 6.4.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	26	19	4 (15.4%)	0.71	80.8	19.2	2.97	12.28	14.15
≥ 2 h	Static	35	25	6 (17.1%)	0.71	80	20	1.45	12.25	15.325
< 2 h	Personal	8 ***	4 **	0	n/a	25	75	=-Values: 0.6 to 24.2		
Respirable dust										
≥ 2 h	Personal	30	20	7 (23.3%)	0.25	80	20	0.45	1.53	2.27
≥ 2 h	Static	32	24	10 (31.3%)	0.25	100	0	0.33	0.964	1.068
< 2 h	Personal	9 ***	5	0	n/a	33.3	66.7	=-Values: 0.58 to 3.68		
< 2 h	Static	12	6	0	n/a	8.3	91.7	1.92	6.732	7.574

6.5 Natural cut stone industry – production, processing and working of natural cut stone, stone masonry

Sector
Minerals and earths (excluding heavy ceramics, excluding manufacture of abrasives), processing
Natural stone, processing
Natural (cut) stone, excluding stone sculpture and stone masonry, processing
Natural cut stone, production
Stone sculpture, stone masonry
Slate, minerals and earths, processing
Natural stone, working and processing

Quarried raw stone blocks are split into smaller units, down to bricks and paving stones, before they leave the quarry or stoneworks, or are cut on stone-cutting machines to form semi-finished products in the form of slabs or ashlars. Further shaping and surface work for production of the end products is generally carried out by specialist stoneworking companies.

Both wet and dry processes are employed in stoneworking. Wet processes are performed primarily on stoneworking machines such as cutting-off, surfacing and milling machines. The bits of these tools, which are generally diamond-tipped, are water-cooled. This has the simultaneous effect of reducing the quantity of dust released. Conversely, methods such as chiselling, bossage, charring, splitting with hand-held pneumatic hammers, abrasive cutting-off, and the grinding of surfaces with hand-held electric tools such as angle grinders, are performed dry. It should be noted in particular that comminution processes involving fast-rotating tools, such as abrasive cutting-off, polishing or bush-hammering, cause heavy shattering of the natural cut stone, and thus produce higher dust concentrations than do manual coarse comminution processes, such as manual chiselling.

6.5.1 Bossage, charring, bush-hammering

These techniques are used to prepare the surfaces and edges of workpieces by dry methods. Both pneumatic hand-held machines and stationary machines are used. Bush-hammering and charring cause heavy shattering of the grain on the surfaces being worked, resulting in high dust exposures. Bossage generates less dust, as only smaller areas of the workpiece are removed, such as the edges. The majority of machines currently in use feature state-of-the-art dust exhaust equipment. The dust collection equipment is subject to extremely high wear and in some cases is limited in its volume, with the result that the exhaust efficiency drops if maintenance is inadequate. As shown in the table, compliance with the permissible workplace concentrations at the 90th percentile is ensured neither for the respirable nor the inhalable dust fractions during bush-hammering and charring. Since neither the machines nor the dust removal equipment have undergone significant technical improvement in recent decades, measurements tend to be performed in areas of activity in which the dust conditions are clearly unfavourable.

Figure 6: Manual working of natural cut stones: bossage

Table 6.5.1

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	15	11	1 (6.7%)	0.69	73.3	26.7	2.005	27.9	39.075
Respirable dust										
≥ 2 h	Personal	16	12	3 (18.8%)	0.25	75	25	0.52	4.866	6.426

Figure 7: Manual working of natural cut stones: bush-hammering

Where water is applied at the machining point for cooling of the cutting segments during sawing and milling, it has the simultaneous effect of reducing dust emissions, since it binds and precipitates the dust. High-speed tools cause water spray and aerosols to be formed. These contain respirable dust particles which may be inhaled by the machine operator. The level of the respirable dust concentration is dependent upon the quality of conditioning of the recirculated water and the scale of aerosol and water spray formation. Facilities on the machines for capturing and precipitating the water spray and aerosols and for purifying the water to drinking water quality are now state of the art. Exposures to respirable and inhalable dust lie below the GDLV. Further reductions in exposure can be attained with the use of dust collection systems.

6.5.3 Stone splitting

High dust concentrations arise during the use of pneumatic hammers for manual stone-splitting, despite the tools generally featuring dust exhaust equipment. The rubber noses on the chisel for production of the lewis holes are subject to very heavy wear, with the result that efficacy of the exhaust is reduced if maintenance is inadequate. Effective dust removal on stationary stone-splitting machines is less difficult; in this case, the dust is exhausted through collection elements on the upper blade, or through suction intakes in the machine's stand.

The results of measurements for splitting work carried out in weatherproof enclosures, which generally lack dust control measures, are significantly worse than those carried out indoors or in the open air (in which the concentrations are lower). Respirable and inhalable dust exposures thus lie below the GDLV, provided they are not measured in enclosures.

Table 6.5.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	73	43	20 (27.4%)	0.71	98.6	1.4	0.945	2.95	3.74
≥ 2 h	Static	57	41	3 (5.3%)	0.69	98.2	1.8	0.755	3.178	5.386
Respirable dust										
≥ 2 h	Personal	89	48	27 (30.3%)	1.25	89.9	10.1	+ 0.375	+ 1.186	2.224
≥ 2 h	Static	60	43	35	0.24	90	10	0.39	1.05	1.51

Table 6.5.3

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	125	37	14 (11.2%)	0.71	84.8	15.2	2.46	14.25	22.4
≥ 2 h	Static	36	23	0	n/a	97.2	2.8	0.77	3.138	3.86
Respirable dust										
≥ 2 h	Personal	125	37	27 (21.6%)	0.25	79.2	20.8	0.52	2.125	2.63
≥ 2 h	Static	37	24	3 (8.1%)	0.07	97.3	2.7	0.285	0.684	0.916

Table 6.5.3 a

Duration of sampling	Point of measure-ment	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Outdoors	52	24	9 (17.3%)	0.71	90.4	9.6	1.59	8.49	13.58
≥ 2 h	Indoors	11	7	0	n/a	90.9	9.1	1.49	5.57	13.883
≥ 2 h	In enclo-sures	57	14	4 (7%)	0.69	77.2	22.8	3.875	18.23	26.495
Respirable dust										
≥ 2 h	Outdoors	52	24	17 (32.7%)	0.25	88.5	11.5	0.31	1.358	4.112
≥ 2 h	Indoors	12	7	2 (16.7%)	0.25	91.7	8.3	0.49	1.186	4.272
≥ 2 h	In enclo-sures	56	14	7 (12.5%)	0.25	67.9	32.1	0.79	2.142	2.446

Figure 8: Mechanized splitting of stone blocks

6.5.4 Chipping, chiselling off

Both pneumatic and electric hand-held machines are used in these working methods. Dust generated during manual working is collected by various types of workplace dust exhaust equipment (positionable exhaust funnels, suction walls). In many cases however, the design and maintenance of this equipment requires improvement, since despite workplace dust exhaust, 90th percentile values for both the respirable and inhalable dust fractions occur here that substantially exceed the GDLV. Since neither the machines nor the dust removal equipment have undergone significant technical improvement in recent decades, measurements tend to be performed in areas of activity in which the dust conditions are clearly unfavourable.

Table 6.5.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	76	45	4 (5.3%)	0.71	60.5	39.5	7.1	32.6	40.54
≥ 2 h	Static	38	28	3 (7.9%)	0.28	97.4	2.6	2.19	6.31	7.76
< 2 h	Personal	10	7	0	n/a	80	20	3.07	17	66.5
Respirable dust										
≥ 2 h	Personal	86	47	15 (17.4%)	1.25	61.6	38.4	+ 0.87	5.16	7.182
≥ 2 h	Static	40	29	7 (17.5%)	0.11	90	10	0.42	1.08	3.12
< 2 h	Personal	12	7	5 (41.7%)	0.5	66.7	33.3	0.59	5.84	19.3

6.5.5 Abrasive blasting

The use of blasting machines equipped with exhaust facilities to blast natural stone surfaces, for example for the surface treatment of natural stone slabs, significantly reduces the dust concentrations compared to the conventional dry, free-jet blasting process. The respirable and inhalable dust exposures nevertheless generally exceed the GDLV to such an extent that particle-filtering respiratory protective devices may be required in addition to state-of-the-art dust collection equipment.

6.5.6 Grinding

In both data collectives, a distinction is drawn between manual and mechanized grinding for surface treatment. Manual grinding is generally performed by means of hand-held electric or pneumatic machines (angle grinders). Mechanized grinding is performed on stationary grinding machines or machining centres.

The surfaces of materials in slab form are generally worked by means of the wet method; this results in lower dust exposure compared to the dry method. Owing to the formation of aerosols, high dust concentrations may however also occur during wet grinding. The criteria for conditioning of the recirculated water during sawing and milling (see above) also apply to grinding (see Section 6.5.2).

Dry work performed with angle grinders without dust exhaust leads to extremely high dust exposure. The historical trend for the dust concentration shows a steady drop in the dust exposure during tasks involving these tools. This is attributable to the increased use of dust removal facilities in the form of various types of machine and workplace dust exhaust systems, particularly on stationary installations. Dust exhaust facilities on these machines are however rare, particularly in mobile use; the same trend is not therefore observed for manual machines. The respirable and inhalable dust exposures generally exceed the GDLV to such an extent that particle-filtering respiratory protective equipment is required, as well as state-of-the-art dust collection equipment.

Table 6.5.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	16	11	2 (12.5%)	0.71	81.3	18.8	1.74	17.9	23.88
≥ 2 h	Static	11	8	0	n/a	90.9	9.1	1.69	6.658	12.209
Respirable dust										
≥ 2 h	Personal	15	11	4 (26.7%)	0.25	80	20	0.435	4.2	4.518
≥ 2 h	Static	11	8	1 (9.1%)	0.08	81.8	18.2	0.38	1.455	3.224

6.5.6.1 Grinding, manual

Table 6.5.6.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	48	29	3 (6.3%)	0.71	79.2	20.8	4.3	15.38	22.48
≥ 2 h	Static	23	19	1 (4.3%)	0.6	95.7	4.3	1.355	6.503	8.448
< 2 h	Personal	7 ***	5	2 (28.6%)	2.6	85.7	14.3	=-Values: 1.59 to 19.5		
< 2 h	Static	6 ***	4 **	0	n/a	83.3	16.7	=-Values: 1.24 to 18.3		
Respirable dust										
≥ 2 h	Personal	49	30	1 (2%)	0.24	57.1	42.9	1.09	5.323	7.719
≥ 2 h	Static	23	19	1 (4.3%)	0.21	82.6	17.4	0.44	1.471	2.568
< 2 h	Personal	7 ***	5	4 (57.1%)	0.91	71.4	28.6	=-Values: 1.16 to 3.63		
< 2 h	Static	6 ***	4 **	0	n/a	83.3	16.7	=-Values: 0.25 to 2.31		

Table 6.5.6.1 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	30	19	0	n/a	73.3	26.7	5.08	15.2	21.85
≥ 2 h	LEV = no	11	9	3 (27.3%)	0.71	81.8	18.2	0.835	15.356	39.005
Respirable dust										
≥ 2 h	LEV = yes	31	20	0	n/a	45.2	54.8	1.42	6.547	7.701
≥ 2 h	LEV = no	11	9	1 (9.1%)	0.24	72.7	27.3	0.495	2.764	11.428

6.5.6.2 Grinding, mechanical

Table 6.5.6.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	28	20	1 (3.6%)	0.7	85.7	14.3	2.75	14.96	26.18
≥ 2 h	Static	22	20	1 (4.5%)	0.69	90.9	9.1	1.61	4.208	10.233
Respirable dust										
≥ 2 h	Personal	28	20	1 (3.6%)	0.25	71.4	28.6	0.89	1.694	2.098
≥ 2 h	Static	22	20	0	n/a	77.3	22.7	0.58	1.846	2.841

Figure 9: Mechanized wet grinding of natural cut stones

6.5.6.3 Grinding, other

Supplementary evaluations of the surface treatment of natural stone by grinding also reveal high dust exposures, which have already been discussed above.

Table 6.5.6.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	26	17	1 (3.8%)	0.55	76.9	23.1	3.31	26.74	32.46
≥ 2 h	Static	10	9	0	n/a	90	10	1.03	9.11	18.505
< 2 h	Personal	7 ***	3 **	0	n/a	14.3	85.7	=-Values: 3.1 to 114		
Respirable dust										
≥ 2 h	Personal	28	17	2 (7.1%)	0.25	57.1	42.9	0.76	3.656	5.662
≥ 2 h	Static	10	9	1 (10%)	0.25	80	20	0.3	1.56	1.595
< 2 h	Personal	5 ***	2 **	0	n/a	20	80	=-Values: 0.58 to 5.35		

6.6 Mineral grinding plants (earth pigments)

Sector
Mineral grinding plants (earth pigments)
Enamel, production

Natural minerals such as bauxites, chrome ores, iron ores, magnesites and feldspars are processed in crushing, screening, drying and grinding installations to form products with a particle size of < 10 µm. These products are used in the iron and steel industry, foundries and the glass and chemical industries, for example for the production of refractory materials.

The preparation of these mineral raw materials involves the same methods and discrete tasks as those described for the extraction and preparation of natural stone. The comments made there apply here by analogy. The areas of mixing, filling (bagging) and packing are comparable to those in the cement and lime industry with regard to the installations and processes employed. Elevated dust exposures may therefore arise, particularly on crushing and grinding installations and during bagging.

Despite a considerable drop in dust exposure across the entire sector in recent decades (refer to the 2005 Quartz Report), which has been achieved by the application and improvement of dust removal measures, the GDLV is occasionally exceeded in personal measurements.

Table 6.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	37	15	3 (8.1%)	0.71	86.5	13.5	2.23	10.42	12.605
≥ 2 h	Static	26	9	0	n/a	92.3	7.7	1.34	8.228	13.213
Respirable dust										
≥ 2 h	Personal	38	17	8 (21.1%)	0.25	71.1	28.9	0.62	1.806	2.509
≥ 2 h	Static	24	8	4 (16.7%)	0.18	79.2	20.8	0.36	1.678	1.874

6.7 Gypsum products, insulating and lightweight building panels, production

Sector
Gypsum products (general), production
Gypsum products (e.g. plasterboard), production
Insulating and lightweight panels (mineral-bonded), production
Insulating and lightweight panels (resin-bonded), production

Gypsum as a raw material is obtained primarily by mining in the form of gypsum rock (natural gypsum) above and below ground, but also occurs as a by-product in flue gas desulfurization (flue gas desulfurization gypsum) and in the production of hydrogen fluoride solution. Gypsum products are used in the construction industry as plasters and dry screeds, as primers, for fire protection, as fillers and in the form of plasterboard. Gypsum is also sold for use in medical and food products. The data collectives presented here exclude the actual extraction of gypsum by mining.

Following comminution by impact or hammer mills for attainment of defined particle sizes and grading curves, the gypsum rock is heated (calcined) in a rotary kiln, hot gas stream plant, continuous mesh belt furnace, kettle calciner or combined grinding and drying system and refined according to the needs of the specific product. A range of building material gypsums are produced by these means. Autoclaves are also used for the production of specific gypsum products. Following the addition of chemicals, the products (gypsum dry mortar) are usually bagged in the desired quantities on fully automatic metering and packing installations, or loaded in bulk form into transportable site hoppers.

Gypsum boards, gypsum fibre boards and gypsum wallboards are used as building elements in interior construction. Gypsum boards are manufactured on continuous belts incorporating a drying process, and consist of a gypsum core and a firmly adhering paperboard sheath. Gypsum fibreboards consist of gypsum and paper fibres, which are evenly distributed in the structure. The paper fibres are recovered during the recycling of waste paper. Solid gypsum wallboards are produced in stainless steel moulds. Unlike plasterboard, they consist of homogeneous plaster.

Dust exposure occurs during comminution and cleaning processes, during bagging (normally performed on semi-automated valve bagging machines with one or more spouts), and during batch changes. Whereas tasks on bagging installations are generally stationary, workers in gypsum product manufacture, such as plant fitters or personnel performing inspection rounds, generally move around and are subject to mixed exposure in all areas of production.

The data collectives of personal mean shift-based exposures reveal values below the GDLV, generally with mixed exposure. Higher dust exposures may occur at operating points that are not permanently manned, as is shown both by the data from static measurements and by data collected over measurement durations of < 2 hours. It should be noted that measurements of < 2 hours in duration are taken for prevention purposes during individual activities such as manual input or dry grinding. The dust conditions during these activities are evidently unfavourable, and allowance may not have been made in all data for soluble components of the dust exposure.

Table 6.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	33	15	2 (6.1%)	0.71	100	0	1.245	5.228	6.701
≥ 2 h	Static	46	14	3 (6.5%)	0.71	89.1	10.9	1.09	9.838	10.84
< 2 h	Personal	15	4 **	1 (6.7%)	1.5	53,3	46.7	5.45	38.05	48.975
Respirable dust										
≥ 2 h	Personal	29	14	8 (27.6%)	0.71	93.1	6.9	+ 0.347	0.892	1.33
≥ 2 h	Static	49	17	12 (24.5%)	1.23	83.7	16.3	+ 0.335	1.607	2.256
< 2 h	Personal	15	4 **	5 (33.3%)	15	33.3	46.7	+ 2.22	+ 13.65	23.125
< 2 h	Static	12	4 **	3 (25%)	1.26	50	41.7	+ 1.02	1.526	1.972

6.8 Asphalt mixing plants

Sector
Asphalt mixing plants
Bituminous mixed product, manufacture (in asphalt mixing plants)

Asphalt is manufactured by the mixing of a pre-dried mineral mixture, employing bitumen as the binder and further additives, in a mixer. The mix components are charged and mixed within a largely enclosed and automated system. The mixing process is controlled from a control panel located away from the installation. Personnel need not be present during the production process. Exceptions are:

- Manual charging of additives
- Inspection rounds
- Clearing of unanticipated faults

Encapsulated mixing plants with fully enclosed mixing tower and central dust exhaust facility for the removal of dust deposits are the state of the art.

Workers manning the closed mixing tower during production are exposed to high levels of dust. Dust sources include screening machines and the transfer points for the metering in of minerals. Inspection rounds generally involve less than one hour's presence in the installation per shift. Exposure is thus reduced to one-eighth of the values indicated. Conversely, the wheel loader is used on the site during the entire shift for transport to and charging of the metering funnels. With the exception of the fine filler materials, the minerals are stored on the site in stockpiles. The driver remains within the closed cab of the wheel loader throughout the transport and charging processes.

Figure 10: Dry drum of an asphalt mixing plant

Table 6.8

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	26	15	9 (34.6%)	0.71	92.3	7.7	+ 0.51	6.538	10.674
≥ 2 h	Static	18	13	1 (5.6%)	0.27	100	0	0.53	1.426	2.775
Respirable dust										
≥ 2 h	Personal	29	17	15 (51.7%)	1.23	93.1	6.9	! LOD	+ 0.75	1.691
≥ 2 h	Static	19	13	5 (26.3%)	0.47	94.7	5.3	+ 0.215	0.61	1.162

6.9 Production of cement and lime

Sector
Cement and cementitious binders, production
Cement, production
Cement works
Cement grinding plant
Lime, production
Fertilizer lime, production

Limestone extracted in quarries is comminuted in crushers, then placed in intermediate storage. This is followed by raw mix preparation by means of drying, grinding to raw meal in cone mills, and possibly also granulation. The raw material – raw meal or raw-meal granulate – is heated to approximately 1,400 °C in rotary kilns and fired in the sintering zone to form cement clinker. Once it has cooled, the clinker is ground in cone mills in a further grinding process with the addition of certain additives to produce various types of cement. It is then stored in silos. A large part of the final cement is loaded in bulk into tanker trailers. The remainder is filled into paper sacks on bagging machines or into FIBCs.

In contrast to cement manufacture, limestone is generally heated in annular shaft kilns. The coarsely comminuted limestone is heated just sufficiently for the carbon dioxide bound within it to be expelled. The further production steps are comparable to those for cement manufacture.

Processes in modern cement and lime works are largely automated; only monitoring tasks, maintenance, and repair work for the clearing of faults need therefore be performed. Raw mix preparation, heating and grinding are controlled from an air-conditioned control station. Workers performing inspection rounds, maintenance personnel, and plant operators in certain parts of plants which are not controlled from the control panel, such as in cement bagging and loading for transport, are assumed to be subject to dust exposure.

Modern cement and lime works feature effective dust removal equipment in the relevant plant areas, not least for environmental reasons. Parts of plants generating high levels of dust (such as cement mills) are generally situated in enclosed buildings, or are equipped with effective state-of-the-art dust exhaust facilities at the points of input, transfer and discharge. Electrofilters are generally used for dust collection in rotary kilns and annular shaft kilns. Filler necks with dust exhaust – supplementing the usual dust removal measures on cement bagging machines – now serve as a benchmark. The compiled exposure data, particularly those from personal measurements, reveal significant violations of the GDLV.

Table 6.9

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	145	49	10 (6.9%)	0.71	77.2	22.8	3.7	20.5	46
≥ 2 h	Static	93	33	28 (30.1%)	0.71	95.7	4,3	+ 0.7	4.885	7.327
< 2 h	Personal	9 ***	8	3 (33.3%)	3.9	77.8	22.2	=-Values: 2.96 to 22.8		
Respirable dust										
≥ 2 h	Personal	121	41	29 (24%)	0.25	76.9	23.1	0.565	2.497	3.651
≥ 2 h	Static	111	36	46 (41.4%)	0.25	90.1	9.9	0.25	1.17	1.882
< 2 h	Personal	10	8	2 (20%)	1	50	50	1,11	3.18	5.175

6.10 Production of dry construction materials

Sector
Mortar, production
Ready-mixed plaster, production
Ready-mixed mortar, production
Special mortar, production
Gypsum, calcined, production
Perlite (expanded), production

Dry mortars and ready-mixed plasters, such as grouting compounds, concrete surfacers and interior and exterior plasters, are produced from cement, lime, gypsum, sand, and additives such as organic polymers, swelling agents and fibres which lend them particular product properties.

Central dust exhaust installations are the state of the art in the production plants. Frequent product changeovers with the resulting need for cleaning and the manual feeding of certain additives into the material flow may cause dust to be released which then leads to elevated concentrations. Industrial vacuum cleaners are therefore available for localized cleaning of workplaces and installations.

6.10.1 Metering, mixing, drying

Dust exposure frequently occurs during the sand drying and dry mixing processes, particularly during filling and emptying of the mixers, and during the manual addition of mix components. Vacuum dust removal technology for manual infeed and semi-encapsulated conveyor systems is the state of the art. The dust exposures nevertheless substantially exceed the GDLV; it must however be taken into account that measurements tended to be taken in parts of installations with scope for optimization of the dust situation.

Table 6.10.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	32	20	1 (3.1%)	0.67	68.8	31.3	5.36	16.98	25.62
≥ 2 h	Static	16	11	0	n/a	100	0	1.82	4,852	5.812
Respirable dust										
≥ 2 h	Personal	34	23	2 (5.9%)	0.25	52.9	47.1	1.1	3.042	3.932
≥ 2 h	Static	21	13	1 (4.8%)	0.25	71.4	28.6	0.82	2.083	2.68
< 2 h	Static	5 ***	3 **	0	n/a	20	80	=-Values: 1 to 12.01		

6.10.2 Filling, packing

The final products are filled and packed by means of rotary packing machines and manually operated bagging machines. In the production of dry mortar and ready-mixed plasters, exposure to dust occurs at workplaces at which finished products are bagged or otherwise packed manually or semi-automatically, and during cleaning operations. In the area of loading and transport, measurements were primarily performed during mixed tasks involving combined bagging and palletizing and also handling by fork-lift truck in storage areas, since these production areas are closely connected. Under normal circumstances, dust is not released during the bulk loading of tanker trailers.

Despite continuous improvements in recent years (refer to the 2005 Quartz Report), the exposure data, particularly from personal measurements, show significant violations of the GDLV for the respirable dust fraction, particularly during semi-automated bagging.

Figure 11: Bagging of ready-mixed plaster

Table 6.10.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) \$	> LV (%) \$	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	98	55	4 (4.1%)	0.71	87.8	12.2	3.04	11.84	16.33
≥ 2 h	Static	69	44	0	n/a	95.7	4.3	1.83	6.92	8.713
< 2 h	Personal	8 ***	6	0	n/a	87.5	12.5	=-Values: 4.34 to 37.8		
Respirable dust										
≥ 2 h	Personal	100	56	6 (6%)	0.68	66	34	0.85	2.38	3.5
≥ 2 h	Static	70	45	3 (4.3%)	1.11	82.9	17.1	+ 0.46	1.45	1.94
< 2 h	Personal	8 ***	7	2 (25%)	0.94	75	25	=-Values: 0.43 to 4.28		

6.10.3 Storage, transport, loading

The mixed activities of packing, order picking, palletizing, transport with forklift trucks and loading of bulk and packaged products reveal significant violations of the GDLV for exposure to the respirable dust fraction.

Figure 12: Packing and loading of ready-mixed plaster on pallets

Table 6.10.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	30	25	0	n/a	86.7	13.3	3.19	11.3	14.65
≥ 2 h	Static	15	13	2 (13.3%)	0.71	100	0	0.85	5.315	6.857
< 2 h	Personal	11	8	0	n/a	63.6	36.4	6.795	39.19	82.5
Respirable dust										
≥ 2 h	Personal	36	26	9 (25%)	0.91	77.8	22.2	+ 0.65	2.364	2.738
≥ 2 h	Static	18	15	4 (22.2%)	0.25	77.8	22.2	0.29	1.536	2.847
< 2 h	Personal	11	8	2 (18.2%)	0.42	45.5	54.5	1.255	1.873	7.919

6.11 Concrete industry (stationary operations)

Sector
Concrete products, excluding prefabricated elements, production
Concrete products, production and processing
Cut concrete blocks, production
Concrete slabs, production
Concrete blocks, production
Concrete pipes and manholes, production
Roof tiles, production
Precast concrete elements, production
Lightweight panels, cement-bonded, production
Aerated concrete blocks, production
Large prefabricated concrete elements for buildings construction, production
Ceiling and wall elements, production
Prefabricated garages etc., production
Ready-mixed concrete and mortar, production
Cut concrete blocks, working and processing

Concrete is produced in mixing plant from gravel, sand, cement, water, certain additives for modification of the flow and setting properties, and in some cases pigments. Depending upon the intended subsequent processing, its consistency ranges from earth-moist to liquid. The concrete is shaped in concrete block machines or on vibrating tables to produce the final product, or in wooden or steel formwork for the production of large concrete elements. It is compacted by vibration, compression or tamping. In order for the tensile strength and stability of certain concrete products to be increased, they are armoured with steel, which is laid into the formwork before the concrete is poured in.

Dust may be released during comminution of the mineral substances, particularly during vibration and tamping of the earth-moist concrete mixture. Exposure, possibly high, to dust also occurs during finishing of the cured concrete products, when burrs or faults are dry-ground off or out, surfaces smoothed, or recesses produced by drilling, sawing, milling or chiselling. The dust exposure in a concrete works is dependent essentially upon regular cleaning of the production areas, i.e. the removal of loose residue and dust deposits. Should these not be removed regularly, dust is raised again.

The situation in mobile concrete installations is the same as that in concrete works, as the same technology is employed. Work processes during cleaning of the mixer, such as removal of the concrete or cement deposits or removal of adhering concrete residue by means of pneumatic or electric hammers, are also among the mixed tasks performed by the plant driver; these are however generally only occasional tasks of brief duration. High dust concentrations may arise here which necessitate the wearing of respiratory masks.

The bodies of measurement data from the stationary areas of activity in the concrete industry are shown below, differentiated by activity or area of activity.

6.11.1 Concrete mixing

Stationary mixing machines are of encapsulated design and are controlled automatically; the area in which they are housed is not therefore permanently manned. They are exhausted, or connected to dust filters for ventilation of the displaced air occurring during the filling process.

The data collectives contain measurement results for partly to fully automated mixers. Measurements were conducted primarily on mixers with dust removal facilities and during activities associated with production of the concrete mix, such as the manual infeed of additives, and also during inspection rounds on mixing installations, possibly involving cleaning tasks.

The percentiles of the measured data show isolated clear violations of the GDLV for the respirable dust fraction. It should be noted that for reasons of prevention, measurements tend to be performed in areas of activity in which the dust conditions are evidently unfavourable.

Table 6.11.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	14	12	1 (7.1%)	0.71	85.7	14.3	1.71	8.868	12.12
≥ 2 h	Static	30	23	3 (10%)	0.71	100	0	0.89	2.78	3.885
Respirable dust										
≥ 2 h	Personal	16	13	3 (18.8%)	0.66	81.3	18.8	+ 0.39	2.816	3.478
≥ 2 h	Static	43	25	7 (16.3%)	0.85	90.7	9.3	+ 0.27	1.035	6.415
< 2 h	Personal	9 ***	4 **	4 (44.4%)	3.28	55.6	11.1	=-Values: 0.33 to 5.38		

6.11.2 Production of concrete products and precast concrete elements

Following production of the concrete, it is shaped in concrete block machines or on vibrating tables on which the final product is produced, such as paving stones, kerbstones, slabs, pipes, tubbing rings or slatted floors for cowsheds; or in wooden or steel formwork for the production of large concrete elements such as stays, girders, wall elements and filigree floors.

Increased dust exposure, possibly exceeding the GDLV for the respirable dust fraction, must be anticipated during the production of

- concrete slabs on older rotary table presses with tampers (tampers are usually encapsulated and the air exhausted) and
- concrete products on vibrating tables or vibrating trestles with an unrestrained mould.

Dust exhaust facilities are the state of the art on slab presses with a tamper facility, but not on the other machine types. For protection against noise pollution, the majority of block-making machines are encapsulated, which also has the effect of preventing dust from spreading. The vibrating table installation causes a reduction in particle size accompanied by the production of respirable dust. The removal of dust is virtually impossible. Production – the insertion and/or distribution of the concrete mix into the moulds – is performed for the most part manually.

The production of manholes and rings, pipes on pipe-making machines, concrete products on transfer-table systems, concrete products including floor slabs on single-pallet block making machines, and precast concrete elements such as floor and wall elements, columns and girders, causes dust exposures lying below the GDLV.

Concrete roof tiles are produced on aluminium moulds (termed "pallets") in continuous-action machines. The concrete mix is produced in conventional concrete mixers. Exposure to dust may occur:

- Near the mixing plant
- During removal of the cured tiles from the pallets
- During cleaning of the pallets
- During sealing of the tile surfaces by spraying with a liquid coating (e.g. a colour dispersion)

A decrease in dust exposure has been noted at the affected workplaces since the sand-coating of roof tiles was discontinued around the mid-1980s, the progressive improvement in dust removal measures (dust exhaust on the concrete mixture, for example, is now state of the art), the increased use of dust collection at the point of dust creation, and application of the surface coating agent without the use of compressed air.

Figure 13: Concrete block machine

Figure 14: Pipe manufacture in the concrete industry

The data collectives show that extreme dust concentrations frequently occurring for brief periods during tasks involving high-speed tools and inadequate dust removal were measured during preventive activity. The measured respirable dust concentrations are seen to rise with increasing comminution of the gravel and sand particles during cosmetic enhancement of the concrete, and during its compaction (e.g. of surplus/residual concrete).

Shift-based measurements, the results of which lay below the GDLV, confirm the efficacy both of a whole range of general dust prevention measures in the plants, and of automation of the production processes.

Table 6.11.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	136	76	6 (4.4%)	0.71	94.9	5.1	1.81	6.786	9.2
≥ 2 h	Static	106	67	15 (14.2%)	0.7	97.2	2.8	1.26	4.068	5.805
< 2 h	Personal	10	7	2 (20.0%)	0.82	70.0	30.0	3.82	23.9	31.45
< 2 h	Static	12	9	1 (8.3%)	0.5	58.3	41.7	7.2	30.74	31.8
Respirable dust										
≥ 2 h	Personal	135	79	41 (30.4%)	0.88	87.4	12.6	+ 0.395	1.345	2.0225
≥ 2 h	Static	112	68	26 (23.2%)	0.25	91.1	8.9	0.31	1.05	1.668
< 2 h	Personal	19	14	6 (31.6%)	1.43	47.4	47.4	+ 0.682	5.914	7.942
< 2 h	Static	12	8	3 (25%)	0.42	50	50	0.58	13.12	21.42

6.11.3 Treatment and finishing of concrete products: blasting

The surfaces of concrete products, such as slabs and paving stones, can be treated by blasting. Blasting is performed in encapsulated installations with dust exhaust. The blasting agent used does not induce silicosis, and is conditioned and re-used within the blasting system.

Table 6.11.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	17	11	1 (5.9%)	0.71	82.4	17.6	1.37	11.44	12.255
≥ 2 h	Static	20	16	1 (5%)	0.71	85	15	1.51	13.9	22.7
Respirable dust										
≥ 2 h	Personal	17	11	8 (47.1%)	0.25	88.2	11.8	+ 0.228	1.551	3.156
≥ 2 h	Static	20	16	1 (5%)	0.25	85	15	0.32	1.5	2.7

6.11.4 Treatment and finishing of concrete products: mechanical

High dust concentrations must be anticipated during drilling, sawing, milling, cutting and grinding, particularly during dry cutting. Dry grinding with angle grinders and cup wheel grinders is used for cosmetic repairs to damaged corners and edges, for the smoothing of concrete surfaces, and for the removal of burrs. Both mobile and stationary dust removal systems are the state of the art. Their efficacy is largely dependent on their performance and maintenance. They are often supplemented by filtering respiratory protective equipment.

Brief activities, often mobile, accompanied by high exposures are typical of "cosmetic" mechanical working of concrete. Effective technical collection arrangements and wet working methods can yield shift-based measurement results compliant with the GDLV. The level of the dust concentration arising during wet sawing is influenced substantially by the formation of aerosols and the quality of the water (recirculated vs. fresh water).

Table 6.11.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	55	41	1 (1.8%)	0.5	85.5	14.5	3.235	11	13.175
≥ 2 h	Static	62	45	5 (8.1%)	0.67	95.2	4.8	1.44	4,.16	9.29
< 2 h	Personal	12	6	3 (25%)	1.36	75	25	1.98	13.12	17.06
< 2 h	Static	10	6	0	n/a	70	30	3.62	16	28.1
Respirable dust										
≥ 2 h	Personal	63	47	10 (15.9%)	0.25	79.4	20.6	0.73	1.718	2.641
≥ 2 h	Static	62	47	10 (16.1%)	0.25	95.2	4.8	0.44	1.008	1.228
< 2 h	Personal	10	4 **	7 (70%)	1.36	20	20	! LOD	1.62	2.5
< 2 h	Static	15	8	1 (6.7%)	1.5	40	53.3	+ 1.23	8.65	19.0425

6.11.5 Treatment and finishing of concrete products: general, coating, hardening, quality control

High dust concentrations, often of brief duration, must be anticipated during drilling, sawing, milling, cutting and grinding, particularly during dry cutting. Such processes are employed for example during the treatment and finishing of concrete surfaces, and the production of connections in concrete shafts and pipes and of recesses in other concrete elements after casting. In particular, dry grinding with angle grinders and cup wheel grinders for cosmetic repairs to damaged corners and edges, for the smoothing of concrete surfaces, and for the removal of burrs is associated with high dust production.

Owing to the need for worker mobility at these workplaces, dust collection is often difficult to implement on high-speed hand-held machines. As a result, filtering respiratory protective equipment is primarily employed.

However, if the activities are not carried out separately and with the use of powerful dust removal equipment, this "cosmetic" treatment of concrete in closed indoor areas can also cause considerable dust exposure in adjacent work areas.

Violation of the GDLV for the respirable dust fraction must be anticipated during:

- sawing, whether dry or wet. The respirable dust concentrations for dry sawing with dust exhaust were lower than those for wet sawing by over 50%.
- Dry grinding without dust exhaust equipment
- Bush-hammering of concrete surfaces without dust exhaust equipment
- Lining of shafts, particularly during cutting of special-quality clinker to size

Wet grinding and bush-hammering in bush-hammering machines with dust exhaust are seen to be the state of the art for the finishing of concrete surfaces. The release of dust can be suppressed only in part by the spraying of water during the work.

Table 6.11.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	57	38	5 (8.8%)	0.71	82.5	17.5	2.925	13.93	19.435
≥ 2 h	Static	57	39	6 (10.5%)	0.71	100	0	0.975	3.815	5.798
< 2 h	Personal	8 ***	5	2 (25%)	1.43	62.5	37.5	=-Values: 3.48 to 110		
Respirable dust										
≥ 2 h	Personal	67	41	15 (22.4%)	0.25	82.1	17.9	0.48	2.748	4.0335
≥ 2 h	Static	74	42	24 (32.4%)	0.25	98.6	1.4	0.28	0.714	0.942
< 2 h	Personal	9 ***	6	3 (33.3%)	1	55.6	44.4	=-Values: 0.4 to 44.5		

6.11.6 Transport, loading, packing of concrete products

Measurements were taken here essentially during making-up and packing of concrete paving stone consignments, transfer of the products from the production shops and placing in outdoor storage, and loading onto goods vehicles for dispatch. The workplaces and packing installations are frequently located within or in the vicinity of production areas in which dust is emitted and from which it is carried over. Elevated exposure to dust can be avoided by regular cleaning of the storage and handling areas. This also includes the low-dust disposal of torn packaging. The exposure data show that the GDLV is complied with.

Table 6.11.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	32	20	3 (9.4%)	0.69	96.9	3.1	1.5	7.318	8.302
≥ 2 h	Static	28	22	2 (7.1%)	0.7	96.4	3.6	1.29	3.446	3.778
Respirable dust										
≥ 2 h	Personal	41	26	15 (36.6%)	0.58	90.2	9.8	+ 0.285	1.017	1.397
≥ 2 h	Static	34	25	13 (38.2%)	0.37	97.1	2.9	+ 0.29	0,.906	1.131

7 Ceramics and glass industry

7.1 Glass fibres, mineral fibres, production and processing

Sector
Artificial mineral fibres, processing
Natural and artificial mineral fibres, processing
Ceramic fibres, production
Ceramic fibres, processing
Rock wool, production
Rock wool, processing
Glass fibres, production and processing

Artificial mineral (glass, slag and rock wool) fibres are produced from molten glass (glass wool) or molten blast furnace slag (slag wool) or from suitable rock material (rock wool) by centrifugal or blowing processes. These materials are mainly used for thermal insulation purposes in buildings construction, or for engineering applications.

If the molten glass is spun through special nozzles to form fibres with a defined, somewhat thicker diameter, the fibres can be used to reinforce plastics, as a base material for glass fibre wallpaper, or in optical fibre cables.

Overall, the 90th percentile values for respirable and inhalable dust in glass and mineral fibre production lie well below the limit values. Elevated exposures are still encountered in production of the batch, which however is not shown separately in the table of values (see Section 7.2). However, these workplaces are not permanently manned.

Table 7.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	59	23	5 (8.5%)	0.71	94.9	5.1	1.55	6.132	8.396
≥ 2 h	Static	171	41	20 (11.7%)	0.71	98.2	1.8	+ 0.56	4.132	6.154
< 2 h	Static	12	7	1 (8.3%)	0.11	91.7	8.3	0.78	6.374	23.612
Respirable dust										
≥ 2 h	Personal	58	20	22 (37.9%)	1.25	89.7	10.3	+ 0.29	+ 1.07	1.782
≥ 2 h	Static	147	42	97 (66%)	0.63	97.3	2.7	! LOD	+ 0.5	0.823
< 2 h	Static	22	10	10 (45.5%)	1.8	54.5	40.9	+ 0.9	4.694	6.463

Table 7.1 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3) 50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	30	12	14 (46.7%)	1.25	100	0	+ 0.27	+ 0.72	+ 0.835
≥ 2 h	LEV = no	10	6	3 (30%)	0.25	70	30	0.56	1.8	2.91

7.2 Glass, production and processing

Sector
Sheet glass, production and processing
Hollow glassware, production and processing
Hollow/pressed glass, production and processing
Technical glass (including laboratory and optical glass), production and processing
Special glass, production and processing

For the production of glass, mineral raw materials, primarily silica sand, sodium and alkali carbonates, alkaline earth oxides and special additives, are added to the batch according to the recipe and homogenized in mixers. This mixture (the batch) is usually melted in a continuous tank (Figure 15) at temperatures of around 1,400 °C to form an incandescent mass, which solidifies after the shaping process into an amorphous, glassy mass. Depending on the product, it is shaped by pressing, blowing, spinning, rolling or drawing.

Examples of hollow glassware, which is produced primarily by blowing or pressing, are glass products for the hospitality sector, such as drinking glasses, bowls, etc., and packaging glassware, such as bottles and jars. However, this category also includes special products such as glass construction elements, TV screens, Christmas decorations, and tubular glass for vials.

Flat glass is produced mainly by the float glass process, in which the molten glass floats on a bath of liquid tin and can thus be drawn out to the desired thickness. However, it can also be drawn, rolled or cast in a number of older processes.

In addition, a whole range of glasses exist for special applications. These include optical glasses, technical glasses, glasses for lighting applications and glass ceramics.

Figure 15: Loading of the batch into the tank

7.2.1 Production of the batch

Relevant areas in which dust arises in the glass industry are preparation of the glass batch, placing of the batch in the tank or pot furnace, and treatment and processing of the finished glass by grinding, sawing, drilling or blasting.

In the majority of areas, the 90th percentile values for respirable and inhalable dust lie well below the limit values. Elevated exposures are still encountered in production of the batch, particularly in older plants; however, the employees in these plants spend a part of their shifts in control rooms with external ventilation. The exposure values shown in the table should therefore normally be assigned a factor for the reduction in their duration.

Table 7.2.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	104	47	13 (12.5%)	0.71	86.5	13.5	1.52	13.02	18. 74
≥ 2 h	Static	226	77	11 (4.9%)	0.71	94.2	5.8	0.75	5.624	14.04
< 2 h	Personal	32	20	9 (28.1%)	2.86	78.1	21.9	+ 1.91	30.7	65.42
< 2 h	Static	72	31	3 (4.2%)	0.12	83.3	16.7	1.26	14.34	24.94
Respirable dust										
≥ 2 h	Personal	96	51	33 (34.4%)	0.31	87.5	12.5	0.4	1.6	2.226
≥ 2 h	Static	219	74	80 (36.5%)	0.25	91.8	8.2	+ 0.23	1.161	1.442
< 2 h	Personal	21	17	13 (61.9%)	1.07	81	19	! LOD	4.517	8.841
< 2 h	Static	82	34	22 (26.8%)	1.48	62.2	35.4	4.517	8.841	5.237

7.2.2 Melting, furnace

Table 7.2.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	25	13	12 (48%)	0.71	96	4	+ 0.355	3.195	4.452
≥ 2 h	Static	54	16	4 (7.4%)	0.25	94.4	5.6	+ 0.19	2.144	7.258
Respirable dust										
≥ 2 h	Personal	20	14	11 (55%)	0.31	90	10	! LOD	0.84	1.26
≥ 2 h	Static	37	16	18 (48.6%)	0.25	100	0	+ 0.133	0.566	0.824

7.2.3 Shaping: blowing, pressing

Table 7.2.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	41	22	15 (36.6%)	0.71	100	0	+ 0.385	1.007	1.116
≥ 2 h	Static	122	54	10 (8.2%)	0.71	99.2	0.8	+ 0.25	1.042	1.571
< 2 h	Static	10	5	5 (50%)	1	100	0	+ 0.39	3.84	3.88
Respirable dust										
≥ 2 h	Personal	30	21	16 (53.3%)	0.25	96.7	3.3	! LOD	0.82	0.945
≥ 2 h	Static	104	53	54 (51.9%)	0.25	100	0	! LOD	0.45	0.594

7.2.4 Mould workshop

Table 7.2.4

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	47	21	19 (40.4%)	0.71	95.7	4.3	+ 0.635	2.057	3.896
≥ 2 h	Static	69	31	2 (2.9%)	0.71	100	0	+ 0.27	1.16	2.788
< 2 h	Personal	5 ***	3 **	3 (60%)	1.23	80	20	=-Values: 1.7 to 56.7		
Respirable dust										
≥ 2 h	Personal	16	11	10 (62.5%)	0.25	93.8	6.3	! LOD	0.478	0.746
≥ 2 h	Static	42	26	26 (61.9%)	0.18	97.6	2.4	! LOD	0.31	0.817

7.2.5 Glass processing, storage, packaging

Table 7.2.5

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	16	12	7 (43.8%)	0.71	93.8	6.3	+ 0.355	3.78	8.2
≥ 2 h	Static	47	34	13 (27.7%)	0.25	100	0	+ 0.12	0.868	1.577
Respirable dust										
< 2 h	Static	54	31	46 (85.2%)	0.5	100	0	! LOD	+ 0.192	0.346

7.2.6 Surface treatment, surface coating

Table 7.2.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	29	18	17 (58.6%)	0.71	100	0	! LOD	1.497	3.144
≥ 2 h	Static	81	41	25 (30.9%)	0.71	100	0	+ 0.125	+ 0.439	1.552
Respirable dust										
≥ 2 h	Personal	12	10	9 (75%)	0.25	100	0	! LOD	0.264	0.322
≥ 2 h	Static	40	24	33 (82.5%)	0.25	100	0	! LOD	+ 0.2	+ 0.23

7.2.7 Mechanical processing and finishing: polishing, grinding, blasting, cutting to size

Table 7.2.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	60	32	17 (28.3)	0.71	93.3	6.7	+ 0.67	5.16	11.7
≥ 2 h	Static	131	57	12 (9.2%)	0.71	98.5	1.5	+ 0.355	2.431	5.052
Respirable dust										
≥ 2 h	Personal	49	27	17 (34.7%)	0.25	87.8	12.2	0.305	1.35	1.823
≥ 2 h	Static	97	52	50 (51.5%)	0.18	93.8	6.2	! LOD	0.813	1.611
< 2 h	Static	14	6	3 (21.4%)	1.05	28.6	71.4	2.18	3.654	4.684

7.3 Quartz glass (including crystal growth), production and processingg

Sector
Quartz glass (including crystal growth), production and processing

Table 7.3

Duration of sampling	Form of sampling	Number of measured values	Number of com- panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per- centile	90th per- centile	95th per- centile
Inhalable dust										
≥ 2 h	Personal	21	12	3 (14.3%)	0.71	95.2	4.8	0.875	2.025	3.068
≥ 2 h	Static	43	15	15 (34.9%)	0.43	100	0	+ 0.1	0.444	0.607
< 2 h	Personal	11	7	4 (36.4%)	2.73	90.9	9.1	+ 1.0875	2.923	9.959
< 2 h	Static	13	8	5 (38.5%)	0.5	92.3	7.7	+ 0.245	1.421	6.293
Respirable dust										
≥ 2 h	Personal	23	11	11 (47.8%)	0.25	100	0	+ 0.193	0.585	0.609
≥ 2 h	Static	43	14	26 (60.5%)	0.18	97.7	2.3	! LOD	0.351	0.412
< 2 h	Personal	8 ***	5	5 (62.5%)	2.73	75	12.5			
< 2 h	Static	14	7	9 (64.3%)	0.71	92.9	7.1	! LOD	0.858	1.434

7.4 Refractory products, production

Sector
Refractory products, production

Refractory materials consist of ceramic materials with a softening point under the influence of temperature of above 1,500 °C. Depending on the application and use, refractory products are capable of withstanding temperatures of up to 2,500 °C.

The raw materials used in the production of these products are sized, metered and mixed. Depending upon the requirements, the products are produced by (semi-) plastic moulding, dry pressing, or punching from powder bodies. The transformation of the refractory materials brought about by subsequent firing lends them their various physical, chemical and thermal properties. Refractory materials are primarily employed in high-temperature processes in the metals, ceramics and glass industries.

Violations of the limit values, for both respirable and inhalable dust, occur mainly during material processing. In these processes, ceramic raw materials are crushed, ground, weighed, mixed and transported, often in the dry state. In these cases however, the workers spend a part of their shifts in control rooms with external ventilation. The exposure values shown, particularly those from static measurements, should therefore normally be assigned a factor for the reduction in their duration. Elevated exposures occur during shaping, firing and finishing of the refractory products, particularly during dry working and processing operations and during handling of the dried and fired products. Optimum collection of the dust is difficult in these processes.

7.4.1 Preparation: mixing, screening, transport

Table 7.4.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	84	32	2 (2.4%)	0.71	71.4	28.6	5.36	19.26	41.34
≥ 2 h	Static	276	49	1 (0.4%)	0.07	84.4	15.6	2.76	12.94	17.26
< 2 h	Personal	5 ***	4 **	0	n/a	40	60	=-Values: 1.48 to 41.1		
< 2 h	Static	24	14	0	n/a	50	50	7.54	49.06	72.74
Respirable dust										
≥ 2 h	Personal	128	45	17 (13.3%)	1.25	55.5	44.5	+ 1.03	4.34	5.916
≥ 2 h	Static	242	47	30 (12.4%)	1.25	72.7	27.3	+ 0.78	1.818	2.116
< 2 h	Personal	8 ***	5	0	n/a	37.5	62.5	=-Values: 0.4 to 7.24		
< 2 h	Static	95	21	4 (4.2%)	5.33	12.6	86.3	+ 3	11.85	16.625

Table 7.4.1 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	64	29	2 (3.1%)	0.71	75	25	5.14	16.62	20.98
≥ 2 h	LEV = no	9 ***	7	0	n/a	66.7	33.3	=-Values: 1.32 to 34.7		
Respirable dust										
≥ 2 h	LEV = yes	97	40	13 (13.4%)	1.25	58.8	41.2	+ 0.95	3.545	5.709
≥ 2 h	LEV = no	15	11	3 (20%)	1.25	46.7	53.3	+ 1.12	4.34	4.543

7.4.2 Preparation: comminution, grinding

Table 7.4.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	15	6	0	n/a	80	20	4.07	24.1	29.25
≥ 2 h	Static	28	12	0	n/a	78.6	21.4	4.47	15.6	21.34
< 2 h	Static	6 ***	3 **	0	n/a	16.7	83.3	=-Values: 5.05 to 97.1		
Respirable dust										
≥ 2 h	Personal	27	10	6 (22.2%)	1.25	59.3	40.7	+ 0.78	4.613	5.8
≥ 2 h	Static	18	10	1 (5.6%)	0.18	83.3	16.7	0.62	1.598	3.065
< 2 h	Static	16	7	0	n/a	6.3	93.8	3.91	10.422	12.96

7.4.3 Shaping

Table 7.4.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	23	14	0	n/a	91.3	8.7	2.875	9.421	28.297
≥ 2 h	Static	243	34	3 (1.2%)	0.71	97.9	2.1	1.05	3.811	5.668
Respirable dust										
≥ 2 h	Personal	30	19	8 (26.7%)	1.25	90	10	+ 0.47	+ 1.05	1.55
≥ 2 h	Static	264	35	79 (29.9%)	0.25	95.1	4.9	0.27	0.94	1.212
< 2 h	Static	10	3 **	3 (30%)	1.42	40	50	+ 1.07	2.31	2.635

7.4.4 Preparation for firing

Figure 16: Placing of refractory products on kiln cars

Table 7.4.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	10	4 **	2 (20%)	0.71	80	20	3.69	23.5	23.9
≥ 2 h	Static	23	10	1 (4.3%)	0.04	100	0	0.785	1.835	2.0755
Respirable dust										
≥ 2 h	Personal	14	4 **	4 (28.6%)	1.25	64.3	35.7	+ 0.625	1.912	2.42
≥ 2 h	Static	23	10	16 (69.6%)	0.18	100	0	! LOD	0.628	0.7

7.4.5 Firing

Table 7.4.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	26	12	0	n/a	76.9	23.1	2.27	22.04	33.19
≥ 2 h	Static	57	22	1 (1.8%)	0.06	100	0	0.71	2.66	3.696
Respirable dust										
≥ 2 h	Personal	6	12	2 (7.7%)	0.25	84.6	15.4	0.38	2.18	2.324
≥ 2 h	Static	61	23	24 (39.3%)	0.18	96.7	3.3	0.225	0.866	1.117

7.4.6 Finishing work

Table 7.4.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	28	14	6 (21.4%)	0.71	89.3	10.7	1.52	5.792	17.28
≥ 2 h	Static	74	31	1 (1.4%)	0.06	97.3	2.7	1.34	4.864	6.939
Respirable dust										
≥ 2 h	Personal	31	16	6 (19.4%)	0.25	87.1	12.9	0.505	1.658	3.575
≥ 2 h	Static	73	31	22 (30.1%)	0.18	90.4	9.6	0.33	1.153	1.619

7.4.7 Packing, quality control

Table 7.4.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	20	11	0	n/a	100	0	0.5	2.89	4.67
Respirable dust										
≥ 2 h	Personal	10	10	3 (30%)	0.25	100	0	0.28	0.9	1.055
≥ 2 h	Static	18	11	7 (38.9%)	0.25	100	0	+ 0.22	0.44	0.512

7.5 Clay and kaolin, extraction

Sector
Slate, clay and kaolin, extraction
Clay and kaolin, extraction

Clays and kaolins are extracted for the most part selectively by excavators in open-cast mines. The raw materials are transported by means of conveyors or dump trucks to intermediate storage points, possibly comminuted in crushers, and coarsely premixed. Since kaolin generally contains contaminants in the form of quartz, mica and feldspar, the kaolin must be separated. Fine kaolin is an important raw material for the porcelain and paper industries. Sands and feldspars are sized and in some cases ground. The resulting silica sands are used, among other things, as a raw material for the production of glass and in the production of high-quality construction products such as ready-mixed plasters.

During the extraction of clay and kaolin, dust exposure is encountered primarily in the preparation processes, in which the materials, which are usually extracted in open-cast mines, are sized, crushed, ground, mixed and bagged. These operations are not shown separately in the table.

Figure 17: Extraction of kaolin in open-cast mining

Table 7.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	18	7	1 (5.6%)	0.71	88.9	11.1	1,03	6.516	12.4
≥ 2 h	Static	15	5	0	n/a	100	0	0,62	2	3.353
Respirable dust										
≥ 2 h	Personal	17	7	7 (41.2%)	0.25	82.4	17.6	+ 0,225	1.624	2.265
≥ 2 h	Static	14	5	3 (21.4%)	0.18	92.9	7.1	0,25	0.844	1.382

7.6 Sand-lime brick, production

Sector
Sand-lime brick, production

Sand and lime are mixed together and fed into a reactor on conveyors. In the reactor, the quicklime slakes with the addition of water to form calcium hydroxide. This is moistened further to attain the optimum press moisture. The bricks (blanks) are formed on hydraulic presses. They are then hardened in autoclaves under steam pressure at temperatures of approximately 200 °C. The silicate structures of lime, sand and water formed during the production process lend the brick blank its strength.

In the process stages of preparation and shaping, the 90th percentile values for respirable and, in particular, inhalable dust still lie in some cases considerably above the relevant limit values. This is partly due to the high moisture content of the unhardened raw mix, which can quickly cause dust collection equipment and lines to become clogged. These workplaces are not generally manned continuously.

Figure 18: Autoclaves for sand-lime bricks

7.6.1 Preparation

Table 7.6.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	7 ***	6	0	n/a	42.9	57.1	=-Values: 3.21 to 37.2		
< 2 h	Static	8 ***	5	0	n/a	0	100	=-Values: 10.5 to 204		
Respirable dust										
≥ 2 h	Static	6 ***	6	1 (16.7%)	0.18	33.3	66.7	=-Values: 0.19 to 2.72		
< 2 h	Static	15	7	0	n/a	0	100	6.045	21.55	21.975

7.6.2 Shaping

Table 7.6.2

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	31	23	0	n/a	87.1	12.9	3.445	11.539	15.69
≥ 2 h	Static	50	27	0	n/a		32	4.94	17.9	33.6
< 2 h	Static	9 ***	4 **	0	n/a		55.6	=-Values: 1.02 to 32.5		
Respirable dust										
≥ 2 h	Personal	35	25	6 (17.1%)	0.25	91.4	8.6	0.38	1.13	1.455
≥ 2 h	Static	42	26	3 (7.1%)	0.18	81	19	0.85	1.484	1.652
< 2 h	Static	32	11	0	n/a	25	75	2.92	6.302	6.408

7.6.3 Finishing work

Table 7.6.3

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	17	15	2 (11.8%)	0.71	100	0	1.555	4.322	5.343
≥ 2 h	Static	25	16	0	n/a	96	4	0.965	4.34	5.827
Respirable dust										
≥ 2 h	Personal	17	15	7 (41.2%)	0.25	100	0	0.3	0.595	0.823
≥ 2 h	Static	24	16	8 (33.3%)	0.18	95.8	4.2	0.34	0.816	1.144
< 2 h	Static	8 ***	4 **	2 (25%)	0.19	37.5	62.5	=-Values: 1.21 to 3.77		

7.7 Porcelain and ceramics (industrial), production

Sector
Porcelain and fine ceramic bodies, production
Porcelain and tableware ceramics, production
Utility, ornamental and art ceramics (industrial), production

50% kaolin, 25% quartz and 25% feldspar can be regarded as the standard composition of a porcelain body. The hard quartz and feldspar materials are ground ultrafine in drum mills and mixed into the kaolin slurry. The kaolin is suspended in water in vats with the aid of blungers. The resulting slurry is either processed directly, or dewatered in filter presses. A further process is the production of granulate by jetting of the slick into a spray tower. Since the mid-1970s, porcelain factories have increasingly obtained the body ready-prepared from manufacturers of the raw material rather than preparing it themselves. This has significantly reduced the dust exposure in the porcelain factories. In the forming process, rotationally symmetrical geometries are turned or rolled on machines. At the casting stage, the slick is poured into plaster-of-paris moulds. The hygroscopic property of the plaster-of-paris causes a ceramic body to be produced at the boundary layer. The surplus slick is poured out and the blank de-formed. Since the late 1980s, large runs have been manufactured by the isostatic pressing of spray-dried powder. Seams and burrs on the dried blanks are scraped off, and the blanks then sponged off. Biscuit firing lends the blank the necessary strength for subsequent glazing. This is followed by glost firing, and possibly also by decoration firing. In the final step, the base surfaces of the porcelain articles are ground smooth.

The porcelain industry is an example of how the dust situation has been significantly improved over the years by modernization of production systems and the associated optimization above all of engineered measures for protection against dust. In addition, preparation of the body has for the most part now been outsourced to external suppliers. These companies are included in the evaluation (Section 7.5).

7.7.1 Preparation

Table 7.7.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	27	15	3 (11.1%)	0.71	96.3	3.7	1.575	5.709	7.925
≥ 2 h	Static	41	19	1 (2.4%)	0.07	95.1	4.9	0.93	5.775	6.59
< 2 h	Personal	13	10	4 (30.8%)	1.3	92.3	7.7	2.825	6.484	15.543
< 2 h	Static	23	13	6 (26.1%)	1	100	0	+ 0.81	4.11	6.117
Respirable dust										
≥ 2 h	Personal	24	14	6 (25%)	0.25	95.8	4.2	0.39	0.942	1.026
≥ 2 h	Static	39	17	18 (46.2%)	0.18	94.9	5.1	+ 0.175	0.754	1.244
< 2 h	Personal	8 ***	7	1 (12.5%)	0.27	62.5	37.5	=-Values: 0.64 to 6.17		
< 2 h	Static	27	13	9 (33.3%)	1.19	59.3	40.7	+ 0.675	4.125	5.095

7.7.2 Shaping

Figure 19: Manufacture of porcelain whiteware

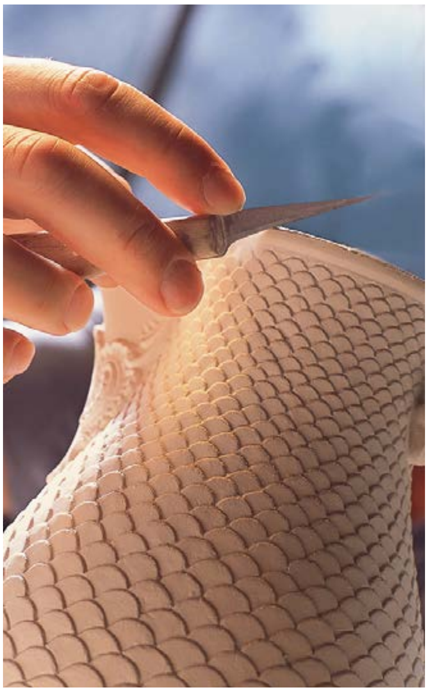

Table 7.7.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	22	13	3 (13.6%)	0.71	95.5	4.5	+ 0.54	2.466	6.103
≥ 2 h	Static	52	27	3 (5.8%)	0.07	100	0	0.41	1.2	1.348
Respirable dust										
≥ 2 h	Personal	28	18	11 (39.3%)	0.25	100	0	+ 0.25	0.352	0.472
≥ 2 h	Static	58	29	28 (48.3%)	0.18	98.3	1.7	+ 0.1	0.448	0.632

7.7.3 Decoration, printing and firing

Table 7.7.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	40	19	18 (45%)	0.71	95	5	+ 0.355	1.97	2.69
≥ 2 h	Static	85	34	25 (29.4%)	0.71	100	0	+ 0.135	+ 0.43	+ 0.527
Respirable dust										
≥ 2 h	Personal	24	13	9 (37.5%)	0.25	87.5	12.5	0.29	1.242	1.974
≥ 2 h	Static	59	27	45 (76.3%)	0.18	98.3	1.7	! LOD	0.211	0.221

Figure 20: Glost firing of porcelain articles

7.7.4 Fettling

Table 7.7.4

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	27	12	9 (33.3%)	0.71	100	0	+ 0.395	2.513	3.378
≥ 2 h	Static	37	18	5 (13.5%)	0.07	100	0	0.175	1.011	1.474
Respirable dust										
≥ 2 h	Personal	21	13	10 (47.6%)	0.25	90.5	9.5	+ 0.207	0.92	1.634
≥ 2 h	Static	42	18	27 (64.3%)	0.18	100	0	! LOD	0.23	0.337

7.7.5 Finishing work

Table 7.7.5

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	13	10	7 (53.8%)	0.71	100	0	! LOD	0.764	3.928
≥ 2 h	Static	29	12	5 (17.2%)	0.07	100	0	0.15	1.114	1.922
Respirable dust										
≥ 2 h	Personal	22	13	16 (72.7%)	1.2	100	0	! LOD	+ 0.55	+ 0.636
≥ 2 h	Static	32	14	21 (65.6%)	0.18	100	0	! LOD	0.256	0.458

7.8 Ceramic sanitary ware, production

Sector
Ceramic sanitary ware, production

Sanitary ware is manufactured from a particularly dense form of porcelain (vitreous china) with high mechanical strength. It includes products such as washbasins, washstands, sinks, lavatories and urinals. During production of these items, the raw materials of quartz, feldspar, kaolin and clay are ground in drum mills. The resulting slick is cast in plaster-of-paris moulds. The hygroscopic property of the plaster-of-paris causes a ceramic body to be produced at the boundary layer. The surplus slick is poured out and the blank de-formed. In recent years, plastic moulds have increasingly been used in the pressure casting process to achieve the desired geometries. Following drying, a glazing layer is applied, usually by spraying. The blank is then fired. Since the mid-1980s, high-quality sanitary ceramics have been finished by grinding or by sawing to size.

The exposure situation is comparable to that described in Section 6.7, Porcelain and ceramics (industrial), production. Dust collection presents difficulties during the dry, predominantly manual working of large products (preparation for firing) such as washstands or toilet bowls. Collection of the dust directly at the fettling point is not possible owing to the size of these products and the wide variation in their shapes and contours.

7.8.1 Preparation

Table 7.8.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	12	7	2 (16. 7%)	0.71	91.7	8.3	2.29	4.298	17.68
Respirable dust										
≥ 2 h	Personal	12	7	3 (25%)	0.25	83.3	16.7	0.42	1.362	1.538

7.8.2 Shaping

Table 7.8.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	7 ***	3 **	1 (14.3%)	0.68	85.7	14.3	=-Values: 1.15 to 22.6		
≥ 2 h	Static	28	8	1 (3.6%)	0.25	92.9	7.1	1.13	5.88	8.776
Respirable dust										
≥ 2 h	Personal	11	5	2 (18.2%)	0.25	63.6	36.4	0.615	1.872	2.991
≥ 2 h	Static	28	7	9 (32.1%)	0.18	100	0	0.44	1.044	1.12
< 2 h	Static	9 ***	5	2 (22.2%)	0.28	66.7	33.3	=-Values: 0.57 to 3.89		

7.8.3 Preparation for firing

Table 7.8.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	52	9	0	n/a	76.9	23.1	2.6	34.24	49.12
≥ 2 h	Static	51	11	1 (2%)	0.71	96.1	3.9	+ 0.38	1.811	4.175
< 2 h	Personal	11	4 **	0	n/a	45.5	54.5	13.03	29.84	39.99
< 2 h	Static	11	7	0	n/a	100	0	0.5	2.514	2.616
Respirable dust										
≥ 2 h	Personal	67	11	17 (25.4%)	0.25	73.1	26.9	0.6	2.509	3.442
≥ 2 h	Static	45	11	27 (60%)	0.25	100	0	! LOD	0.285	0.525
< 2 h	Personal	15	6	3 (20%)	0.45	26.7	73.3	1.76	4.545	7.452
< 2 h	Static	13	7	6 (46.2%)	0.39	53.8	46.2	0.453	7.675	8.681

Table 7.8.3 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	52	9	0	n/a	76.9	23.1	2.6	34.24	49.12
Respirable dust										
≥ 2 h	LEV = yes	66	11	16 (24.2%)	0.25	72.7	27.3	0.67	2.522	3.466

7.8.4 Finishing work

Table 7.8.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	11	5	1 (9.1%)	0.71	90.9	9.1	1.365	8.432	25.331
Respirable dust										
≥ 2 h	Personal	11	6	1 (9.1%)	0.25	90.9	9.1	0.535	0.985	2.476
≥ 2 h	Static	9 ***	5	5 (55.6%)	0.18	88.9	11.1	=-Values: 0.28 to 1.38		

Figure 21: Fettling of sanitary articles

7.9 Technical ceramics, production

Sector
Technical ceramics, production
Special ceramics, production

Technical ceramics is a generic term for products used in the most diverse of technical applications (such as electrical engineering and electronics, the chemical industry, laboratories, dental technology and mechanical and automotive engineering). The properties of these products are specifically optimized for certain technical applications. Besides the raw materials normally used in porcelain, a wide variety of materials such as steatite, cordierite, aluminium oxide, zirconium oxide and silicate ceramics, and also non-oxide materials such as carbides and nitrides, are used in the production process.

The preparation, shaping and firing processes reflect the raw materials concerned. Special shaping and firing processes are often used in production, such as hot isostatic pressing (HIP) and firing in a reducing atmosphere.

During preparation of the batch (Sections 7.9.1 and 7.9.2), the 90th percentile values for inhalable and respirable dust, particularly those measured on the person, lie above the limit values. In these cases, the workers usually spend several hours of each shift in control rooms with external ventilation. These values should therefore normally be assigned a factor for the reduced duration of exposure. In the downstream production steps, dust protection measures are usually of a high technical standard, which is reflected in the present evaluation.

7.9.1 Preparation: mixing, screening, transport

Table 7.9.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) \$	> LV (%) \$	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	58	27	2 (3.4%)	0.44	87.9	12.1	2.78	10.82	18.1
≥ 2 h	Static	75	29	0	n/a	94.7	5.3	0.845	5.425	9.88
< 2 h	Static	21	10	4 (19%)	0.15	95.2	4.8	0.555	6.768	7.466
Respirable dust										
≥ 2 h	Personal	56	29	8 (14.3%)	0.25	82.1	17.9	0.5	1.684	2.384
≥ 2 h	Static	75	28	22 (29.3%)	0.25	92	8	0.275	1.035	1.365
< 2 h	Static	27	13	7 (25.9%)	1.19	48.1	51.9	+ 1.14	4.779	6.189

Table 7.9.1 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	41	21	1 (2.4%)	0.44	90.2	9.8	2.815	9.025	11.27
≥ 2 h	LEV = no	8 ***	6	1 (12.5%)	0.25	75	25	=-Values: 0.58 to 31.1		
Respirable dust										
≥ 2 h	LEV = yes	39	22	6 (15.4%)	0.25	82.1	17.9	0.52	1.618	2.336
≥ 2 h	LEV = no	7 ***	6	1 (14.3%)	0.25	71.4	28.6	=-Values: 0.26 to 2.7		

7.9.2 Preparation: comminution, grinding

Table 7.9.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	25	21	5 (20%)	0.25	80	20	2,47	11.7	18.55
≥ 2 h	Static	30	18	5 (16.7%)	0.07	90	10	0,94	8.06	23.5
< 2 h	Personal	10	5	2 (20%)	1.5	80	20	2,52	18.1	20.25
< 2 h	Static	11	7	1 (9.1%)	0.08	90.9	9.1	0,375	4.572	8.419
Respirable dust										
≥ 2 h	Personal	22	19	3 (13.6%)	0.25	81.8	18.2	0.63	1.78	2.951
≥ 2 h	Static	27	16	7 (25.9%)	0.18	85.2	14.8	0.34	1.995	2.115
< 2 h	Personal	5 ***	5	2 (40%)	1.43	60	20	=-Values: 0.61 to 6.24		
< 2 h	Static	11	8	3 (27.3%)	0.71	54.5	45.5	1.005	9.123	10.725

7.9.3 Shaping

Figure 22: Pressing of ceramic articles for technical applications

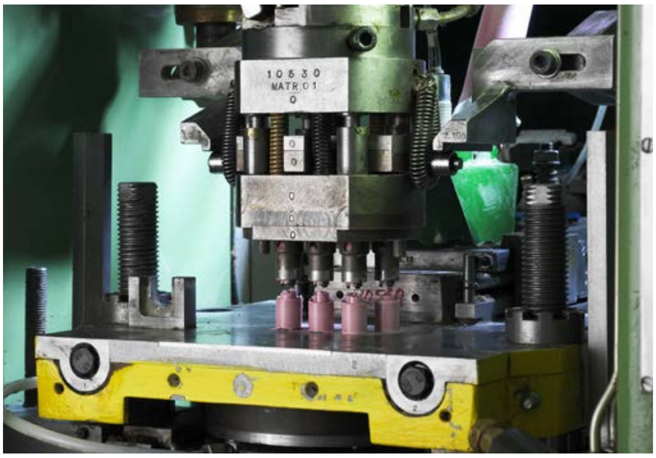

Table 7.9.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	47	22	15 (31.9%)	0.71	93.6	6.4	+ 0.555	3.346	10.215
≥ 2 h	Static	133	45	7 (5.3%)	0.07	98.5	1.5	0.41	2.117	2.86
< 2 h	Personal	6 ***	3 **	2 (33.3%)	30	83.3	0	=-Values: 2.8 to 6.35		
Respirable dust										
≥ 2 h	Personal	52	27	28 (53.8%)	0.25	100	0	! LOD	0.64	1.006
≥ 2 h	Static	124	45	51 (41.1%)	0.18	96	4	+ 0.18	0.77	0.94
< 2 h	Static	8 ***	4 **	3 (37.5%)	0.27	50	50	=-Values: 0.45 to 4.83		

Table 7.9.3 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	29	13	11 (37.9%)	0.71	93.1	6.9	+ 0.333	3.228	9.705
≥ 2 h	LEV = no	9 ***	6	2 (22.2%)	0.2	100	0	=-Values: 0.38 to 3.92		

7.9.4 Preparation for firing

Table 7.9.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	29	13	9 (31%)	0.71	96.6	3.4	1.445	7.983	9.175
≥ 2 h	Static	36	22	0	n/a	97.2	2.8	0.44	3.24	5.228
< 2 h	Static	9 ***	6	4 (44.4%)	0.38	66.7	33.3	=-Values: 0.09 to 56.2		
Respirable dust										
≥ 2 h	Personal	38	17	14 (36.8%)	0.25	86.8	13.2	0.29	1.332	1.5
≥ 2 h	Static	47	22	17 (36.2%)	0.18	95.7	4.3	0.225	0.668	0.975
< 2 h	Static	7 ***	4 **	2 (28.6%)	1.19	42.9	57.1	=-Values: 0.73 to 5.42		

7.9.5 Firing

Table 7.9.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	16	9	4 (25%)	0.71	100	0	1.2	5.686	6.65
≥ 2 h	Static	47	25	10 (21.3%)	0.07	97.9	2.1	0.24	1.569	1.722
Respirable dust										
≥ 2 h	Personal	12	9	2 (16.7%)	0.25	91.7	8.3	0.55	1.088	1.204
≥ 2 h	Static	39	23	21 (53.8%)	0.18	97.4	2.6	! LOD	0.527	0.611

7.9.6 Finishing work

Table 7.9.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	35	17	8 (22.9%)	0.71	94.3	5.7	+ 0.67	6.02	10.707
≥ 2 h	Static	85	34	5 (5.9%)	0.07	100	0	0.565	2.83	4.957
< 2 h	Static	12	8	0	n/a	100	0	0.52	1.786	2.584
Respirable dust										
≥ 2 h	Personal	41	20	21 (51.2%)	0.35	92.7	7.3	! LOD	0.943	4.125
≥ 2 h	Static	97	35	51 (52.6%)	0.18	99	1	! LOD	0.602	0.763
< 2 h	Static	16	10	5 (31.3%)	0.25	87.5	12.5	+ 0.25	1.498	3.702

7.9.7 Packing, quality control

Table 7.9.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	9 ***	4 **	2 (22.2%)	0.59	88.9	11.1	=-Values: 0.09 to 38.8		
≥ 2 h	Static	9 ***	4 **	0	n/a	88.9	11.1	=-Values: 0.09 to 28.7		
Respirable dust										
≥ 2 h	Personal	13	5	6 (46.2%)	0.25	92.3	7.7	+ 0.095	+ 0.171	1.506
≥ 2 h	Static	13	6	7 (53.8%)	0.18	100	0	! LOD	0.502	0.797

7.10 Wall/floor tiles, stove tiles and heavy ceramics, production

Sector
Wall/floor tiles, stove tiles and heavy ceramics, production
Wall and floor tiles, production
Stove tiles, production
Heavy ceramics, production

The body from which wall and floor tiles are manufactured consists of clay, kaolin, and aggregates such as feldspar, dolomite and chamotte. The raw materials are ground in drum mills and subsequently suspended in water. The slick produced by this process is jetted into a heated spray tower. The resulting spray granulate, and in some cases dry-pressed body, is formed under high pressure on hydraulic presses to produce tiles. Wall and floor tiles may be fired by means of the once-fired method, or the glaze applied in a second firing. Stove tiles are pressed from plastic clay body diluted with chamotte; complex geometries are also cast. The glaze is applied by immersion, pouring, spraying or painting.

In batch preparation involving grinding, screening and mixing processes, and in the spray drying process typically used in the tile industry, 90th percentile values close to or above the limit value are observed (see Sections 7.4 and 7.9). Potential for improvement still exists in the areas of shaping and pressing, where dust and waste collection at the presses and in downstream operations still presents problems and a need for optimization.

7.10.1 Preparation: comminution, grinding

Table 7.10.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	10	7	0	n/a	90	10	1.79	9.35	10.625
≥ 2 h	Static	17	11	0	n/a	88.2	11.8	2.06	11.709	17.525
< 2 h	Static	6 ***	5	0	n/a	66.7	33.3	=-Values: 0.98 to 51.6		
Respirable dust										
≥ 2 h	Personal	15	11	1 (6.7%)	0.25	73.3	26.7	0.72	2.705	3.18
≥ 2 h	Static	16	10	4 (25%)	0.18	75	25	0.69	1.462	1.502
< 2 h	Static	12	7	1 (8.3%)	1.42	8.3	83.3	2.23	9.016	10.352

7.10.2 Preparation: mixing, screening, transport

Table 7.10.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	44	23	1 (2.3%)	0.25	90.9	9.1	2.52	8.522	15.5
≥ 2 h	Static	69	30	0	n/a	97.1	2.9	1.24	6.034	7.346
< 2 h	Static	13	8	1 (7.7%)	0.18	69.2	30.8	1.725	50.81	62.335
Respirable dust										
≥ 2 h	Personal	45	25	4 (8.9%)	0.25	82.2	17.8	0.52	1.695	3.08
≥ 2 h	Static	66	29	9 (13.6%)	0.18	92.4	7.6	0.4	1.104	1.524
< 2 h	Static	30	12	3 (10%)	0.71	23.3	76.7	2.74	5.92	7.555

Table 7.10.2 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	19	16	1 (5.3%)	0.25	84.2	15.8	2.53	15.31	17.29
≥ 2 h	LEV = no	15	10	0	n/a	100	0	1.845	4.955	6.393
Respirable dust										
≥ 2 h	LEV = yes	18	15	3 (16.7%)	0.25	83.3	16.7	0.46	1.644	3.148
≥ 2 h	LEV = no	17	12	1 (5.9%)	0.17	82.4	17.6	0.385	1.474	1.629

7.10.3 Shaping

Table 7.10.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	22	13	1 (4.5%)	0.71	95.5	4.5	2.3	8.086	8.283
≥ 2 h	Static	65	34	0	n/a	98.5	1.5	1.205	5.265	6.13
< 2 h	Static	5 ***	3 **	0	n/a	80	20	=-Values: 0.41 to 17		
Respirable dust										
≥ 2 h	Personal	29	17	4 (13.8%)	0.25	96.6	3.4	0.44	1.027	1.123
≥ 2 h	Static	56	31	8 (14.3%)	0.18	96.4	3.6	0.38	0.886	1.06
< 2 h	Static	22	11	2 (9.1%)	0.27	22.7	77.3	2.13	5.28	5.541

7.10.4 Preparation for firing

Table 7.10.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	20	12	2 (10%)	0.74	100	0	0.94	1.89	3.51
≥ 2 h	Static	65	34	0	n/a	98.5	1.5	0.695	3.235	4.125
Respirable dust										
≥ 2 h	Personal	14	9	4 (28.6%)	0.25	92.9	7.1	0.33	0.69	1.034
≥ 2 h	Static	70	33	22 (31.4%)	0.18	92.9	7.1	0.29	0.98	1.325
< 2 h	Static	7 ***	2 **	0	n/a	57.1	42.9	=-Values: 0.33 to 3.87		

7.10.5 Firing

Figure 23: Tile production in a fast-firing kiln

Table 7.10.5

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	5 ***	4 **	0	n/a	100	0	=-Values: 0.4 to 2.33		
≥ 2 h	Static	26	17	0	n/a	100	0	0.37	1.724	2.266
Respirable dust										
≥ 2 h	Personal	7 ***	6	5 (71.4%)	0.25	100	0	=-Values: 0.38 to 0.54		
≥ 2 h	Static	25	16	11 (44%)	0.18	100	0	+ 0.165	0.675	0.922

7.10.6 Finishing work

Table 7.10.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	12	11	5 (41.7%)	0.71	91.7	8.3	+ 0.53	3.87	10.476
≥ 2 h	Static	31	17	1 (3.2%)	0.04	100	0	0.405	1.181	2.0575
< 2 h	Static	7 ***	3 **	0	n/a	85.7	14.3	=-Values: 0.36 to 13.3		
Respirable dust										
≥ 2 h	Personal	12	11	5 (41.7%)	0.25	91.7	8.3	+ 0.18	0.964	2.364
≥ 2 h	Static	35	17	16 (45.7%)	0.18	100	0	+ 0.135	0.395	0.55
< 2 h	Static	7 ***	4 **	2 (28.6%)	0.36	71.4	28.6	=-Values: 0.3 to 3.77		

7.10.7 Packing, quality control

Table 7.10.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	12	8	0	n/a	100	0	0.34	0.946	1.174
Respirable dust										
≥ 2 h	Static	13	9	7 (53.8%)	0.18	100	0	! LOD	0.565	0.614

7.11 Abrasive tools, production

Sector
Abrasive tools and agents, production

Grinding wheels, abrasive cutting wheels, roughing wheels, scythe stones and other abrasive tools are employed for the chip-forming working of various materials. They consist of an abrasive agent such as corundum, silicon carbide or diamond, embedded in a matrix to form a composite material. The bond is either ceramic or organic, for example employing mineral bodies or glass, artificial resin or bakelite. The abrasive particles and binder are mixed and pressed together. Abrasive tools employing a ceramic bond are fired, those with an organic bond are cured.

The problems in the area of processing are similar to those described in Sections 7.2, 7.4, 7.9 and 7.10. The 90th percentile values for the shaping, firing and finishing steps are largely below the dust limit values. Problematic cases can be attributed to the particular structure of the sector (in some cases, the state of the art or standard good practice in the sector are not implemented).

7.11.1 Preparation

Table 7.11.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	53	28	3 (5.7%)	0.71	83	17	3.395	14.15	25.05
≥ 2 h	Static	73	26	3 (4.1%)	0.71	93.2	6.8	0.815	7.274	11.65
< 2 h	Static	14	7	1 (7.1%)	1.43	78.6	21.4	+ 0.715	12.06	15.91
Respirable dust										
≥ 2 h	Personal	58	29	16 (27.6%)	1.25	82.8	17.2	+ 0.47	1.57	2.432
≥ 2 h	Static	66	25	26 (39.4%)	1.25	97	3	+ 0.19	+ 0.663	+ 1.004
< 2 h	Personal	5 ***	5	0	n/a	0	100	=-Values: 1.69 to 16.4		
< 2 h	Static	17	9	7 (41.2%)	0.5	64.7	35.3	+ 0.32	2.598	3.595

Table 7.11.1 a

Duration of sampling	Collection	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	LEV = yes	42	23	3 (7.1%)	0.71	78.6	21.4	2.5	15.66	25.6
Respirable dust										
≥ 2 h	LEV = yes	45	24	14 (31.1%)	1.25	84.4	15.6	+ 0.48	1.6	2.277
≥ 2 h	LEV = no	6 ***	5	0	n/a	66.7	33.3	=-Values: 0.27 to 1.44		

7.11.2 Shaping

Table 7.11.2

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	23	14	4 (17.4%)	0.71	91.3	8.7	0.82	7.331	12.957
≥ 2 h	Static	51	18	0	n/a	98	2	0.515	1.537	2.263
Respirable dust										
≥ 2 h	Personal	22	14	10 (45.5%)	1.25	86.4	13.6	+ 0.21	1.526	1.744
≥ 2 h	Static	50	18	31 (62%)	0.25	96	4	! LOD	0.43	0.58

7.11.3 Firing

Table 7.11.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	23	10	4 (17.4%)	0.71	100	0	2.105	4.799	5.417
≥ 2 h	Static	20	10	0	n/a	100	0	0.9	2.01	2.51
Respirable dust										
≥ 2 h	Personal	24	10	9 (37.5%)	1.25	100	0	+ 0.44	+ 0.84	+ 0.88
≥ 2 h	Static	19	10	9 (47.4%)	1.25	100	0	+ 0.22	+ 0.625	+ 0.643

7.11.4 Finishing work

Table 7.11.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	38	19	6 (15.8%)	0.71	94.7	5.3	1.7	7.666	9.037
≥ 2 h	Static	42	16	17 (40.5%)	0.71	100	0	+ 0.355	1.782	2.747
Respirable dust										
≥ 2 h	Personal	40	20	17 (42.5%)	1,25	85	15	+ 0.38	1.8	2.21
≥ 2 h	Static	37	15	26 (70.3%)	1,25	100	0	! LOD	+ 0.625	+ 0.625

7.12 Brickwork and tilework products, production

Sector
Brickwork and tilework products, production

The most common products in the brickwork group are common bricks, façade bricks and roof tiles. The argillaceous raw materials are metered out into box feeders, and subsequently crushed and mixed in crushers and pug mills. The final preparation stage are fine rolling mills, the gap widths of which have fallen progressively since the 1980s and are now < 1 mm. The body is aged in the tempering house to ensure thorough homogenization. Pore-forming agents such as polystyrene or papermaking residues are mixed into the body used for common bricks. The body, plasticized with water or steam, is drawn in vacuum presses into a continuous extrusion from which the individual bricks or roof tiles are cut. Roof tiles with seams and more complicated geometries are produced in revolving presses. The products are then dried. Roof tiles are slipped or glazed before firing. Since the 1990s, common bricks have increasingly been ground plane after firing.

The explanations in Sections 7.2, 7.4, 7.9 and 7.10 apply to the preparation processes: comminution, grinding, mixing, screening and transport.

For the preparatory work processes for firing (loading/unloading of brick/tile products onto/from kiln cars at the kiln or in production before and after firing), the evaluation yields 90th percentile values, in particular for respirable dust, that exceed the relevant limit value. A particular problem here is the abrasion occurring during the handling of dried and fired brick products. Collection of the dust produced in these processes, and of falling material, is often implemented only selectively. For the production of façade bricks, silica sand is also frequently used to bed the kiln cars, which causes additional dust emissions.

In tasks for finishing (sawing, grinding) of the fired products, the state of the art (including closed systems, optimum dust collection) has not yet become standard practice. In addition, the existing plants are subject to a high degree of wear and tear owing to the heavy-duty processes.

7.12.1 Preparation: comminution, grinding

Table 7.12.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	34	26	2 (5.9%)	0.71	73.5	26.5	4	15.76	32.87
≥ 2 h	Static	90	55	0	n/a	87.8	12.2	3.54	10.9	16.45
< 2 h	Static	31	14	1 (3.2%)	0.5	71	29	5,84	22,99	165.615
Respirable dust										
≥ 2 h	Personal	38	29	8 (21.1%)	0.25	65.8	34.2	0.73	2.452	3.351
≥ 2 h	Static	77	48	5 (6.5%)	0.18	77.9	22.1	0.825	1.623	1.745
< 2 h	Static	66	28	4 (6.1%)	0.36	22.7	77.3	2.57	5.682	7.307

7.12.2 Preparation: mixing, screening, transport

Table 7.12.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	70	58	7 (10%)	0.71	90	10	1.77	8.31	13.65
≥ 2 h	Static	92	51	0	n/a	94.6	5.4	1.54	6.63	9.69
< 2 h	Static	13	6	0	n/a	76.9	23.1	3.835	10.75	36.765
Respirable dust										
≥ 2 h	Personal	81	70	17 (21%)	0.25	84	16	0.385	1.665	2.066
≥ 2 h	Static	86	52	20 (23.3%)	0.25	91.9	8.1	0.38	1.116	1.428
< 2 h	Personal	7 ***	6	2 (28.6%)	2	57.1	28.6	=-Values: 0.58 to 2.37		
< 2 h	Static	35	13	3 (8.6%)	0.71	25.7	74.3	1.965	5.085	8.402

Table 7.12.2 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	37	30	4 (10.8%)	0,71	91.9	8.1	1.895	8.261	11.36
≥ 2 h	LEV = no	13	12	0	n/a	76.9	23.1	2,185	14.29	24.06
Respirable dust										
≥ 2 h	LEV = yes	39	33	8 (20.5%)	0.25	84.6	15.4	0.38	1.671	1.842
≥ 2 h	LEV = no	18	17	4 (22.2%)	0.25	66.7	33.3	0.63	2.17	2.341

7.12.3 Shaping

Table 7.12.3

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	29	26	4 (13.8%)	0.71	100	0	0.89	4.966	5.125
≥ 2 h	Static	150	85	2 (1.3%)	0.71	98.7	1.3	+ 0.47	2.53	3.55
< 2 h	Static	8 ***	5	0	n/a	62.5	37.5	=-Values: 0.32 to 16.2		
Respirable dust										
≥ 2 h	Personal	34	29	8 (23.5%)	0.25	97.1	2.9	0.3	0.876	1.011
≥ 2 h	Static	153	86	66 (43.1%)	0.25	98	2	+ 0.175	0.597	0.913
< 2 h	Static	15	5	1 (6.7%)	0.36	40	60	1.565	6.945	10.498

7.12.4 Preparation for firing

Table 7.12.4

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	15	11	1 (6.7%)	0.25	100	0	1.16	3.04	3.13
≥ 2 h	Static	70	35	2 (2.9%)	0.71	95.7	4.3	+ 0.56	6.99	9.24
< 2 h	Static	7 ***	3 **	0	n/a	57.1	42.9	=-Values: 0.46 to 123		
Respirable dust										
≥ 2 h	Personal	16	13	9 (56.3%)	0.25	87.5	12.5	! LOD	1.262	1.88
≥ 2 h	Static	65	34	32 (49.2%)	0.25	90.8	9.2	+ 0.147	1.185	1.962
< 2 h	Static	10	4 **	1 (10%)	0.36	20	80	1.75	3.37	6.375

Figure 24: Bricks on the drying rack

7.12.5 Firing

Table 7.12.5

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	34	25	5 (14.7%)	0.71	94.1	5,9	1	5.718	9.036
≥ 2 h	Static	150	87	8 (5.3%)	0.48	100	0	+ 0.46	2.82	4.34
< 2 h	Static	11	6	2 (18.2%)	1.4	100	0	+ 0.47	3.575	4.128
Respirable dust										
≥ 2 h	Personal	32	23	9 (28.1%)	0.25	93.8	6.3	0.34	0.884	1.426
≥ 2 h	Static	154	87	75 (48.7%)	0.75	96.8	3.2	+ 0.12	+ 0.556	0.979
< 2 h	Static	17	8	6 (35.3%)	0.44	82.4	17.6	+ 0.435	1.61	2.0495

7.12.6 Finishing

Table 7.12.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	19	15	2 (10.5%)	0.71	94.7	5.3	1.12	4.18	7.19
≥ 2 h	Static	78	52	4 (5.1%)	0.07	100	0	0.62	3.864	4.889
Respirable dust										
≥ 2 h	Personal	24	20	5 (20.8%)	0.25	83.3	16.7	0.39	1.632	2.004
≥ 2 h	Static	81	54	35 (43.2%)	0.18	97.5	2.5	+ 0.18	1.059	1.169
< 2 h	Static	10	4 **	5 (50%)	0.51	60	40	+ 0.255	7.66	8.595

7.12.7 Packing, quality control

Table 7.12.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	10	9	4 (40%)	0.71	100	0	+ 0.355	1.63	4.19
≥ 2 h	Static	32	25	3 (9.4%)	0.36	100	0	+ 0.25	1.878	2.724
Respirable dust										
≥ 2 h	Personal	10	9	6 (60%)	0.25	100	0	! LOD	0.36	0.38
≥ 2 h	Static	40	30	29 (72.5%)	0.18	100	0	! LOD	0.43	0.57

8 Chemical, pharmaceutical, rubber and plastics industry

8.1 Chemical industry

Sector
Chemical industry
Lead-based stabilizers for the plastics industry, production
Biochemical industry
Explosives, pyrotechnics, munitions manufacture
Man-made fibres, manufacture
Mineral oil refinery including pitch processing
Gases (technical), production, transfer

Solids such as raw materials, auxiliary materials or fillers are used in the chemical industry in the production of a wide variety of products, and dusts can occur when these solids are introduced into reaction vessels, mixers or other plant and machinery. Dusts may be released during the production process or during the packaging of finished products, and may arise during the finishing of manufactured products, for example during cutting, milling, drilling or grinding.

8.1.1 Weighing out

Weighing-out processes may be fully automatic or manual. During manual weighing-out, the additives are retrieved with a shovel for example from drums, tubs or sacks and weighed out openly on a scale. The weighing stations often feature exhaust equipment.

Table 8.1.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	27	19	4 (14.8%)	0.71	92.6	7.4	1.845	6.02	9.68
≥ 2 h	Static	15	13	7 (46.7%)	0.72	100	0	+ 0.58	2.6	2.95
< 2 h	Personal	16	11	4 (25%)	6	87.5	12.5	+ 2.85	14.98	27.44
Respirable dust										
≥ 2 h	Personal	21	19	3 (14.3%)	1.22	66.7	33.3	+ 0.515	1.778	3.036
≥ 2 h	Static	13	11	5 (38.5%)	0.23	92.3	7.7	0.355	1.091	1.609
< 2 h	Personal	13	11	9 (69.2%)	2.3	76.9	0	! LOD	+ 1.135	+ 1.167
< 2 h	Static	8 ***	5	5 (62.5%)	3	75	0	=-Values: 0.53 to 1.2		

8.1.2 Preparation of liquid mixtures

During the production of coatings, paints, varnishes or adhesives, solids are filled into feed or agitated vessels, either fully automatically from silos or FIBCs, or manually. Depending on the material properties, quantities and exhaust systems, different dust exposures arise.

Table 8.1.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	10	8	5 (50%)	0.61	100	0	+ 0.305	0.96	1.03
< 2 h	Personal	22	16	7 (31.8%)	2.9	95.5	4.5	+ 1.45	7.846	8.705
< 2 h	Static	7 ***	5	3 (42.9%)	1.9	85.7	14.3	=-Values: 0.76 to 14.5		
Respirable dust										
≥ 2 h	Personal	10	7	3 (30%)	0-23	100	0	0-38	0-96	1.01
< 2 h	Personal	20	14	12 (60%)	2	60	30	! LOD	+ 1.8	2.3
< 2 h	Static	6 ***	4 **	4 (66-7%)	2-7	16-7	33-3	=-Values: 1.4 to 1.5		

8.1.3 Preparation of dry mixtures

Plasters, mortars, adhesives and surfacing compounds are produced by the mixing of different solid materials. When the aggregates are introduced into the feed vessels and mixers, exposure to the corresponding dusts may arise.

Figure 25: Preparation of a dry mixture

Table 8.1.3

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	117	70	29 (24.8%)	0.72	89.7	10.3	1.8	8.94	16.54
≥ 2 h	Static	56	39	26 (46.4%)	0.72	100	0	+ 0.355	2.928	3.988
< 2 h	Personal	72	40	29 (40.3%)	8.6	84.7	15.3	+ 1.9	17.02	47
< 2 h	Static	20	16	10 (50%)	5.7	85	15	+ 0.7	27	29.8
Respirable dust										
≥ 2 h	Personal	116	74	43 (37.1%)	1.3	80.2	19.0	+ 0.48	2.5	3.512
≥ 2 h	Static	46	32	20 (43.5%)	1.1	97.8	2.2	+ 0.24	+ 0.806	+ 1.1
< 2 h	Personal	63	45	29 (46%)	6	57.1	30.2	+ 0.615	+ 4.57	6.55
< 2 h	Static	23	19	15 (65.2%)	3	52.2	26.1	! LOD	3.11	3.974

Table 8.1.3 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	81	51	21 (25.9%)	0.72	90.1	9.9	1.905	8.37	11.92
≥ 2 h	LEV = no	7 ***	5	3 (42.9%)	0.71	71.4	28.6	=-Values: 0.32 to 98.2		
< 2 h	LEV = yes	39	25	17 (43.6%)	8.6	89.7	10.3	+ 1.505	9.29	14.105
< 2 h	LEV = no	8 ***	6	2 (25%)	3.1	87.5	12.5	=-Value: 1.26 to 64.6		
Respirable dust										
≥ 2 h	LEV = yes	68	44	19 (27.9%)	1.1	75.0	25.0	+ 0.53	3.18	5.888
≥ 2 h	LEV = no	13	11	9 (69.2%)	1.3	84.6	7.7	! LOD	+ 0.6425	+ 1.0175
< 2 h	LEV = yes	32	27	14 (43.8%)	2.48	53.1	37.5	+ 0.62	5.28	7.26
< 2 h	LEV = no	10	8	6 (60%)	1.3	70	20	! LOD	1.98	2.34

8.1.4 Filling, packing

Once products have been produced, in most cases by mixing processes, they must be filled into various types of packaging such as FIBCs, sacks, drums or boxes. Depending on the type of product, quantity and filling technology used, different levels of dust may arise.

Table 8.1.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	85	47	31 (35.6%)	0.72	89.7	10.3	1.165	9.04	13.9
≥ 2 h	Static	45	30	20 (44.4%)	0.71	100	0	+ 0.355	2.35	2.595
< 2 h	Personal	27	20	17 (63%)	5.71	88.9	11.1	! LOD	10.27	23.44
< 2 h	Static	10	7	8 (80%)	6	90	10	! LOD	+ 3	8.8
Respirable dust										
≥ 2 h	Personal	70	40	26 (37.1%)	1.3	82.9	15.7	+ 0.39	1.59	2.19
≥ 2 h	Static	41	26	20 (48.8%)	0.45	97.6	2.4	+ 0.225	0.619	0.811
< 2 h	Personal	21	17	15 (71.4%)	2	52.4	14.3	! LOD	2.17	2.775
< 2 h	Static	7 ***	6	3 (42.9%)	0.77	57.1	42.9	=-Value: 0.28 to 10.4		

Table 8.1.4 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	66	34	20 (30.3%)	0.72	89.4	10.6	1.4	9.32	16.13
≥ 2 h	LEV = no	12	9	6 (50%)	0.71	83.3	16.7	! LOD	11.62	13.78
Respirable dust										
≥ 2 h	LEV = yes	53	31	19 (35.8%)	1.3	83.0	15.1	+ 0.39	1.597	2.2185
≥ 2 h	LEV = no	6 ***	5	3 (50%)	0.25	83.3	16.7	=-Values: 0.31 to 1.4		

8.1.5 Production, reactors

Many production facilities are largely enclosed, with the result that dust exposures tend to be lower. On open production installations such as open mixers or screening machinery, higher dust exposures may occur.

Table 8.1.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	100	51	34 (34%)	0.71	92	8	0.83	6	14.9
≥ 2 h	Static	45	26	32 (71.1%)	0.74	97.8	2.2	! LOD	1.195	2.705
< 2 h	Personal	38	32	20 (52.6%)	7.1	94.7	5.3	! LOD	8.142	10.6
< 2 h	Static	18	14	10 (55.6%)	5.7	88.9	11.1	! LOD	23.24	81.96
Respirable dust										
≥ 2 h	Personal	71	39	25 (35.2	1.3	81.7	16.9	+ 0.405	2.145	3.341
≥ 2 h	Static	36	24	25 (69.4%)	2.3	94.4	2.8	! LOD	+ 1.036	+ 1.2
< 2 h	Personal	34	28	20 (58.8%)	67.5	50	23.5	! LOD	+ 3.98	+ 13.485
< 2 h	Static	11	9	6 (54.5%)	3	63.6	18.2	! LOD	+ 1.77	3.249

Table 8.1.5 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	60	32	20 (33.3%)	0.71	95	5	0.94	5.7	9.4
≥ 2 h	LEV = no	14	9	8 (57.1%)	0.71	92.9	7.1	! LOD	5.056	107.692
Respirable dust										
≥ 2 h	LEV = yes	38	25	13 (34.2%)	1.1	84.2	15.8	+ 0.45	2.26	2.858
≥ 2 h	LEV = no	12	8	7 (58.3%)	1.3	75	16.7	! LOD	2.288	4.39

8.1.6 Grinding, chip-forming machining processes, blasting

Many of the manufactured products and semi-finished goods must undergo further processing steps, such as deburring, grinding, blasting or polishing, before they are processed further or sold. These steps may be either manual or fully automatic. Elevated dust loads may arise during manual finishing, especially in the absence of an exhaust system.

Table 8.1.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	36	17	20 (55.6%)	0.72	100	0	! LOD	2.81	3.46
≥ 2 h	Static	15	10	10 (66.7%)	0.74	100	0	! LOD	1.35	1.71
< 2 h	Personal	8 ***	5	4 (50%)	2.3	87.5	12.5	=-Values: 2 to 32.5		
< 2 h	Static	10	4 **	4 (40%)	0.95	100	0	1.3	2.5	2.7
Respirable dust										
≥ 2 h	Personal	32	16	26 (81.3%)	1.1	100	0	! LOD	+ 0.532	+ 0.578
≥ 2 h	Static	16	11	9 (56.3%)	0.25	93.8	6.3	! LOD	0.726	1.34
< 2 h	Personal	9 ***	6	6 (66.7%)	13.2	66.7	22.2	=-Values: 0.65 to 5.16		

8.2 Roofing felt and bitumen sheeting, production

Sector
Roofing felt and bitumen roof sheeting, manufacture

Roofing felt and bitumen roof sheeting are made from a range of materials. Paperboard, plastic sheeting, rubber sheeting, glass fibre cloth, polyester or jute webbing may be used. Significant dust exposures are possible when these materials are rolled up and cut. The surfaces are often sprinkled with mineral substances such as gravel, silica sand or slate chippings, as a result of which dust containing quartz may arise. More details can be found in the IFA Report on quartz exposures at the workplace.

Table 8.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	15	7	3 (20%)	0.71	93.3	6.7	1.55	4.69	8.35
≥ 2 h	Static	15	7	4 (26.7%)	0.71	100	0	0.995	4.485	5.955
Respirable dust										
≥ 2 h	Personal	20	8	2 (10%)	0.23	65	35	0.51	3.44	5.04
≥ 2 h	Static	15	8	3 (20%)	0.25	73.3	26.7	0.84	4.19	4.668

8.3 Paints, coatings and adhesives, jointing and surfacing compounds, production

Sector
Coatings, adhesives, jointing and surfacing compounds, production and use
Glue, gelatin, etc., production, general
Gelatin, bone glue, production and disposal of animal cadavers
Surfacing compounds, production
Paints (containing solvents), production
Paints (water-based), production
Paints (emulsion paints and plasters), production
Paints (powder coatings), production and use
Paints (screen printing inks), production and use

Paints, coatings and adhesives, and jointing and surfacing compounds are produced in liquid, paste or powder form. Binders, pigments, fillers, solvents and other additives are used in the production process. Dust exposure may occur in all process steps, such as weighing, preparation, mixing, dispersing, screening, filling, and the cleaning of containers or plant components.

8.3.1 Filling, packing

Once the products have been produced, they must be filled into different types of packaging such as FIBCs, sacks, drums or boxes. Depending on the type of product, quantity and filling technology used, different levels of dust may be generated.

Table 8.3.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	24	14	10 (41.7%)	0.72	95.8	4.2	0.89	7.492	9.564
< 2 h	Personal	11	7	3 (27.3%)	3.7	100	0	+ 1.775	8.403	8.861
Respirable dust										
≥ 2 h	Personal	26	15	10 (38.5%)	0.26	84.6	15.4	0.36	1.52	1.718
≥ 2 h	Static	13	9	3 (23.1%)	0.23	69.2	30.8	0.53	2.49	3.26
< 2 h	Personal	8 ***	7	5 (62.5%)	1.28	87.5	0	=-Values: 0.45 to 0.74		

8.3.2 Preparation of liquid mixtures

At the formulation stage, binders, pigments, fillers, solvents and other additives must be filled manually into feed or agitated vessels. Depending on the material properties, quantities and exhaust systems, different dust exposures arise.

Figure 26: Formulating a paint mixture by the addition of pigment

Table 8.3.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	24	15	6 (25%)	0.72	95.8	4.2	1.5	5.84	7.84
< 2 h	Personal	22	14	4 (18.2%)	2.48	77.3	22.7	3.2	20.06	21.88
Respirable dust										
≥ 2 h	Personal	17	13	2 (11.8%)	0.63	82.4	17.6	+ 0.5	1.436	1.577
≥ 2 h	Static	8 ***	6	5 (62.5%)	0.25	87.5	12.5	=-Values: 0.22 to 8.4		
< 2 h	Personal	15	10	6 (40%)	1.5	60	33.3	+ 0.66	2.22	3.76
< 2 h	Static	8 ***	3 **	2 (25%)	0.51	37.5	62.5	=-Values: 0.66 to 4.16		

8.3.3 Preparation of dry mixtures

Paints, coatings and adhesives, and jointing and surfacing compounds are produced by the mixing of different solids and possibly solvents. Corresponding dust exposures may arise when the aggregates are introduced into the feed vessels and mixers.

Figure 27: Dry mixing

Table 8.3.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	58	37	8 (13.8%)	0.71	96.6	3.4	1.8	6.956	9.24
≥ 2 h	Static	15	11	2 (13.3%)	0.24	100	0	1.005	2.44	3.192
< 2 h	Personal	24	17	4 (16.7%)	1.8	83.3	16.7	2	14.72	21.84
< 2 h	Static	11	7	2 (18.2%)	4.28	90.9	9.1	+ 2.97	5.607	17.0465
Respirable dust										
≥ 2 h	Personal	49	33	16 (32.7%)	1.25	81.6	18.4	+ 0.465	1.826	3.485
≥ 2 h	Static	18	13	7 (38.9%)	1.25	94.4	5.6	+ 0.27	+ 0.754	+ 1.057
< 2 h	Personal	28	18	9 (32.1%)	1.88	57.1	35.7	+ 0.8	3.26	6.408
< 2 h	Static	17	9	7 (41.2%)	1.5	52.9	35.3	+ 0.748	3.071	9.978

8.3.4 Weighing out

The required raw materials, auxiliary materials and additives may be weighed out either fully automatically or manually. During manual weighing-out, the additives are retrieved with a shovel for example from drums, tubs or sacks and weighed out openly on a scale. The weighing stations often feature exhaust equipment.

Table 8.3.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	18	11	3 (16.7%)	0.71	77.8	22.2	1.68	13.08	14.24
< 2 h	Personal	11	6	7 (63.6%)	6.6	90.9	9.1	! LOD	8.425	12.688
Respirable dust										
≥ 2 h	Personal	23	14	5 (21.7%)	1.1	65.2	34.8	+ 0.515	2.122	3.22
< 2 h	Personal	19	9	13 (68.4%)	3	42.1	31.6	! LOD	+ 2.153	3.866

8.4 Pharmaceutical, cosmetic, cleaning and sanitary products, production

Sector
Pharmaceutical products, production
Cosmetic products, production
Cleaning and sanitary products

8.4.1 Production, reactors, filling, packing

The raw materials, auxiliary materials and additives required for the production of pharmaceutical, cosmetic, cleaning and sanitary products are weighed out and mixed. Depending on the product, wet or dry mixing processes may be employed. The finished products are then filled into containers and packed. The required raw materials, auxiliary materials and additives may be weighed out either fully automatically or manually. During manual weighing-out, the auxiliary materials are retrieved with a shovel for example from drums, tubs or sacks and weighed out openly on a scale. The weighing stations often feature exhaust equipment.

Figure 28: Filling station with exhaust equipment

Table 8.4.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	59	29	21 (35.6%)	0.72	96.6	3.4	0.855	6.454	9.11
≥ 2 h	Static	41	25	25 (61%)	0.72	97.6	2.4	! LOD	2.99	3.195
< 2 h	Personal	27	17	12 (44.4%)	5.7	77.8	22.2	+ 2.375	20.18	53.135
< 2 h	Static	17	8	1 (64.7%)	1.1	100	0	! LOD	1.42	1.775
Respirable dust										
≥ 2 h	Personal	54	24	25 (46.3%)	1.1	87	13	+ 0.29	1.66	1.83
≥ 2 h	Static	35	23	26 (74.3%)	0.71	97.1	2.9	! LOD	+ 0.605	+ 0.63
< 2 h	Personal	35	19	24 (68.6%)	1.9	65.7	17.1	! LOD	3.4	12.625
< 2 h	Static	17	9	15 (88.2%)	1.4	94.1	0	! LOD	+ 0.651	+ 0.718

8.4.2 Weighing-out and formulation of mixtures

The required raw materials, auxiliary materials and additives may be weighed out either fully automatically or manually. During manual weighing-out, the additives are retrieved with a shovel for example from drums, tubs or sacks and weighed out openly on a scale. The weighing stations are generally equipped with exhaust equipment.

Figure 29: Mixing drum for the production of dry mixtures

Table 8.4.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	37	25	11 (29.7%)	0.74	83.8	16.2	1.55	18.84	40.34
≥ 2 h	Static	18	10	9 (50%)	0.72	100	0	+ 0.29	1.56	1.88
< 2 h	Personal	19	14	8 (42.1%)	3.5	78.9	21.1	+ 1.475	19.61	28.125
< 2 h	Static	10	8	5 (50%)	2.9	80	20	+ 1.05	10.3	14
Respirable dust										
≥ 2 h	Personal	33	20	14 (42.4%)	1.1	78.8	21.2	+ 0.32	2.377	2.935
≥ 2 h	Static	12	8	8 (66.7%)	0.24	91.7	8.3	! LOD	0.662	1.078
< 2 h	Personal	11	10	5 (45.5%)	1.1	72.7	27.3	+ 0.405	1.68	2.168
< 2 h	Static	11	10	6 (54.5%)	0.99	90.9	9.1	! LOD	1.1	1.496

8.5 Foundry auxiliaries, production

Sector
Foundry auxiliaries, production

Sand and other minerals such as aluminium silicates, chamotte or magnesite are used in the production of moulding sand for the foundry industry. Binders such as clays, aqueous glass or cement are also required. Corresponding dust exposure occurs for example during infeed, mixing and drying, during filling of the product into packaging, and during cleaning of the plants.

Table 8.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	30	11	0	n/a	73.3	26.7	3.69	17	21.05
≥ 2 h	Static	14	8	6 (42.9%)	0.73	92.9	7.1	+ 0.365	2.048	4.824
Respirable dust										
≥ 2 h	Personal	38	13	5 (13.2%)	0.25	68.4	31.6	0.71	4.304	5.383
≥ 2 h	Static	14	8	7 (50%)	0.25	92.9	7.1	+ 0.125	0.484	1.199
< 2 h	Personal	6 ***	4 **	1 (16.7%)	0.81	33.3	66.7	=-Values: 0.4 to 4.35		

8.6 Abrasives and polishes, production

Sector
Abrasives and polishes (dry), production
Abrasive and polishing pastes, production

Abrasives and polishes for the treatment of metal, stone and wood generally consist primarily of corundum (aluminium oxide), silicon carbide or boron nitride. Corresponding dust exposures are possible both during production (electrothermal processes) and during further processing into grinding and polishing tools.

Table 8.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	35	8	8 (22.9%)	0.71	85.7	14.3	2.11	12.2	16.175
≥ 2 h	Static	13	7	4 (30.8%)	0.71	92.3	7.7	+ 0.657	3.96	6.86
< 2 h	Personal	9 ***	4 **	2 (22.2%)	2	88.9	11.1	=-Values: 2.36 to 19.8		
Respirable dust										
≥ 2 h	Personal	39	8	14 (35.9)	0.25	84.6	15.4	0.295	1.453	2.712
≥ 2 h	Static	11	6	7 (63.6%)	0.25	90.9	9.1	! LOD	0.979	1.347
< 2 h	Personal	11	5	4 (36.4%)	2	63.6	27.3	+ 0.75	+ 1.953	2.468

8.7 Rubber products, production and processing

Sector
Rubber products, production and processing
Tyres, production and retreading
Rubber articles (technical), production
Fine rubber articles (latex products etc.)

Rubber compounds contain numerous raw and auxiliary materials. Examples include natural rubber, carbon black, anti-ageing agents, vulcanization agents, release agents and other additives. The processes involved in the production of rubber goods are mixing, kneading, compounding and vulcanizing, and where applicable finishing and further processing.

8.7.1 Weighing out, mixing

The required raw materials, auxiliary materials and additives may be weighed out either fully automatically or manually. During manual weighing-out, the additives are retrieved with a shovel for example from drums, tubs or sacks and weighed out openly on a scale. The weighing stations are generally equipped with exhaust equipment. The mixtures are produced primarily in closed mixers.

Figure 30: Weighing out and mixing station in the rubber industry

Table 8.7.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	Concentrations (mg/m³) 90th percentile	Concentrations (mg/m³) 95th percentile
Inhalable dust										
≥ 2 h	Personal	24	16	7 (29.2%)	0.71	95.8	4.2	1	3.744	7.064
≥ 2 h	Static	22	11	3 (13.6%)	0.71	100	0	1	2.424	2.608
< 2 h	Personal	9 ***	8	2 (22.2%)	0.81	77.8	22.2	=-Values: 1.4 to 132		
< 2 h	Static	8 ***	5	4 (50%)	3.3	87.5	12.5	=-Values: 1.32 to 23.4		
Respirable dust										
≥ 2 h	Personal	27	18	12 (44.4%)	1.1	85.2	14.8	+ 0.285	1.436	1.91
≥ 2 h	Static	19	10	6 (31.6%)	0.26	94.7	5.3	+ 0.24	0.992	1.13
< 2 h	Personal	6 ***	6	3 (50%)	0.48	83.3	16.7	=-Values: 0.46 to 2.68		
< 2 h	Static	11	8	5 (45.5%)	1.5	54.5	18.2	+ 0.7	5.392	6.0845

8.7.2 Production and processing of the rubber compound

Following compounding, the rubber compounds are processed further on kneaders and rolling mills. In their various forms (blanks, strips, sheets, shaped pieces or granulates), the items then undergo further processing/assembly. Further materials such as steel mesh, textile cord or metal parts are incorporated at this stage to form semi-finished products. Dust exposure is caused primarily by mechanical processes such as abrasion.

Figure 31: Processing of the rubber compound

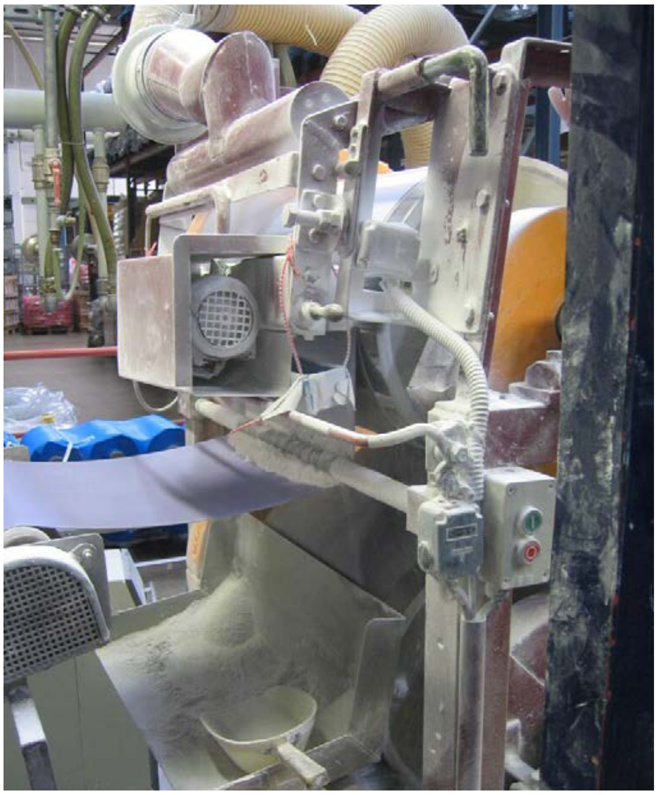

Table 8.7.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	40	26	14 (35%)	0.72	95	5	0.76	3.35	4.1
≥ 2 h	Static	25	20	9 (36%)	0.71	100	0	+ 0.43	3.335	5.317
< 2 h	Personal	15	8	5 (33.3%)	2.9	86.7	13.3	+ 1.8	13.7	18.775
Respirable dust										
≥ 2 h	Personal	28	23	12 (42.9%)	1.17	96.4	3.6	+ 0.33	+ 1.12	1.2
≥ 2 h	Static	26	19	15 (57.7%)	0.25	96.2	3.8	! LOD	0.378	0.502
< 2 h	Personal	17	9	12 (70.6%)	2.8	76.5	5.9	! LOD	+ 1.19	+ 1.865
< 2 h	Static	7 ***	7	4 (57.1%)	1	85.7	14.3	=-Values: 0.41 to 2.4		

8.7.3 Vulcanization

The semi-finished products may be vulcanized either discontinuously or continuously. Vulcanization cross-links the rubber. It may be performed for example in vulcanizing autoclaves, presses, chambers or moulds, in UHF, hot air or salt bath vulcanizing systems, or in drum or conveyor belt vulcanizing systems. These vulcanization processes generate vapours in varying concentrations.

8.7.4 Processing: reworking of rubber goods

Some rubber goods must be reworked following the vulcanization process. Processes such as grinding, roughening, drilling, punching or cutting are employed for this purpose. The dust exposures arising in these processes differ according to the type of process and the local conditions (e.g. use of dust exhaust systems).

Table 8.7.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	18	10	9 (50%)	0.71	100	0	+ 0.355	2.22	2.793
Respirable dust										
≥ 2 h	Personal	8 ***	6	0	n/a	50	50	=-Values: 0.42 to 9.6		
≥ 2 h	Static	28	13	15 (53.6%)	0.25	96.4	3.6	! LOD	0.442	0.596

Table 8.7.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	15	12	5 (33.3%)	0.71	100	0	+ 0.468	3.55	3.9
≥ 2 h	Static	17	14	10 (58.8%)	0.72	100	0	! LOD	2.686	4.532
Respirable dust										
≥ 2 h	Personal	16	12	6 (37.5%)	0.25	81.3	18.8	0.45	5.32	5.524
≥ 2 h	Static	20	15	14 (70%)	0.73	95	5	! LOD	+ 0.365	+ 0.43
< 2 h	Personal	9 ***	7	7 (77.8%)	1	88.9	11.1	=-Values: 0.86 to 4.42		

8.8 Fibre-reinforced plastics, production and processing

Sector
Glass-fibre reinforced plastics, production
Carbon-fibre reinforced plastics, production
Carbon-fibre reinforced plastics, processing

Fibre-reinforced plastics are used for example in the construction of moulds for vessels, pipes, or vehicles of all types. Glass fibre, carbon or other fabric is impregnated with phenolic, epoxy or other resins and chemically cured with the use of hardeners. Dust exposure may occur for example during activities relating to the fabrics, and in particular during finishing work.

8.8.1 Production of plastic parts, processing of plastics

The glass fibre, carbon or other fabric must be cut or punched to size and fitted into moulds. Dust exposure may arise, depending upon the method used and the surface area of the application.

Table 8.8.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	17	8	10 (58.8%)	0.72	100	0	! LOD	3.356	4.643
≥ 2 h	Static	15	11	8 (53.3%)	0.71	100	0	! LOD	1.1	1.25
Respirable dust										
≥ 2 h	Personal	16	7	11 (68.8%)	0.43	87.5	12.5	! LOD	0.916	1.834
≥ 2 h	Static	12	9	10 (83.3	0.42	100	0	! LOD	+ 0.378	0.464

8.8.2 Chip-forming machining processes

Manufactured fibre-reinforced plastic parts frequently require reworking. Processes such as grinding, sawing or drilling are employed for this purpose. Dust loads occur as a function of the type of work process and the local conditions (such as the presence of dust exhaust systems).

Table 8.8.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	40	22	18 (45%)	0.72	85	15	+ 0.53	38.3	53
≥ 2 h	Static	11	8	6 (54.5%)	0.71	100	0	! LOD	1.585	1.69
< 2 h	Personal	12	5	4 (33.3%)	1.5	66.7	33.3	3.7	26.62	44.48
Respirable dust										
≥ 2 h	Personal	41	21	25 (61%)	1.25	82.9	17.1	! LOD	3.23	5.484

8.9 Plastics, production and processing

Sector
Plastic roofing and sheeting, production
Plastic and plastic foam, processing
Lead-based stabilizers, application
Plastic moulded parts, production
Plastic injection moulding
Plastic film, production
Plastic tarpaulins, production
Floor coverings and PVC, production
Semi-finished plastic products, production
Plastics and plastic foam, production
Seals, production
Seals, processing
Film and foil production
Plastic goods, production
Vehicle seats, production
Advertising materials, production
Protective helmets, production
Vehicle interior fittings, production
Screen making and stencilling services
Windows, doors and façade elements (plastic), production
Window construction, plastic
Floor coverings and linoleum, production
Acid-proof installation, plastics and tank construction
Acid-proof installation
Boat and shipbuilding

Plastics are produced from monomers by polymerization. A distinction is drawn between thermoplastics, thermosets and elastomers. A wide range of downstream processes, such as injection moulding, extrusion or deep-drawing, result in an enormous wealth of plastic end products. Dust exposure occurs mainly during the downstream processing steps.

8.9.1 Production of plastic parts: extrusion, casting, calendering, laminating (GFRP), prepreg and foaming

Plastic granulates are melted by the application of heat and shaped in various ways. As they cool, the plastics solidify again and the shape that they have assumed becomes permanent. Foams are produced by means of chemical reactions, such as the reaction of isocyanates with polyols or other reactants. Dust exposure may occur for example during metering of the plastic granulates into the machines and feed vessels or cutting of the mats (GFRP).

Figure 32: GFRP mats for laminating

Table 8.9.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	191	131	82 (42.9%)	7.3	98.4	1.6	+ 0.365	+ 3.456	+ 6.9
≥ 2 h	Static	262	152	157 (59.9%)	2.5	100	0	! LOD	+ 1.328	3.459
< 2 h	Personal	29	20	12 (41.4%)	5	69	31	+ 2.0625	17	26.325
< 2 h	Static	28	19	11 (39.3%)	12	85.7	10.7	+ 0.57	+ 10.14	12.02
Respirable dust										
≥ 2 h	Personal	161	116	92 (57.1%)	1.25	93.8	6.2	! LOD	+ 0.844	1.329
≥ 2 h	Static	229	138	171 (74.7%)	1.25	96.5	3.5	! LOD	+ 0.48	+ 0.683
< 2 h	Personal	25	16	8 (32%)	1	60	40	+ 0.6	12.865	13.85
< 2 h	Static	29	19	21 (72.4%)	5.4	65.5	10.3	! LOD	+ 1.44	+ 3.244

Table 8.9.1 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	85	57	50 (58.8%)	1.25	95.3	4.7	! LOD	+ 0.745	+ 1.123
≥ 2 h	LEV = no	54	49	35 (64.8%)	1.18	94.4	5.6	! LOD	+ 0.644	+ 1.154

8.9.2 Preparation: conveying, filling, mixing, weighing

Some products require further additives to be mixed into the plastic granulates. Weighing-out is normally performed manually, but may also be automated. The weighing stations do not generally feature exhaust equipment. The mixtures are produced manually or automatically, for example on eccentric tumblers, and either piped to processing machines or fed into them manually. Dust may occur as a function of the activity and the technology used.

Table 8.9.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	94	56	18 (19.1%)	0.72	85.1	14.9	2.1	12.632	18.73
≥ 2 h	Static	171	73	56 (32.7%)	0.72	98.2	1.8	+ 0.38	2.869	5.141
< 2 h	Personal	32	20	8 (25%)	6	81.3	18.8	+ 2.85	12.7	14.78
< 2 h	Static	15	12	6 (40%)	1.68	86.7	13.3	+ 0.77	11.15	21.875
Respirable dust										
≥ 2 h	Personal	105	59	28 (26.7%)	1.27	76.2	22.9	+ 0.55	2.815	4.075
≥ 2 h	Static	143	66	88 (61.5%)	1.31	93	5.6	! LOD	+ 0.83	+ 1.276
< 2 h	Personal	23	16	11 (47.8%)	2	60.9	30.4	+ 0.88	3.111	8.534
< 2 h	Static	20	15	11 (55%)	0.59	70	30	! LOD	2.32	2.7

Table 8.9.2 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	63	39	14 (22.2%)	0.72	87.3	12.7	2.1	12.44	18.07
≥ 2 h	LEV = no	13	8	1 (7.7%)	0.7	84.6	15.4	1.795	18.632	24.955
Respirable dust										
≥ 2 h	LEV = yes	58	33	16 (27.6%)	1.1	77.6	22.4	+ 0.49	3.128	6.048
≥ 2 h	LEV = no	19	11	4 (21.1%)	0.25	73.7	26.3	0.51	2.892	3.834

8.9.3 Comminution: grinding

Comminution and grinding processes are primarily carried out during recycling. This may be performed on compact grinders, in which case homogeneous ground product is fed back into the production process, or on larger grinders, in which case less homogeneous ground product is usually processed in further steps to form granulate. Dust may escape from openings on the grinder and may be generated during conveying and filling processes.

Table 8.9.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	20	18	9 (45%)	0.71	90	10	+ 0.49	8.48	37.1
≥ 2 h	Static	43	30	26 (60.5%)	0.88	93	7	! LOD	2.509	9.558
Respirable dust										
≥ 2 h	Personal	23	19	18 (78.3%)	1.25	100	0	! LOD	+ 0.479	+ 0.585
≥ 2 h	Static	41	28	34 (82.9%)	1.3	95.1	0	! LOD	+ 0.385	+ 0.642

8.9.4 Processing of plastics

Plastics can be processed in a wide range of ways. These include processes such as cutting, punching, drilling, milling, turning and grinding. Dust may occur owing to the processing method and local conditions.

Table 8.9.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	54	33	23 (42.6%)	0.72	90.7	9.3	+ 0.41	5.486	17.275
≥ 2 h	Static	93	42	39 (41.9%)	2.6	96.8	3.2	+ 0.355	4.116	7.265
< 2 h	Personal	8 ***	6	1 (12.5%)	0.73	75	25	=-Values: 0.5 to 198		
Respirable dust										
≥ 2 h	Personal	49	29	31 (63.3%)	1.24	91.8	8.2	! LOD	+ 0.865	1.581
≥ 2 h	Static	88	40	63 (71.6%)	1.25	96.6	3.4	! LOD	+ 0.66	+ 0.848
< 2 h	Personal	11	7	3 (27.3%)	1.25	90.9	9.1	+ 0.632	+ 1.078	1.325
< 2 h	Static	5 ***	4 **	4 (80%)	1.05	80	20	=-Values: 1.4 to 1.4		

Table 8.9.4 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	28	18	12 (42.9%)	0.72	85.7	14.3	+ 0.36	14.058	17.5
≥ 2 h	LEV = no	24	15	10 (41.7%)	0.72	95.8	4.2	+ 0.63	2.064	4.116
Respirable dust										
≥ 2 h	LEV = yes	26	18	17 (65.4%)	1.24	92.3	7.7	! LOD	+ 0.85	1.453
≥ 2 h	LEV = no	21	11	13 (61.9%)	0.94	95.2	4.8	! LOD	+ 0.65	+ 0.822

8.9.5 Finishing of plastic articles: Deburring, polishing, grinding

During production, the mould may for example leave sprues on the plastic moulded parts. These are often removed manually with a deburring tool. Furthermore, processes such as polishing or grinding are important for attainment of the desired product quality. Dust exposure may occur owing to the nature of the process (manual or automatic) and the local conditions.

Table 8.9.5

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	153	93	34 (22.2%)	0.73	84.3	15.7	1.995	15.85	56.425
≥ 2 h	Static	96	47	40 (41.7%)	0.74	97.9	2.1	+ 0.355	3.956	6.02
< 2 h	Personal	29	20	13 (44.8%)	2.86	89.7	10.3	+ 1.045	6.692	24.91
< 2 h	Static	12	10	3 (25%)	1.42	91.7	8.3	+ 0.99	3.68	9
Respirable dust										
≥ 2 h	Personal	162	102	71 (43.8%)	1.25	85.2	14.8	+ 0.43	1.88	2.608
≥ 2 h	Static	91	45	64 (70.3%)	1.25	96.7	3.3	! LOD	+ 0.522	+ 0.745
< 2 h	Personal	29	23	23 (79.3%)	1.2	89.7	10.3	! LOD	+ 0.712	2.453
< 2 h	Static	13	10	8 (61.5%)	1.43	76.9	15.4	! LOD	+ 1.327	2.045

Table 8.9.5 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	121	72	30 (24.8%)	0.73	83.5	16.5	1.785	18.67	59.455
≥ 2 h	LEV = no	18	14	3 (16.7%)	0.71	83.3	16.7	2.3	21.62	73.45
Respirable dust										
≥ 2 h	LEV = yes	118	73	56 (47.5%)	1.25	83.9	16.1	+ 0.3	1.882	2.628
≥ 2 h	LEV = no	20	16	9 (45%)	1.11	85	15	+ 0.38	2.5	7.8

8.9.6 Finishing of plastic articles: drilling, milling, sawing, punching, cutting, and machining on CNC machines

During cutting, punching, drilling, milling, turning and grinding, dust may occur as a function of the type of process and the local conditions.

Figure 33: Manual finishing of plastic articles

Table 8.9.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	116	71	63 (54.3%)	0.72	100	0	! LOD	3.06	4.418
≥ 2 h	Static	66	46	28 (42.4%)	0.71	98.5	1.5	+ 0.355	1.566	2.75
< 2 h	Personal	33	22	20 (60.6%)	6.1	87.9	12.1	! LOD	11.755	17.895
< 2 h	Static	15	8	6 (40%)	2.85	86.7	13.3	+ 1.13	21.145	34.325
Respirable dust										
≥ 2 h	Personal	128	71	99 (77.3%)	1.25	96.9	3.1	! LOD	+ 0.565	+ 0.858
≥ 2 h	Static	67	49	57 (85.1%)	1.25	98.5	1.5	! LOD	+ 0.431	+ 0.609
< 2 h	Personal	35	20	23 (65.7%)	3	60	25.7	! LOD	4.15	9.275
< 2 h	Static	13	8	11 (84.6%)	1.9	76.9	7.7	! LOD	+ 0.915	+ 1.72

8.9.7 Finishing: printing, surface coating

Manufactured plastic products may be refined, for example by printing or coating of the surfaces. Print can be applied for example by means of pad printing; coatings may take the form of painting or vapour deposition. Exposure to dust is possible in particular during application of coatings.

Table 8.9.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	25	15	5 (20%)	2.5	92	8	+ 1.415	7.7	29.727
≥ 2 h	Static	43	25	19 (44.2%)	0.72	95.3	4.7	+ 0.355	3.822	8.068
< 2 h	Personal	5 ***	4 **	3 (60%)	1.8	80	20	=-Values: 9.2 to 11.9		
Respirable dust										
≥ 2 h	Personal	20	11	7 (35%)	0.25	85	15	0.4	1.36	1.67
≥ 2 h	Static	39	23	23 (59%)	0.25	100	0	! LOD	0.764	0.834
< 2 h	Personal	7 ***	6	5 (71.4%)	2.5	28.6	28.6	=-Values: 2.43 to 556.6		
< 2 h	Static	6 ***	4 **	3 (50%)	0.86	83.3	16.7	=-Values: 0.21 to 4.49		

8.9.8 Storage, transport, packing

Dust deposits from the production process or material abraded from packaging materials (such as paper or paperboard) may also cause dust exposure during storage, transport and packing activities.

Table 8.9.8

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	16	10	3 (18.8%)	0.69	93.8	6.3	1	5.49	9.44
≥ 2 h	Static	40	21	13 (32.5%)	0.71	100	0	+ 0.285	1.15	1.91
< 2 h	Personal	5 ***	3 **	1 (20%)	1.8	80	20	=-Values: 0.84 to 41.8		
Respirable dust										
≥ 2 h	Personal	18	11	8 (44.4%)	0.78	77.8	22.2	+ 0.34	1.876	1.969
≥ 2 h	Static	58	33	40 (69%)	0.5	96.6	3.4	! LOD	+ 0.344	+ 0.491

8.10 Electrothermal production of alloys and silicon compounds

Sector
Metal alloys (excluding silicon compounds), electrothermal production
Silicon compounds, electrothermal production

Substances such as silicon carbide or pure silicon are produced from sand in electric furnaces. Exposure to dust may occur during the preparatory grinding, drying, screening or mixing processes. This also applies to the process in the electric furnace itself, and to transfer processes.

Figure 34: Electric furnace for the production of silicon compounds

Table 8.10

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	28	8	3 (10.7%)	0.71	92.9	7.1	2.71	8.25	13.496
≥ 2 h	Static	12	7	5 (41.7%)	0.71	91.7	8.3	+ 0.52	3.384	7.998
< 2 h	Personal	6 ***	3 **	0	n/a	66.7	33.3	=-Values: 1.02 to 19.7		
Respirable dust										
≥ 2 h	Personal	23	4 **	3 (13%)	0.23	47.8	52.2	1.24	3.641	3.829
≥ 2 h	Static	13	5	8 (61.5%)	0.23	84.6	15.4	! LOD	1.603	2.151
< 2 h	Personal	11	5	2 (18.2%)	0.34	90.9	9.1	0.625	1.236	1.762

9 Wood, leather, paper, textile industry

9.1 Wood processing

Sector
Office furniture, production
Sawmill
Production of wood glue
Production of wood mouldings
Wood fibre and chipboard plant
Production of OSB board
Woodworking and wood processing
Carpentry, joinery
Window construction, wood
Production of wooden doors
Parquet production
Laminate production
Production of boxes and pallets
Furniture production
Building and furniture joinery
Upholstered furniture, production
Planing mill, moulding plant
Production of writing and drawing utensils
Timber construction, including wood preservation, excluding interior fittings, production
Carpentry, timber construction

The measured values listed here are for dusts in the respirable and inhalable fractions which were released for the most part during the treatment and processing of wood substitutes or composite materials with a low wood content, and which could not be classified clearly during on-site sampling as wood dust in the sense of the TRGS 553 technical rules.

9.1.1 Drilling, turning, milling, planing, sawing (manually and on CNC machines)

Elevated dust exposures arise above all during the manual machining of workpieces. The CNC machines are stationary systems. The workers' activities are usually limited to loading and retrieval of the workpieces and monitoring and control of the system.

The 90th percentile values lie below the limit values for both inhalable and respirable dust, irrespective of the form and duration of sampling.

Table 9.1.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	43	25	10 (23.3%)	0.71	100	0	1.02	4.56	5.737
≥ 2 h	Static	21	16	7 (33.3%)	0.71	100	0	+ 0.44	5.038	6.731
Respirable dust										
≥ 2 h	Personal	91	50	66 (72.5%)	1.25	94.5	5.5	! LOD	+ 0.68	+ 1.232
≥ 2 h	Static	35	26	23 (65.7%)	1.25	97.1	2.9	! LOD	+ 0.743	+ 1.005

9.1.2 Wood production: machining, assembly

Table 9.1.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	27	17	4 (14.8%)	0.71	96.3	3.7	1.405	4.491	5.282
≥ 2 h	Static	24	16	8 (33.3%)	0.71	100	0	+ 0.32	1.288	1.784
Respirable dust										
≥ 2 h	Personal	48	30	28 (58.3%)	1.25	100	0	! LOD	+ 0.836	+ 1.048
≥ 2 h	Static	20	14	13 (65%)	0.48	95	5	! LOD	0.54	0.81
< 2 h	Personal	6 ***	3 **	3 (50%)	1.37	83.3	0	=-Values: 0.38 to 0.5		

9.1.3 Polishing, sanding

Sanding is by definition an activity associated with high dust generation. Exposures above the limit value for both respirable and inhalable dust arise primarily during the use of manually guided (electric or pneumatic) sanding tools, particularly during the working of large workpieces. Ideally, the dust exhaust systems used (usually with a flexible dust capture element) are kept close to the machining point at all times; this is however not always possible in practice owing to the size and shape of the workpieces.

During personal measurements and a sampling duration of over two hours, the 90th percentile for the respirable dust clearly exceeds the limit value.

Figure 35: Manual sanding with a hand-held sanding block, with dust exhaust

Table 9.1.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	94	58	10 (10,6%)	0.71	92.6	7.4	2.02	8.642	12.821
≥ 2 h	Static	17	12	2 (11.8%)	0.71	100	0	1.19	3.959	5.284
< 2 h	Personal	13	8	8 (61.5%)	1.42	100	0	! LOD	2.576	4.114
Respirable dust										
≥ 2 h	Personal	119	66	63 (52.9%)	1.25	84	16	! LOD	2.14	3.09
≥ 2 h	Static	31	21	19 (61.3%)	0.83	93.5	6.5	! LOD	+ 0.514	1.0335

Table 9.1.3 a

Duration of sampling	Collection	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	LEV = yes	72	48	9 (12.5%)	0.71	91.7	8.3	2.42	8.656	15.702
≥ 2 h	LEV = no	16	12	1 (6.3%)	0.71	93.8	6.3	1.33	3.018	5.668
Respirable dust										
≥ 2 h	LEV = yes	98	59	50 (51%)	1.25	82.7	17.3	! LOD	2.278	3.251
≥ 2 h	LEV = no	17	12	11 (64.7%)	0.78	94.1	5.9	! LOD	1.162	1.284

9.1.4 Gluing, surface coating

Table 9.1.4

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	25	21	3 (12%)	0.71	96	4	1.195	4.115	5.418
≥ 2 h	Static	17	8	6 (35.3%)	0.71	100	0	+ 0.417	3.816	5.952
Respirable dust										
≥ 2 h	Personal	32	21	23 (71.9%)	1.25	96.9	3.1	! LOD	+ 0.6	+ 0.728
≥ 2 h	Static	16	8	9 (56.3%)	1.06	93.8	6.3	! LOD	+ 0.7	1.078

9.1.5 Storage, transport, packing

The 90th percentile values for the inhalable and respirable fractions lie well below the limits, irrespective of the form of sampling.

Table 9.1.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	10	8	3 (30%)	0.71	100	0	+ 0.42	1.31	1.725
≥ 2 h	Static	10	6	1 (10%)	0.65	100	0	+ 0.325	1.18	1.4
Respirable dust										
≥ 2 h	Personal	14	12	11 (78.6%)	0.95	92.9	7.1	! LOD	+ 0.413	+ 0.797
≥ 2 h	Static	60	24	28 (46.7%)	1.15	100	0	+ 0.05	+ 0.2	+ 0.37

9.2 Paper and paperboard, production and processing

Sector
Paper and paperboard, production and processing
Paper and paperboard packaging, production

The production and use of paper and paperboard may give rise to dust exposure in a variety of ways. Paper consists of fibrous materials, most of which originate from vegetable fibres (wood, rags, etc.) or waste paper. In addition, a range of auxiliary materials are used in paper production, including fillers, glues, pigments, retention agents, coating compounds and wet strength agents.

Elevated exposure to paper dust may occur during activities involving large quantities of paper, in particular during its mechanical processing by tearing and abrasion. In all areas, cleaning processes also lead to dust exposure, particularly where they involve the use of compressed air. In addition, the deposited paper dusts may be raised in air in indoor areas, for example as a result of activities in these areas.

9.2.1 Finishing

The rolls or sheets of paper or paperboard, which are as wide as the machines on which they are produced, are prepared at the finishing stage for further processing. Paper dust is generated here primarily during slitting and guillotine-trimming, and also during packing. Exposure is largely continuously to inhalable dust; however, levels rarely exceed that of the GDLV.

Table 9.2.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	53	32	19 (35.8%)	0.71	88.7	11.3	0.865	9.998	14.105
≥ 2 h	Static	144	61	15 (10.4%)	0.71	95.1	4.9	+ 0.355	5.11	9.628
< 2 h	Static	37	18	12 (32.4%)	5.71	94.6	5.4	+ 0.615	+ 3.772	9.051
Respirable dust										
≥ 2 h	Personal	16	12	12 (75%)	1.25	100	0	! LOD	+ 0.294	+ 0.389
≥ 2 h	Static	77	40	52 (67.5%)	0.25	100	0	! LOD	+ 0.223	0.284
< 2 h	Static	26	13	23 (88.5%)	0.36	100	0	! LOD	+ 0.264	0.39

9.2.2 Production of sanitary products

Tissue paper, an absorbent, fine-crepe hygiene paper made of cellulose, is usually used in multi-layer form in toilet rolls, kitchen rolls, paper napkins and paper tissues. The dust generated during industrial production and processing of hygiene articles and tissue papers generally lies below the GDLV when time-weighted over the shift. Owing to the very thin and light structure of the paper however, tearing frequently occurs, together with dust turbulence. The use of compressed air for regular cleaning may therefore cause high levels of dust to be generated for brief periods.

Table 9.2.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	23	9	3 (13%)	0.83	95.7	4.3	2.67	5.938	8.604
≥ 2 h	Static	47	13	10 (21.3%)	0.83	95.7	4.3	+ 0.79	3.587	5.346
< 2 h	Static	16	4 **	1 (6.3%)	0.53	100	0	0.69	1.52	2.47
Respirable dust										
≥ 2 h	Static	16	6	9 (56.3%)	0.25	100	0	! LOD	+ 0.25	0.28

9.2.3 Paper and paperboard production

In paper and paperboard machines, the paper web is guided over rollers, screens and felts from the sheet formation stage to winding or the delivery unit. At this point, abrasion, tearing and possibly cutting processes cause paper dust to be released, often leading to exposure to airborne inhalable dust in the magnitude of the OEL. In particular, the regular use of compressed air lances to clean the machines results in considerable quantities of dust being generated.

Table 9.2.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	31	18	13 (41.9%)	0.72	77.4	22.6	1.19	20.55	27.31
≥ 2 h	Static	54	27	7 (13%)	0.71	87	13	1.43	16.06	23.18
< 2 h	Personal	10	8	2 (20%)	0.77	60	40	4.84	52.8	54.85
< 2 h	Static	21	11	7 (33.3%)	0.53	81	19	+ 0.315	21.86	29.455
Respirable dust										
≥ 2 h	Personal	14	9	12 (85.7%)	1.25	100	0	! LOD	+ 0.571	+ 0.625
≥ 2 h	Static	29	20	24 (82.8%)	1.25	100	0	! LOD	+ 0.163	+ 0.245
< 2 h	Static	20	9	15 (75%)	0.53	100	0	! LOD	+ 0.265	+ 0.39

9.2.4 Preparation of raw and finished stock

In the stock treatment process, dust is generated primarily during transport of the stock. The stock is transported to the pulpers loose or baled via feed and input belts and, if necessary, wire cutters and crushers. During these activities, the drop heights of the cutting and separating processes cause paper dust to be released. The GDLV for exposure to the inhalable dust fraction may be exceeded during discrete activities of brief duration.

Table 9.2.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	7 ***	6	4 (57.1%)	0.71	85.7	14.3	=-Values: 1.95 to 21		
≥ 2 h	Static	19	14	3 (15.8%)	0.71	94.7	5.3	0.8	6.727	7.634
< 2 h	Personal	5 ***	4 **	1 (20%)	1.43	60	40	=-Values: 8.02 to 37.7		
< 2 h	Static	32	9	17 (53.1%)	17.1	68.8	25	! LOD	18.6	25.24
Respirable dust										
≥ 2 h	Static	16	11	8 (50%)	0.25	100	0	+ 0.125	0.856	0.918

9.2.5 Stock warehouse

Driving operations during handling activities in the stock warehouse may also cause increased exposure to inhalable dust owing to abrasion and turbulence.

Table 9.2.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) \$	> LV (%) \$	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	15	7	3 (20%)	0.71	86,7	13.3	1.665	9.9	17.225
≥ 2 h	Static	34	15	0	n/a	97,1	2.9	0.74	6.624	9.016
< 2 h	Static	20	12	2 (10%)	0.53	85	15	2.49	10.9	12.3
Respirable dust										
≥ 2 h	Static	40	18	24 (60%)	0.25	100	0	! LOD	+ 0.21	0.28
< 2 h	Static	14	8	7 (50%)	0.36	92.9	7.1	+ 0.18	0.766	1.253

9.3 Printing industry

Sector
Printing industry
E-mail (laser printing)

On slitter rewinders and folding machines in newspaper, offset and rotogravure printing presses, paper dust is produced by the cutting and folding processes as a function of the consistency of the paper. Stationary dust exhaust systems on the circular knives are the state of the art.

During the production of paperbacks, catalogues and brochures at the postpress stage, the spine must be evenly milled before being glued to the cover, to ensure a durable bond. The resulting paper dust is usually exhausted directly on the milling machine and separated in cyclones.

Paper dust also arises on paper waste shredding plants during further processing. Here too, it is separated after exhaust by means of cyclones, after which it is pressed into briquettes.

Table 9.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	56	34	35 (62.5%)	0.71	100	0	! LOD	1.172	1.606
≥ 2 h	Static	81	49	47 (58%)	0.71	100	0	! LOD	0.749	2.378
< 2 h	Static	55	24	14 (25.5%)	2.86	96.4	3.6	+ 0.465	4.145	5.94
Respirable dust										
≥ 2 h	Personal	44	28	39 (88.6%)	0.71	97.7	2.3	! LOD	+ 0.329	+ 0.5
≥ 2 h	Static	82	48	64 (78%)	1.25	100	0	! LOD	+ 0.234	+ 0.299
< 2 h	Static	44	20	36 (81.8%)	1	97.7	2.3	! LOD	+ 0.472	+ 0.516

9.4 Leather industry

Sector
Leather production
Tannery
Leather working
Car upholstery
Shoemaking
Shoemaker, shoe repairs
Orthopaedic shoemaking
Orthopaedic technology

The leather industry includes both craft activities and industrial leather working processes.

9.4.1 Polishing, sanding, milling

Shoemakers work with a wide variety of materials. Whereas in the past, leather, chrome leather and rubber were the dominant materials, shoemakers now generally work with a range of man-made materials such as crepe, poromeric rubber, EVA, PUR, TR, latex, PVC, polystyrene, polyethylene and polypropylene. Shoemakers use adhesives specially formulated for shoemaking and permitting reversible bonding. Sanding and gluing are consequently the main activities in the shoe repair trade in its present form, which is often combined with other trades and possible dust exposures. These include key cutting and engraving work and the corresponding workplaces.

In industrial shoe manufacture, dust exposure comparable to that in other industries arises during the use of high-speed sanding, milling and polishing tools. Depending on whether suitable dust exhaust systems are present, elevated concentrations of inhalable dust may occur briefly in isolated cases.

Table 9.4.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	32	24	21 (65.6%)	0.71	96.9	3.1	! LOD	2.172	4.214
≥ 2 h	Static	23	19	12 (52.2%)	0.71	100	0	! LOD	1.1	1.185
< 2 h	Personal	13	11	9 (69.2%)	1.55	84.6	15.4	! LOD	22.069	53.55
Respirable dust										
≥ 2 h	Personal	37	24	30 (81.1%)	1.2	91.9	8.1	! LOD	+ 0.648	1.383
≥ 2 h	Static	21	17	14 (66.7%)	0.25	100	0	! LOD	0.359	0.427
< 2 h	Personal	14	11	12 (85.7%)	1.18	92.9	7.1	! LOD	+ 0.644	1.22

9.4.2 Other areas of activity in the leather industry, shoe manufacture and repair and orthopaedics

The data available on other areas of activity in the leather industry enable qualitative conclusions to be drawn regarding the dust exposure in discrete processes. Examples are:

- Staking machine: in order to release the internal tension in the leather, the dry leathers are treated individually in the staking machine. Staking has a softening effect. Once the leathers have passed through the staking process, they are stacked on a trestle. Dust arises during staking.
- Shaving machine: rotating knives are used to shave leather hides to a uniform thickness. The workers feed the leathers into the shaving machine repeatedly, then stack them on a pallet. Dust is generated during shaving in the machine.
- Leather sanding machine: in the leather sanding machine, the leathers are roughened by means of abrasive paper. The leathers are fed into the machine one after the other, then stacked on a trestle. Dust is generated by abrasion during sanding.
- Tumbling barrels: tumbling (or rumbling) is a process for softening leather. The workers place the dry leathers in the tumbling barrels. After tumbling, the leathers are stacked on trestles. Dust is generated when adhering particles are released as the leathers are removed from the barrel.
- Weighing-out of tanning auxiliaries, cleaning work: tanning auxiliaries in powder form are transferred and weighed out manually on scales. As during cleaning work, high dust exposures may occur briefly if suitable binding agents or exhaust systems are not used.
- Processing of plaster moulds in orthopaedics: in orthopaedic shoemaking and orthopaedic technology, elevated concentrations of respirable and inhalable dust may arise briefly during working of the plaster moulds.

Table 9.4.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	47	24	33 (70.2%)	0.71	100	0	! LOD	1.216	1.662
≥ 2 h	Static	39	20	26 (66.7%)	0.71	100	0	! LOD	1.089	2.624
< 2 h	Personal	13	9	3 (23.1%)	2.86	61.5	38.5	4.21	77.16	127.125
< 2 h	Static	10	4 **	10 (100%)	4.76	100	0	! LOD	! LOD	! LOD
Respirable dust										
≥ 2 h	Personal	38	24	34 (89.5%)	0.66	100	0	! LOD	+ 0.314	+ 0.39
≥ 2 h	Static	45	22	27 (60%)	0.94	97.8	2.2	! LOD	+ 0.455	+ 0.723
< 2 h	Personal	10	9	6 (60%)	5.95	60	20	! LOD	7.06	17.23
< 2 h	Static	14	6	11 (78.6%)	1.66	92.9	0	! LOD	+ 0.644	+ 0.767

9.5 Textile industry, textile recycling

Sector
Flocking
Textile materials such as raw cotton (excluding asbestos), preparation
Spinning and weaving
Textile finishing
Dressing materials, production
Textiles, other
Production of nonwovens
Clothing industry, general
Ironing, sewing
Textile recycling

9.5.1 Textile production

During the production of textiles, yarn is produced from fibres in spinning mills. In weaving mills, fabric is produced on looms from warp and weft threads. Nonwoven fabrics constitute another textile fabric of technical importance. In addition to fluff (coarse particle dispersions), respirable and inhalable dusts are also released during the robust mechanical processes.

Table 9.5.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	127	63	41 (32.3%)	1.06	92.9	7.1	+ 0.75	4.186	14.655
≥ 2 h	Static	195	90	106 (54.4%)	0.72	99	1	! LOD	1.645	2.527
Respirable dust										
≥ 2 h	Personal	129	62	67 (51.9%)	0.25	96.1	3.9	! LOD	0.678	1.025
≥ 2 h	Static	193	87	109 (56.5%)	0.25	96.9	3.1	! LOD	0.537	0.88

9.5.2 Surface coating

Besides textile dyeing and printing, special coating processes are used to lend particular properties to the textiles. In these processes, the release of dust must be anticipated owing to the mechanical stress upon the materials.

9.5.3 Cutting, punching

The further processing of textiles causes dusts to be released, particularly during mechanical processes such as cutting and punching. This applies above all in the area of textile recycling, i.e. the processing of end-of-life textiles. The raw materials recovered in this process are used in the cleaning cloth, reprocessed material, nonwovens and paper industries.

Table 9.5.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	15	11	6 (40%)	0.71	86.7	13.3	+ 0.427	8.14	12
≥ 2 h	Static	16	13	14 (87.5%)	0.71	100	0	! LOD	1.017	2.812
Respirable dust										
≥ 2 h	Personal	12	9	8 (66.7%)	0.25	100	0	! LOD	0.29	0.404
≥ 2 h	Static	16	12	13 (81.3%)	0.25	100	0	! LOD	0.744	0.798

Table 9.5.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	23	17	15 (65.2%)	0.72	95.7	4.3	! LOD	2.525	3.235
≥ 2 h	Static	28	19	22 (78.6%)	0.71	100	0	! LOD	+ 0.355	+ 0.388
Respirable dust										
≥ 2 h	Personal	23	16	20 (87%)	0.25	100	0	! LOD	+ 0.205	0.52
≥ 2 h	Static	28	19	24 (85.7%)	0.25	100	0	! LOD	+ 0.125	+ 0.125

10 Metal production, foundries

10.1 Foundries

Sector
Iron and steel foundry, mixed
Iron foundry
Steel foundry
Non-ferrous metal foundry, mixed
Light metals foundry
Heavy metals foundry
Iron, steel and non-ferrous metals foundry, mixed
Suppliers to the foundry industry
Service work for the foundry industry

Foundries are industrial companies that produce shaped products by means of casting. In foundries, liquid material (the molten mass) is poured into moulds, where it solidifies to form a casting, usually of metal. A distinction is drawn between sand, shell, gravity die, pressure die, centrifugal, continuous and artistic casting processes. A further distinction is drawn between iron, malleable iron, steel and non-ferrous metal foundries, according to the casting material category. Foundries provide the shortest and most direct means of shaping a wide range of metal products.

10.1.1 Core shop

Cores are required for the production of recesses or cavities in the casting. A distinction is drawn between expendable cores, such as sand cores, which are used for a single casting only and are destroyed when the casting is de-formed or during fettling, and non-expendable cores manufactured from metals, which can be re-used. Since 1990, the majority of coremaking machines have been encapsulated or equipped with dust exhaust equipment. The sand mixers connected to them have also been encapsulated. By 1990, the sand feeding systems, previously open hoppers with a large drop height, had been converted into continuous closed systems.

The 90th percentile for the inhalable dust lies below the limit value, irrespective of the mode of sampling. Compliance with the limit value for respirable dust, however, presents difficulties.

Table 10.1.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	132	78	13 (9.8%)	0.71	95.5	4.5	2.16	6.348	9.058
≥ 2 h	Static	113	67	10 (8.8%)	0.71	97.3	2.7	1.185	4.254	7.0445
Respirable dust										
≥ 2 h	Personal	180	94	58 (32.2%)	1.25	87.8	12.2	+ 0.5	1.49	1.88
≥ 2 h	Static	129	72	43 (33.3%)	1.25	93	7	+ 0.385	+ 1.01	1.587
< 2 h	Static	11	5	2 (18.2%)	2.14	9.1	81.8	+ 1.815	2.866	3.0575

Table 10.1.1 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	120	64	44 (36.7%)	1.25	90.8	9.2	+ 0.43	+ 1.14	1.68
≥ 2 h	LEV = no	52	36	12 (23.1%)	1.22	80.8	19.2	+ 0.6	1.672	2.136

10.1.2 Moulding shop

In the production of casting moulds, particularly sand moulds, a distinction is drawn between hand moulding and machine moulding. In hand moulding, sand moulds for smaller castings are produced on a moulding bench/table or in a moulding pit. Machine moulding is performed on moulding machines with pattern plates.

The 90th percentile values in personal measurements lie above the limit values for both dust fractions, irrespective of the duration of sampling.

Table 10.1.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	246	117	1 (0.4%)	0.71	88.2	11.8	4.02	11.3	20.4
≥ 2 h	Static	171	91	4 (2.3%)	0.71	93	7	2.995	8.395	13.165
< 2 h	Personal	14	10	0	n/a	78.6	21.4	4.05	11.76	13.12
≥ 2 h	Static	38	12	0	n/a	97.4	2.6	3.24	7.076	9.341
Respirable dust										
≥ 2 h	Personal	296	132	38 (12.8 %)	1.25	65.5	34.5	+ 0.97	2.22	2.844
≥ 2 h	Static	185	95	19 (10.3%)	1.25	78.4	21.6	+ 0.785	1.595	2.612
< 2 h	Personal	15	12	1 (6.7%)	1.29	73.3	20	+ 0.885	2.835	4.388
< 2 h	Static	58	21	2 (3.4%)	0.55	44.8	55.2	1.3	3.254	4.135

Table 10.1.2 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	75	51	1 (1.3)	0.71	90.7	9.3	3.095	9.54	13.5
≥ 2 h	LEV = no	147	78	0	n/a	87.8	12.2	4.345	11.96	18.145
Respirable dust										
≥ 2 h	LEV = yes	87	58	11 (12.6%)	1.25	62.1	37.9	+ 0.95	2.126	2.478
≥ 2 h	LEV = no	184	92	18 (9.8%)	1.25	66.8	33.2	+ 0.98	2.23	2.832

10.1.3 Melting shop

In order for the materials, particularly metals and their alloys, to be cast into shape, they must be melted into the liquid state. The solid metals and alloys are melted in the melting furnace by the application of heat. Various essential properties are attained by a suitable form of firing or treatment with chemical or physical agents. Owing to the high temperatures arising during the melting phase, a large number of reactions occur which can lead at times to fumes rising in large quantities. The fumes produced during thermal processes (such as melting) consist largely of particles in the respirable fraction.

The 90th percentile values for inhalable dust measured both on the person and statically over a sampling duration of ≥ 2 hours lie below the limit value. Conversely, the 90th percentile value for respirable dust substantially exceeds the limit value in both personal and static measurements, irrespective of the sampling duration.

Table 10.1.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	138	85	6 (4.3%)	0.71	97.1	2.9	3.48	8.09	8.85
≥ 2 h	Static	139	75	8 (5.8%)	0.71	97.1	2.9	1.97	6.053	8.984
< 2 h	Personal	10	7	3 (30%)	5.36	70	30	+ 1.85	17.5	23.35
< 2 h	Static	46	16	1 (2.2%)	1.34	84.8	15.2	4.98	11.54	16.94
Respirable dust										
≥ 2 h	Personal	131	84	23 (17.6%)	1.25	58.8	41.2	+ 1.055	2.69	3.199
≥ 2 h	Static	122	68	18 (14.8%)	0.93	75.4	24.6	+ 0.66	2.138	2.648
< 2 h	Personal	13	9	4 (30.8%)	2	46.2	38.5	+ 0.86	15.312	25.8
< 2 h	Static	74	24	6 (8.1%)	0.65	27	73	2,3	6.812	8.812

Table 10.1.3 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	100	70	16 (16%)	1.25	63	37	+ 0.9	2.69	3.06
≥ 2 h	LEV = no	24	17	6 (25%)	1.25	50	50	+ 0.93	2.712	3.996

10.1.4 Casting bay, general operations

Casting is the insertion of a liquid material into a mould in which, under the influence of gravity, centrifugal force or pressure, it assumes the geometry of the desired finished product, in which it solidifies. Decomposition of the binding agents and the combustion of casting gases give rise to large quantities of hazardous substances in the form of fumes during casting and cooling.

The 90th percentile values for both inhalable and respirable dust substantially exceed the limit values, irrespective of the form and duration of sampling.

Table 10.1.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^{3})	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^{3})		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	151	97	1 (0.7%)	0.71	78.1	21.9	4.585	19.18	31.6
≥ 2 h	Static	157	83	7 (4.5%)	0.71	86	14	3.015	12	16.96
< 2 h	Personal	11	7	0	n/a	72.7	27.3	4.68	18.09	21.5
< 2 h	Static	12	3 **	0	n/a	66.7	33.3	4.69	44.12	63.28
Respirable dust										
≥ 2 h	Personal	169	106	7 (4.1%)	1.25	63.3	36.7	+ 0.96	3.297	4.264
≥ 2 h	Static	145	82	18 (12.4%)	1.25	76.6	23.4	+ 0.685	2.13	2.672
< 2 h	Personal	22	12	8 (36.4%)	5	45.5	40.9	+ 1.15	+ 2.628	+ 4.127
< 2 h	Static	61	19	1 (1.6%)	0.47	27.9	72.1	1.67		4.846

Table 10.1.4 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^{3})	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^{3})		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	83	59	1 (1,2%)	0.71	78.3	21.7	3.66	14.44	19.285
≥ 2 h	LEV = no	54	41	0	n/a	75.9	24.1	5.33	28.68	37.07
Respirable dust										
≥ 2 h	LEV = yes	90	65	4 (4.4%)	1.05	64.4	35.6	+ 0.99	1.8	2.625
≥ 2 h	LEV = no	63	44	3 (4.8%)	1.25	60.3	39.7	+ 1	4.121	5.437

10.1.5 Casting operations

The 90th percentile values for inhalable dust measured on the person and statically both lie below the limit value, particularly over a sampling duration of ≥ 2 hours. Conversely, the 90th percentile for respirable dust lies substantially above the limit value, irrespective of the form and duration of sampling.

Table 10.1.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	255	132	33 (12.9%)	0.72	94.1	5.9	2.18	7.005	10.85
≥ 2 h	Static	256	131	46 (18%)	1.25	98.8	1.2	+ 1.23	4.374	6.802
< 2 h	Personal	11	10	2 (18.2%)	14.3	72.7	18.2	+ 3.31	+ 9.985	+ 14.08
< 2 h	Static	12	6	0	n/a	100	0	3	6.21	6.898
Respirable dust										
≥ 2 h	Personal	254	137	46 (18.1%)	1.25	73.2	26.8	+ 0.73	2.188	3.111
≥ 2 h	Static	276	135	53 (19.2%)	1.25	83.3	16.7	+ 0.58	1.676	2.7
< 2 h	Personal	19	13	8 (42.1%)	5	47.4	26.3	+ 1.123	7.808	8.69
< 2 h	Static	28	14	3 (10.7%)	2	39.3	57.1	+ 1.27	2.282	3.212

Table 10.1.5 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	154	80	21 (13.6%)	0.72	92.9	7.1	1.81	7.356	11.7
≥ 2 h	LEV = no	84	55	9 (10.7%)	0.72	96.4	3.6	2.5	5.404	7.932
Respirable dust										
≥ 2 h	LEV = yes	150	82	30 (20%)	1.25	72.7	27.3	+ 0.73	2.28	3.615
< 2 h	LEV = no	86	55	12 (14%)	1.25	73.3	26.7	+ 0.72	1.984	2.68

10.1.6 Fettling, mechanical

Fettling describes the work performed on the raw casting which is retrieved from the mould following cooling. Fettling removes adhering residues of the mould and core sand from the casting. A distinction is drawn between coarse and fine fettling. A high-speed angle grinder is normally used for fettling. The particles released during fettling possess high kinetic energy; an exhaust system is able to capture them only if the particle stream is directed as closely as possible in the direction of the collection device.

The 90th percentile values for both the inhalable and respirable fractions lie well above the limit, irrespective of the form and duration of sampling, when an angle grinder is used for fettling.

Table 10.1.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	372	169	36 (9.7%)	0.72	76.1	23.9	4.15	20.3	33.26
≥ 2 h	Static	190	92	12 (6.3%)	0.71	83.2	16.8	2.74	15.3	24
< 2 h	Personal	46	24	1 (2.2%)	0.73	45.7	54.3	10.5	81.96	107.23
< 2 h	Static	26	14	0	n/a	61.5	38.5	5.55	21.78	31,08
Respirable dust										
≥ 2 h	Personal	399	179	65 (16.3%)	1.25	59.4	40.6	+ 0.98	4.105	6.0255
≥ 2 h	Static	204	103	53 (26%)	1.25	75.5	24.5	+ 0.54	2.74	3.736
< 2 h	Personal	48	26	10 (20.8%)	1.67	16.7	70.8	3.25	14.16	24.9
< 2 h	Static	50	19	3 (6%)	0.94	30	70	1.81	6.3	10.55

Table 10.1.6 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	253	131	23 (9.1%)	0.72	75.9	24.1	4.32	19.07	31.285
≥ 2 h	LEV = no	105	59	11 (10.5%)	0.71	80	20	3.28	17.9	35.45
< 2 h	LEV = yes	29	13	1 (3.4%)	0.73	48.3	51.7	10.075	37.86	63.195
< 2 h	LEV = no	15	9	0	n/a	40	60	12	109.55	126.75
Respirable dust										
≥ 2 h	LEV = yes	279	142	38 (13.6%)	1.25	58.1	41.9	+ 1.035	3.962	5.856
≥ 2 h	LEV = no	105	65	25 (23.8%)	1.25	65.7	34.3	+ 0.75	4.91	7.428
< 2 h	LEV = yes	30	17	8 (26.7%)	1.5	23.3	63.3	2.74	7.13	12.85
< 2 h	LEV = no	17	10	2 (11.8%)	1.67	5.9	82.4	6.01	23.4	30.845

10.1.7 Fettling, blasting

Fine fettling includes final blasting with blasting agent consisting of metal, including non-ferrous metal (in the past also silica sand), corundum or plastics, which is blasted or projected at the casting or workpiece.

The 90th percentile values for inhalable and especially respirable dust exceed the limit values by a considerable margin in the personal measurements.

Table 10.1.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) \$	> LV (%) \$	Concentrations (mg/m^3) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	74	43	12 (16.2%)	0.72	85.1	14.9	2.18	12.1	16.01
≥ 2 h	Static	57	34	2 (3.5%)	0.71	98.2	1.8	1.615	5.601	6.404
< 2 h	Static	9 ***	5	0	n/a	55.6	44.4	=-Values: 1.61 to 27.5		
Respirable dust										
≥ 2 h	Personal	82	50	16 (19.5%)	1.25	69.5	30.5	+ 0.71	2.922	4.221
≥ 2 h	Static	57	34	10 (17.5%)	1.25	86	14	+ 0.595	1.362	1.696
< 2 h	Static	17	7	2 (11.8%)	0.48	41.2	58.8	1.42	3.569	3.801

Table 10.1.7 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) \$	> LV (%) \$	Concentrations (mg/m^3) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	60	36	12 (20%)	0.72	86.7	13.3	1.64	11.5	15.8
≥ 2 h	LEV = no	13	8	0	n/a	76.9	23.1	6.925	12.2	13.9
Respirable dust										
≥ 2 h	LEV = yes	66	42	15 (22.7%)	1.25	74.2	25.8	+ 0.61	2.85	4.123
≥ 2 h	LEV = no	15	10	1 (6.7%)	0.2	46.7	53.3	1.39	2.775	3.485

10.1.8 Drilling, turning, planing

Table 10.1.8

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	25	6	6 (24%)	0.71	96	4	1.295	4.695	7.997
≥ 2 h	Static	8 ***	5	0	n/a	87.5	12.5	=-Values: 0.14 to 15.6		
Respirable dust										
≥ 2 h	Personal	7 ***	5	2 (28.6%)	1.25	71.4	28.6	=-Values: 0.42 to 2.02		
≥ 2 h	Static	10	5	4 (40%)	1.25	100	0	+ 0.39	+ 0.63	+ 0.76

10.1.9 Sand conditioning

Sand conditioning involves production of a sand suitable for use in a mould in sand or shell casting or in core-making. In the casting shop, the sand recovered when the castings are de-formed generally serves as the basis for the reconditioned sand, i.e. the used sand is reconditioned for re-use. The used sand component separated off in screening and exhaust installations or removed together with the castings must be made up by the addition of fresh sand. Sand conditioning comprises the following steps: collection of the used sand, removal of sand lumps and metal impurities, cooling of the used sand, and mixing with additives consisting of binders, water, fresh sand, and other substances for enhancement of the quality.

The 90th percentile values for both inhalable and respirable dust lie above the limit values, irrespective of the form and duration of sampling.

Table 10.1.9

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	50	32	3 (6%)	0.71	72	28	5.48	18.5	28.3
≥ 2 h	Static	29	19	1 (3.4%)	0.25	86.2	13.8	2.22	12.3	21.74
Respirable dust										
≥ 2 h	Personal	56	36	8 (14.3%)	1.25	73.2	26.8	+ 0.89	2.042	2.626
≥ 2 h	Static	29	20	5 (17.2%)	1.25	86.2	13.8	+ 0.715	1.383	1.841
< 2 h	Static	6 ***	3 **	1 (16.7%)	0.38	16.7	83.3	=-Values: 2.58 to 4.6		

Table 10.1.9 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	29	20	3 (10.3%)	0.71	75.9	24.1	3.86	16.52	23.175
≥ 2 h	LEV = no	12	9	0	n/a	66.7	33.3	5.62	15.4	17.78
Respirable dust										
≥ 2 h	LEV = yes	31	22	6 (19.4%)	0.96	87.1	12.9	+ 0.64	1.41	1.774
≥ 2 h	LEV = no	17	12	2 (11.8%)	1.25	58.8	41.2	+ 0.995	3.061	3.182

10.1.10 Industrial trucks, transport, warehouse work

Table 10.1.10

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	17	11	5 (29.4%)	0.71	94.1	5.9	1.565	4.253	6.298
≥ 2 h	Static	16	14	4 (25%)	0.71	100	0	+ 0.28	4.626	5.282
Respirable dust										
≥ 2 h	Personal	23	14	7 (30.4%)	0.4	91.3	8.7	0.47	1.075	1.286
≥ 2 h	Static	17	15	6 (35.3%)	0.63	88.2	11.8	+ 0.2	1.304	1.617

10.1.11 Inspection, test benches

Table 10.1.11

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	14	13	4 (28.6%)	0.71	100	0	+ 0.59	4.342	5.119
Respirable dust										
≥ 2 h	Personal	10	9	1 (10%)	0.25	60	40	0.89	1.77	3.99
≥ 2 h	Static	18	14	4 (22.2%)	1.02	88.9	11.1	+ 0.2	1.538	2.785

10.1.12 Precision casting

Table 10.1.12

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	19	9	2 (10.5%)	0.71	100	0	2.87	5.816	7.273
Respirable dust										
≥ 2 h	Personal	19	10	5 (26.3%)	0.25	89.5	10.5	0.49	1.247	1.984
≥ 2 h	Static	7 ***	5	1 (14.3%)	0.25	85.7	14.3	=-Values: 0.11 to 1.37		

10.2 Metal production

Sector
Blast furnace, steel and hot rolling mills
Blast furnace
Electric steel plant
Basic oxygen steel plants (argon oxygen decarburizing and oxygen bottom blowing processes)
Electroslag remelting process
Rolling mills, general
Rod mill
Wire mill
Sheet metal mill
Tube mill
Profile mill
Hot rolling mill
Cold rolling mill
Non-ferrous metal production (excluding lead)
Aluminium works

Iron ore is prepared and converted to pig iron in a blast furnace. The pig iron is in turn melted, together with added scrap, in a steel plant in a suitable melting furnace such as a Siemens-Martin open-hearth furnace or electric steel furnace, and converted into steel. Exposure to dust must be anticipated in the blast furnace and rolling mill, specifically in the furnace house and casting bay, at the dies/permanent moulds and in the fettling shop. Exposure also occurs during the handling of slag, maintenance work on crucibles and furnaces, and removal and replacement of refractory linings.

10.2.1 Casting, smelting

The fumes produced during thermal processes such as smelting and casting consist for the most part of particles in the respirable fraction. The 90th percentile values for inhalable dust measured both on the person and statically over a sampling duration of ≥ 2 hours lie substantially below the limit value. Conversely, the 90th percentile value for respirable dust measured on the person substantially exceed the limit value.

Figure 36: Continuous slab caster

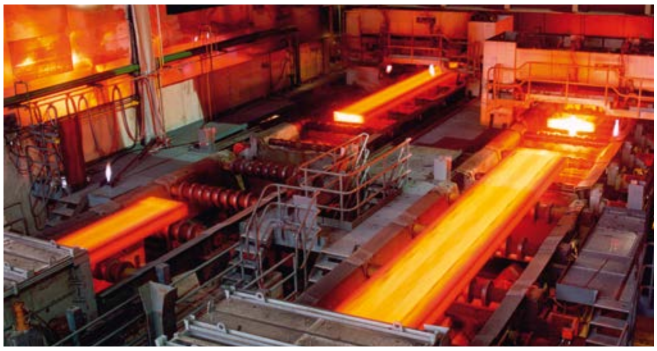

Table 10.2.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	Concentrations (mg/m³) 90th percentile	Concentrations (mg/m³) 95th percentile
Inhalable dust										
≥ 2 h	Personal	20	11	1 (5%)	0.25	90	10	1.22	5.89	13.8
≥ 2 h	Static	93	22	12 (12.9%)	0.71	96.8	3.2	1.375	4.835	5.819
< 2 h	Static	21	5	0	n/a	81	19	3.73	30.56	32.795
Respirable dust										
≥ 2 h	Personal	14	10	1 (7.1%)	0.19	71.4	28.6	0.99	1.648	5.66
≥ 2 h	Static	84	21	17 (20.2%)	1.19	90.5	9.5	+ 0.42	+ 1.188	1.702
< 2 h	Static	19	4 **	1 (5.3%)	0.88	21.1	78.9	2.745	5.412	9.825

10.2.2 Wire drawing, rolling

Table 10.2.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) \$	> LV (%) \$	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	46	20	10 (21.7%)	0.71	91.3	8.7	1.05	6.994	18.57
≥ 2 h	Static	74	20	14 (18.9%)	0.71	98.6	1.4	+ 0.64	3.578	4.708
< 2 h	Static	8 ***	2 **	0	n/a	87.5	12.5	=-Values: 1.6 to 10.2		
Respirable dust										
≥ 2 h	Personal	41	20	16 (39%)	0.95	85.4	14.6	+ 0.352	2.328	3.284
≥ 2 h	Static	79	25	34 (43%)	0.91	91.1	8.9	+ 0.195	1.146	1.855
< 2 h	Static	9 ***	5	1 (11.1%)	0.36	55.6	44.4	=-Values: 0.72 to 11.4		

Table 10.2.2 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) \$	> LV (%) \$	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	21	8	5 (23.8%)	0.71	90.5	9.5	0.75	6.235	20.841
≥ 2 h	LEV = no	20	11	5 (25%)	0.71	95	5	1.14	5.04	7.84
Respirable dust										
≥ 2 h	LEV = yes	16	7	6 (37.5%)	0.25	87.5	12.5	+ 0.25	1.644	3.108
≥ 2 h	LEV = no	20	12	10 (50%)	0.95	90	10	+ 0.29	1.1	1.5

10.2.3 Grinding

Grinding is by definition an activity associated with high dust generation. Exposures above the limit value for both respirable and inhalable dust arise primarily during the use of manually guided (electric or pneumatic) grinding tools, particularly during the working of large workpieces.

The 90th percentile values for personal measurement of both dust fractions lie substantially above the limit values.

10.2.4 Machining (excluding grinding)

Machining is largely carried out in a wet process with the use of a cooling lubricant. The chips produced are predominantly coarser and non-inhalable. The 90th percentile values of both dust fractions measured both on the person and statically over a sampling duration of ≥ 2 hours lie substantially below the limit values.

Table 10.2.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	24	14	4 (16.7%)	0.71	83.3	16.7	1.46	21.84	36
≥ 2 h	Static	15	11	1 (6.7%)	0.71	93.3	6.7	+ 0.7	6.725	15.0275
Respirable dust										
≥ 2 h	Personal	21	14	8 (38.1%)	1.25	76.2	23.8	+ 0.395	2.668	3.187
≥ 2 h	Static	15	11	4 (26.7%)	0.25	86.7	13.3	+ 0.225	1.465	3.145

Table 10.2.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	11	7	6 (54.5%)	0.71	81.8	18.2	! LOD	9.655	15.855
≥ 2 h	Static	18	11	7 (38.9%)	0.71	100	0	+ 0.355	1.276	1.964
Respirable dust										
≥ 2 h	Personal	10	5	5 (50%)	1.25	100	0	+ 0.625	+ 1.04	+ 1.085
≥ 2 h	Static	17	10	9 (52.9%)	1.06	100	0	! LOD	+ 0.488	+ 0.633

10.2.5 Storage, transport, packing

Table 10.2.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	13	5	8 (61.5%)	0.71	100	0	! LOD	1.301	1.77
Respirable dust										
≥ 2 h	Personal	7 ***	6	1 (14.3%)	0.25	85.7	14.3	=-Values: 0.26 to 1.4		
≥ 2 h	Static	34	15	14 (41.2%)	0.63	97.1	2.9	+ 0.1	+ 0.313	0.7

11 Metalworking and metal processing, machine and vehicle production

11.1 CNC machines for metals (cross-sector)

The CNC machines are stationary systems; they are generally encapsulated and are equipped with dust exhaust systems. Machining is largely carried out in a wet process with use of a cooling lubricant. The activities of the workers are limited to the loading and retrieval of the workpieces and control and monitoring of the system.

The 90th percentile values for both dust fractions measured both on the person and statically over a sampling duration of ≥ 2 hours lie substantially below the limit value.

Table 11.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	166	109	81 (48.8%)	0.72	99.4	0.6	+ 0.355	3.124	4.885
≥ 2 h	Static	131	90	52 (39.7%)	0.72	98.5	1.5	+ 0.355	1.753	4.156
Respirable dust										
≥ 2 h	Personal	154	100	95 (61.7%)	1.25	94.8	5.2	! LOD	+ 0.668	1.256
≥ 2 h	Static	128	90	70 (54.7%)	1	96.9	3.1	! LOD	+ 0.592	1.016
< 2 h	Static	13	6	2 (15.4%)	0.29	30.8	69.2	1.47	2.225	2.607

11.2 Carbide production and processing

Sector
Cemented carbides, iron powder, manufacture and processing

Cemented carbides are alloys of carbides and a binder metal. The carbides most commonly used are tungsten (WC), titanium (TiC), tantalum (TaC) and chromium (CrC). Cobalt (Co), nickel (Ni), iron (Fe) and nickel-chromium (NiCr) are used as binders. The carbides most commonly produced involve the combination of tungsten carbide and cobalt (WC + Co).

Powders consisting of a desired composition of carbide and the selected binder are mixed and ground. In the next step, the powder is dried in a spray-drying system. The carbide granulate is then pressed into shape. The pressed part (green compact) can then be shaped mechanically. Finally, the green compact is sintered at approximately 1,300 to 1,500 °C.

11.2.1 Filling, grinding, mixing, weighing

Where dust collection equipment is used during filling, grinding, mixing and weighing, the 90th percentile values for both dust fractions measured on the person lie well below the limit values.

Table 11.2.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	98	34	20 (20.4%)	0.72	91.8	8.2	1.28	7.518	11.23
≥ 2 h	Static	31	17	12 (38.7%)	0.71	96.8	3.2	+ 0.27	2.5	3.99
Respirable dust										
≥ 2 h	Personal	85	28	49 (57.6%)	1.25	89.4	10.6	! LOD	1.26	1.847
≥ 2 h	Static	33	17	23 (69.7%)	1.25	100	0	! LOD	+ 0.701	+ 0.911

Table 11.2.1 a

Duration of sampling	Collection	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	LEV = yes	77	28	16 (20.8%)	0.71	92.2	7.8	1.115	5.478	11.03
≥ 2 h	LEV = no	15	8	4 (26.7%)	0.72	86.7	13.3	2.305	11.165	14.4
Respirable dust										
≥ 2 h	LEV = yes	65	22	41 (63.1%)	1.11	89.2	10.8	! LOD	+ 1	1.805
≥ 2 h	LEV = no	14	8	6 (42.9%)	1.25	92.9	7.1	+ 0.59	+ 1.11	1.377

11.2.2 Shaping

The 90th percentile values of both dust fractions lie substantially below the limit values in both personal and static measurements.

Table 11.2.2

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	75	28	30 (40%)	0.72	100	0	+ 0.485	2.33	2.665
≥ 2 h	Static	47	19	31 (66%)	0.71	100	0	! LOD	0.78	0.87
Respirable dust										
≥ 2 h	Personal	70	26	56 (80%)	0.25	98.6	1.4	! LOD	0.47	0.65
≥ 2 h	Static	39	19	32 (82.1%)	1.25	100	0	! LOD	+ 0.262	+ 0.625

11.2.3 Chip-forming machining processes

Machining is largely carried out using a wet process with the use of a cooling lubricant. The chips produced are predominantly coarser and non-inhalable. The 90th percentile values measured for both dust fractions, both on the person and statically, lie substantially below the limit values.

Table 11.2.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	78	29	37 (47.4%)	0.72	98.7	1.3	+ 0.36	3.142	4.648
≥ 2 h	Static	33	20	23 (69.7%)	0.71	100	0	! LOD	+ 0.667	1.0505
Respirable dust										
≥ 2 h	Personal	71	27	54 (76.1%)	0.97	94.4	5.6	! LOD	+ 0.569	1.051
≥ 2 h	Static	34	19	26 (76.5%)	0.25	94.1	5.9	! LOD	0.396	1.145

11.3 Metalworking, machine and vehicle production

Sector
Plant and equipment construction (metal)
Construction/production of installations
Construction of technical apparatus
Fittings, production
Tank construction
Retail trade in motor vehicles
Retail trade in motor vehicle parts, accessories and tyres
Retail trade in two-wheeled vehicles, two-wheeled vehicle parts, accessories and tyres
Electrical machinery construction
Vehicle construction
Aircraft construction
Forming processes, other
Drop-forging shop
Wholesale trade in motor vehicles, machinery, mechanical equipment and related technical supplies (excluding tyres and rubber articles)
Hammer mill
Production of vehicle bodies
Production of windows, doors, façade elements (metal)
Production of parts for motor vehicles and engines (automotive suppliers)
Assembly of industrial installations
Refrigeration equipment, production
Construction of agricultural machinery
Construction of machinery and vehicles, general
Construction of machinery
Drop forging and open-die forging
Metalworking and metal processing, general
Surface treatment and hardening
Profiling shops, general
Powder coating
Powder coating and lamination, flocking
Pipe production, general

Sector
Rail manufacture
Shipbuilding
Fitter's shop
Forging, general
Forging press shop
Steel and light metal construction
Steel construction
Structural steel
Extrusion shop, general
Environmental equipment, production
Toolmaking
Drawing shops, general

A large number of methods are employed for the shaping, cutting and joining of metals; material properties are modified and workpieces thereby ultimately produced. Machining processes include those employing geometrically defined cutting tools, such as turning, drilling, planing, sawing, milling and filing, and those employing geometrically undefined cutting tools, such as grinding, honing, lapping, polishing and blasting. The joining processes include the various welding and soldering methods. The properties of a metal can be changed, including by hardening or annealing.

11.3.1 Electric-discharge machining (EDM)

EDM is a thermal, chip-forming or eroding manufacturing process that can be used on stationary systems to machine conductive material of any hardness with high precision. During the process of electrical discharge between the tool (electrode) and the workpiece, material on the latter is vaporized by the high temperature, effectively turning it into fumes. The fumes generated during the process are generally exhausted by means of a flexible collection element positioned close to the point at which they are produced. Since EDM systems are in most cases operated automatically, workers are usually present in the immediate vicinity of the systems only for short periods (e.g. for inspection rounds, fault clearance). For this reason, personal measurements were not carried out; all measured values were determined statically.

The 90th percentile values for both inhalable and respirable dust lie substantially below the limit values.

Table 11.3.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	11	10	6 (54.5%)	0.71	100	0	! LOD	0.926	1.8
Respirable dust										
≥ 2 h	Static	12	10	10 (83.3%)	1.13	91.7	8.3	! LOD	+ 0.552	1.255

11.3.2 Cutting, punching

Table 11.3.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	71	46	43 (60.6%)	0.72	98.6	1.4	! LOD	1.97	2.538
≥ 2 h	Static	57	42	32 (56.1%)	0.71	100	0	! LOD	0.859	1.666
Respirable dust										
≥ 2 h	Personal	68	47	44 (64.7%)	0.26	98.5	1.5	! LOD	0.46	0.5
≥ 2 h	Static	52	39	40 (76.9%)	1.23	100	0	! LOD	+ 0.525	+ 0.606

11.3.3 Drilling, turning, milling, planing

These machining processes are carried out largely by means of a wet process involving a cooling lubricant. The chips produced are predominantly coarser and non-inhalable. The 90th percentile values measured both on the person and statically over a sampling duration of ≥ 2 hours lie substantially below the limit value

Table 11.3.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	167	108	73 (43.7%)	0.73	98.8	1.2	0.74	3.352	4.944
≥ 2 h	Static	121	80	57 (47.1%)	0.71	100	0	+ 0.355	1.337	2.373
< 2 h	Static	14	5	2 (14.3%)	0.09	100	0	1.08	2.478	2.739
Respirable dust										
≥ 2 h	Personal	153	103	77 (50.3%)	1.25	97.4	2,6	! LOD	+ 0.751	+ 1.0815
≥ 2 h	Static	125	81	73 (58.4%)	1.19	99.2	0.8	! LOD	+ 0.485	+ 0.621
< 2 h	Static	13	6	6 (46.2%)	1.02	76.9	23.1	+ 0.495	1.726	

11.3.4 Deburring, filing, polishing, general grinding work

Figure 37: Manual filing in a vice

Table 11.3.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	550	316	153 (27.8%)	0.76	87.5	12.5	1.41	12	27.8
≥ 2 h	Static	161	111	52 (32.3%)	0.71	96.3	3.7	+ 0.63	4.92	7.439
< 2 h	Personal	38	22	8 (21.1%)	1.76	71.1	28.9	4.33	43.7	63.8
< 2 h	Static	31	10	6 (19.4%)	1.42	87.1	12.9	3.04	10.907	25.08
Respirable dust										
≥ 2 h	Personal	496	296	223 (45%)	1.25	83.9	16.1	+ 0.33	1.818	3.118
≥ 2 h	Static	158	111	73 (46.2%)	1.25	95.6	4.4	+ 0.24	+ 0.9	+ 1.093
< 2 h	Personal	54	32	22 (40.7%)	5.4	42.6	44.4	+ 1.14	9.52	32.99
< 2 h	Static	33	10	6 (18.2%)	1.62	30.3	66.7	1.755	5.49	6.77

Table 11.3.4 a

Duration of sampling	Collection	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	LEV = yes	376	210	116 (30.9%)	0.76	88.6	11.4	1.26	10.9	23.56
≥ 2 h	LEV = no	161	117	33 (20.5%)	0.72	84.5	15.5	1.875	18.36	29.57
Respirable dust										
≥ 2 h	LEV = yes	340	198	161 (47.4%)	1.25	87.6	12.4	+ 0.3	1.42	2.11
≥ 2 h	LEV = no	146	109	56 (38.4%)	1.25	75.3	24.7	+ 0.44	2.88	4.057
< 2 h	LEV = yes	34	21	14 (41.2%)	5.4	44.1	41.2	+ 1.135	10.96	32.99
< 2 h	LEV = no	13	8	7 (53.8%)	3.75	53.8	38.5	! LOD	6.604	21.012

11.3.5 Wet grinding

In wet grinding, use of a cooling lubricant (typically water-based) reduces the frictional heat generated during grinding and cools the workpiece. In addition, the particles released during grinding are bound in the cooling lubricant, generally resulting in lower dust exposures at the workplace.

The table shows results of measurements at stationary installations; the 90th percentile values measured on the person lie substantially below the limit values for both inhalable and respirable dust.

Table 11.3.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	125	83	57 (45.6%)	0.72	99.2	0,8	+ 0,355	1.88	2.675
≥ 2 h	Static	125	84	63 (50.4%)	0.72	99.2	0,8	! LOD	1.51	2.408
Respirable dust										
≥ 2 h	Personal	97	62	58 (59.8%)	0.25	100	0	! LOD	0.553	0.721
≥ 2 h	Static	104	69	63 (60.6%)	0.25	99	1	! LOD	0.54	0.854

11.3.6 Dry grinding

Dry grinding in particular is by its nature associated with high dust levels. Exposures above the limit value for both respirable and inhalable dust arise primarily during the use of manually guided (electric or pneumatic) grinding tools, particularly during the working of large workpieces. Ideally, the dust exhaust systems used (usually with a flexible dust capture element) are kept close to the machining point at all times; this is however not always possible in practice owing to the size and shape of the workpieces.

The 90th percentile values for both dust fractions lie substantially above the limit values in personal measurements, irrespective of the duration of sampling.

Table 11.3.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	1018	623	243 (23.9%)	0.72	87	13	1.51	12.22	21.338
≥ 2 h	Static	271	197	92 (33.9%)	0.71	95.9	4.1	+ 0.595	4.544	8.752
< 2 h	Personal	95	60	26 (27.4%)	2.86	72.6	27.4	3.495	27.6	43.05
< 2 h	Static	39	18	5 (12.8%)	1.65	84.6	15.4	+ 1.495	17.43	33.61
Respirable dust										
≥ 2 h	Personal	1031	635	418 (40.5%)	1.25	84.3	15.7	+ 0.375	1.719	2.695
≥ 2 h	Static	271	207	152 (56.1%)	1.25	92.6	7.4	! LOD	+ 0.866	1.671
< 2 h	Personal	119	75	39 (32.8%)	5	46.2	48.7	+ 1.16	6.401	8.234
< 2 h	Static	42	21	10 (23.8%)	1.79	52.4	45.2	+ 1.03	5.376	7.02

Table 11.3.6 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	696	440	214 (30.7%)	0.72	89.2	10.8	1.06	11.08	21.86
≥ 2 h	LEV = no	287	217	23 (8%)	0.71	84	16	3.225	13.11	19.795
< 2 h	LEV = yes	59	38	20 (33.9%)	2.86	74.6	25.4	+ 1.775	29.85	34.03
< 2 h	LEV = no	28	20	6 (21.4%)	2	71.4	28.6	4.13	29.02	82.48
Respirable dust										
≥ 2 h	LEV = yes	710	448	337 (47.5%)	1.25	88.6	11.4	+ 0.28	1.49	2.12
≥ 2 h	LEV = no	289	224	69 (23.9%)	1.25	75.1	24.9	+ 0.623	2.111	3.0165
< 2 h	LEV = yes	63	42	25 (39.7%)	5	50.8	44.4	+ 1.005	5.932	7.279
< 2 h	LEV = no	48	32	12 (25%)	2	35.4	58.3	+ 1.78	8.048	12.2

11.3.7 Parting-off grinders

High-speed angle grinders are used for parting-off grinding. The particles released possess high kinetic energy; an exhaust system is able to capture them only if the particle stream is directed as far as possible in the direction of the collection device.

The 90th percentile values of the measurements on the person for both inhalable and respirable dust lie considerably above the limit values, irrespective of the duration of sampling, when angle grinders are used for parting-off.

Table 11.3.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	28	21	4 (14.3%)	0.71	75	25	4.42	17.44	32.22
≥ 2 h	Static	11	8	2 (18.2%)	0.04	90.9	9.1	1.19	7.696	10.806
< 2 h	Static	8 ***	4 **	0	n/a	62.5	37.5	=-Values: 2.52 to 23.7		
Respirable dust										
≥ 2 h	Personal	28	22	5 (17.9%)	1.25	78.6	21.4	+ 0.72	1.896	2.23
≥ 2 h	Static	10	9	4 (40%)	0.25	90	10	+ 0.19	1.01	2.205
< 2 h	Personal	8 ***	3 **	0	n/a	12.5	87.5	=-Values: 0.33 to 8.95		
< 2 h	Static	9 ***	3 **	0	n/a	0	100	=-Values: 1.4 to 3.56		

11.3.8 Sawing, parting-off

Table 11.3.8

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	112	76	34 (30.4%)	0.71	94.6	5.4	1.06	6.962	9.836
≥ 2 h	Static	111	71	25 (22.5%)	0.71	100	0	0.815	2.534	3.623
< 2 h	Personal	20	14	5 (25%)	14.6	70	25	+ 3.75	23.9	30.9
< 2 h	Static	14	8	3 (21.4%)	2.86	78.6	21.4	4.09	12.24	16.57
Respirable dust										
≥ 2 h	Personal	112	78	51 (45.5%)	1.25	82.1	17.9	+ 0.33	2.172	3.296
≥ 2 h	Static	107	65	41 (38.3%)	0.63	92.5	7.5	+ 0.28	0.976	1.619
< 2 h	Personal	22	16	11 (50%)	14.2	50	36.4	+ 1	+ 7.776	+ 9.97
< 2 h	Static	20	11	4 (20%)	2	40	55	+ 1.48	4.98	5.94

Table 11.3.8 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	63	46	31 (49.2%)	1.25	90.5	9.5	+ 0.27	+ 1.179	2.251
≥ 2 h	LEV = no	34	28	18 (52.9%)	1.25	76.5	23.5	! LOD	2.298	3.595

11.3.9 Casting, smelting

Table 11.3.9

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	42	21	16 (38.1%)	0.71	100	0	0.9	3.666	4.089
≥ 2 h	Static	37	16	15 (40.5%)	0.71	100	0	+ 0.347	1.423	1.45
Respirable dust										
≥ 2 h	Personal	36	19	17 (47.2%)	1.25	94.4	5.6	+ 0.23	+ 1.076	1.356
≥ 2 h	Static	29	16	17 (58.6%)	0.25	96.6	3.4	! LOD	0.618	0.861

11.3.10 Comminution: mills, shredders, coarse work

Table 11.3.10

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	20	12	5 (25%)	0.71	85	15	1.11	14.1	15
≥ 2 h	Static	23	9	3 (13%)	0.71	91.3	8.7	1.995	4.328	10.806
< 2 h	Personal	7 ***	4 **	3 (42.9%)	1.42	85.7	14.3	=-Values: 1.67 to 10.5		
Respirable dust										
≥ 2 h	Personal	21	13	6 (28.6%)	0.25	81	19	0.71	1.474	1.661
≥ 2 h	Static	13	8	7 (53.8%)	1.1	100	0	! LOD	+ 0.676	+ 0.768
< 2 h	Personal	6 ***	4 **	5 (83.3%)	2	50	16.7	=-Values: 3.38 to 3.38		
< 2 h	Static	9 ***	2 **	2 (22.2%)	5.08	55.6	33.3	=-Values: 0.25 to 9.9		

11.3.11 Production of plastic parts, processing of plastics

Relevant dust exposures may occur in particular during deburring, sawing and grinding of plastic mouldings. The 90th percentile values measured for both dust fractions, both on the person and statically, lie substantially below the limit values.

Table 11.3.11

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	37	26	22 (59.5%)	0.72	97.3	2.7	! LOD	3.105	5.33
≥ 2 h	Static	37	24	24 (64.9%)	0.72	100	0	! LOD	+ 0.652	1.0355
Respirable dust										
≥ 2 h	Personal	33	25	25 (75.8%)	1.25	100	0	! LOD	+ 0.595	+ 0.63
≥ 2 h	Static	43	25	39 (90.7%)	0.91	100	0	! LOD	! LOD	+ 0.418

11.3.12 Pressing, forging, forming

Table 11.3.12

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	176	104	70 (39.8%)	0.71	97.2	2.8	0.72	5.162	7.918
≥ 2 h	Static	174	86	52 (29.9%)	0.72	94.3	5.7	+ 0.4	6.118	10.29
< 2 h	Personal	12	9	6 (50%)	4.29	91.7	8.3	+ 2.145	5.29	10.146
< 2 h	Static	11	7	2 (18.2%)	1.43	100	0	+ 0.198	+ 0.714	4.263
Respirable dust										
≥ 2 h	Personal	169	100	84 (49.7%)	1.25	89.3	10.7	+ 0.28	1.277	2.033
≥ 2 h	Static	175	87	104 (59.4%)	1.25	84	16	! LOD	1.8	2.393
< 2 h	Personal	14	10	8 (57.1%)	2.5	57.1	28.6	! LOD	2.99	3.361

Table 11.3.12 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	81	44	40 (49.4%)	0.63	85.2	14.8	+ 0.23	1.51	2.317
≥ 2 h	LEV = no	70	52	35 (50%)	1.25	94.3	5.7	+ 0.28	+ 0.84	1.325

11.3.13 Abrasive blasting

Table 11.3.13

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	179	143	47 (26.3%)	0.72	92.2	7.8	1.42	7.364	16.545
≥ 2 h	Static	101	69	42 (41.6%)	0.71	95	5	+ 0.375	2.858	9.973
< 2 h	Personal	24	15	8 (33.3%)	3.75	83.3	16.7	+ 2.25	81.68	128.8
Respirable dust										
≥ 2 h	Personal	176	144	84 (47.7%)	1.17	88.6	11.4	+ 0.26	1.344	2.014
≥ 2 h	Static	95	70	50 (52.6%)	1.25	90.5	9.5	! LOD	+ 0.875	2.817
< 2 h	Personal	25	18	13 (52%)	3.75	64	24	! LOD	20.75	28.525
< 2 h	Static	9 ***	8	5 (55.6%)	1.07	55.6	44.4	=-Values: 1.29 to 2.08		

Table 11.3.13 a

Duration of sampling	Collection	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	LEV = yes	162	134	44 (27.2%)	0.72	92.6	7.4	1.36	6.344	16.39
≥ 2 h	LEV = no	16	11	2 (12.5%)	0.71	87.5	12.5	2.3	11.962	15.86
Respirable dust										
≥ 2 h	LEV = yes	160	135	80 (50%)	1.17	89.4	10.6	+ 0.24	1.27	1.89
≥ 2 h	LEV = no	15	11	4 (26.7%)	0.25	80	20	0.53	4.385	7.02

11.3.14 Surface coating, thermal spraying

Thermal spraying is a surface coating process in which a material melted in a spray torch is projected in the form of spray particles in a gas stream at high velocity onto the surface of the component to be coated; this results in the formation of a layer.

The 90th percentile values for both dust fractions measured both on the person and statically over a sampling duration of ≥ 2 hours lie substantially below the limit value.

Table 11.3.14

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	49	34	23 (46.9%)	0.71	98	2	+ 0.355	3.526	4.99
≥ 2 h	Static	24	18	12 (50%)	0.71	100	0	+ 0.31	0.886	2.146
< 2 h	Personal	15	9	6 (40%)	5.71	80	20	+ 1.795	15.9	26.725
Respirable dust										
≥ 2 h	Personal	43	32	32 (74.4%)	1.15	95.3	4,7	! LOD	+ 0.621	+ 0.775
≥ 2 h	Static	22	17	16 (72.7%)	1.25	100	0	! LOD	+ 0.426	+ 0.607
< 2 h	Personal	16	9	10 (62.5%)	2	62.5	18.8	! LOD	15.94	18.1

11.3.15 Surface coating, paint spraying

In paint spraying, the surface coating agent (typically lacquer) is atomized with compressed air as it exits the nozzle of a spray gun. The dust particles in this case are predominantly binder components and pigments.

The 90th percentile values for both dust fractions measured on the person over a sampling duration exceeding two hours lie substantially above the limit values.

11.3.16 Powder coating

Powder coating is used on electrically conductive material. The process may be performed on a continuous line or manually. The powder coating material is atomized by a nozzle on the spray gun. Powder coatings are usually epoxy or polyester resin-based. Hybrid systems containing both epoxy and polyester resins as binders are also used.

The 90th percentile values for both dust fractions measured on the person lie substantially above the limit values, irrespective of the sampling duration.

Table 11.3.15

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	33	18	6 (18.2%)	0.71	81.8	18.2	2.32	14.23	18.805
≥ 2 h	Static	23	16	7 (30.4)	0.71	95.7	4.3	0.78	2.601	2.814
Respirable dust										
≥ 2 h	Personal	30	19	9 (30%)	0.25	63.3	36.7	0.83	4.12	4.69
≥ 2 h	Static	18	12	11 (61.1%)	1.25	94.4	5.6	! LOD	+ 0.882	+ 1.092

Table 11.3.16

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $ $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	241	161	53 (22%)	0.71	82.6	17.4	2.14	20.37	35.695
≥ 2 h	Static	119	73	40 (33.6%)	0.71	95.8	4.2	+ 0.355	4.019	9.206
< 2 h	Personal	24	22	7 (29.2%)	6.12	54.2	45.8	+ 5.97	30.62	35.94
Respirable dust										
≥ 2 h	Personal	246	170	116 (47.2%)	1.25	85.8	14.2	+ 0.34	1.66	2.736
≥ 2 h	Static	117	78	68 (58.1%)	1.25	96.6	3.4	! LOD	+ 0.608	+ 0.814
< 2 h	Personal	27	23	11 (40.7%)	2.14	44.4	44.4	+ 0.995	3.117	7.625

Table 11.3.16 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	221	152	43 (19.5)	0.71	81	19	2.405	21.13	47.48
≥ 2 h	LEV = no	15	11	9 (60%)	0.71	100	0	! LOD	1.83	3.155
Respirable dust										
≥ 2 h	LEV = yes	227	160	106 (46.7%)	1.25	84.6	15.4	+ 0.352	1.709	2.767
≥ 2 h	LEV = no	14	11	8 (57.1%)	0,25	100	0	! LOD	0.32	0.379

11.3.17 Surface coating, other

Table 11.3.17

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	96	60	40 (41.7%)	0.72	97.9	2.1	0.75	2.654	3.794
≥ 2 h	Static	92	48	39 (42.4%)	0.72	100	0	+ 0.355	1.08	1.578
Respirable dust										
≥ 2 h	Personal	76	53	43 (56.6%)	1.25	93.4	6.6	! LOD	+ 1.088	1.344
≥ 2 h	Static	70	43	50 (71.4%)	0.25	100	0	! LOD	0.43	0.645

Table 11.3.17 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	55	36	32 (58.2%)	0.63	92.7	7.3	! LOD	1.095	1.347
≥ 2 h	LEV = no	16	13	8 (50%)	1.25	93.8	6.3	+ 0.19	+ 0.916	1.278

11.3.18 Surface treatment

Table 11.3.18

								Concentrations (mg/m³)		
Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	81	62	44 (54.3%)	0.71	96.3	3.7	! LOD	3.951	7.0095
≥ 2 h	Static	79	55	46 (58.2%)	0.71	100	0	! LOD	1.171	2.167
< 2 h	Static	10	5	3 (30%)	5.75	80	20	+ 2,875	40.21	73.235
Respirable dust										
≥ 2 h	Personal	74	56	43 (58.1%)	1.25	90.5	9.5	! LOD	+ 0.876	1.819
≥ 2 h	Static	76	51	52 (68.4%)	0.25	97.4	2.6	! LOD	0.458	0.626

Table 11.3.18 a

								Concentrations (mg/m³)		
Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	57	43	33 (57.9%)	1.25	91.2	8.8	! LOD	+ 0.828	1.738
≥ 2 h	LEV = no	12	11	7 (58.3%)	0.25	83.3	16.7	! LOD	1.588	3.274

11.3.19 Hardening, sintering

The 90th percentile values for both dust fractions measured both on the person and statically over a sampling duration of ≥ 2 hours lie substantially below the limit value.

Table 11.3.19

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	80	60	44 (55%)	0.72	98.8	1.3	! LOD	2.02	3
≥ 2 h	Static	98	56	48 (49%)	1.25	100	0	+ 0.355	1.444	2.876
< 2 h	Personal	7 ***	6	3 (42.9%)	5.7	85.7	14.3	=-Values: 1.47 to 10.4		
Respirable dust										
≥ 2 h	Personal	86	68	58 (67.4%)	1.25	98.8	1.2	! LOD	+ 0.625	+ 0.864
≥ 2 h	Static	77	47	54 (70.1%)	0.83	94.8	5.2	! LOD	+ 0.59	0.951
< 2 h	Personal	10	8	8 (80%)	2	70	0	! LOD	+ 1	+ 1
< 2 h	Static	5 ***	3 **	3 (60%)	0.5	60	40	=-Values: 3.11 to 3.17		

11.3.20 Storage, packing

The 90th percentile values for both dust fractions measured both on the person and statically over a sampling duration of over two hours lie substantially below the limit values.

Table 11.3.20

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	57	42	21 (36.8%)	0.71	94.7	5.3	0.715	5.062	9.234
≥ 2 h	Static	84	57	46 (54.8%)	0.71	100	0	! LOD	+ 0.64	0.978
Respirable dust										
≥ 2 h	Personal	66	48	42 (63.6%)	0.86	97	3	! LOD	+ 0.518	+ 0.787
≥ 2 h	Static	184	102	122 (66.3%)	1.25	100	0	! LOD	+ 0.306	+ 0.492

11.3.21 Conveying, filling, mixing, weighing of solids

Table 11.3.21

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	79	48	8 (10.1%)	0.71	88.6	11.4	1.875	10.23	13.115
≥ 2 h	Static	74	35	37 (50%)	0.71	100	0	+ 0.355	1.56	2.072
< 2 h	Personal	23	18	8 (34.8%)	8.57	60.9	39.1	+ 4.428	38.76	43.98
< 2 h	Static	8 ***	5	2 (25%)	0.86	87.5	12.5	=-Values: 0.15 to 11		
Respirable dust										
≥ 2 h	Personal	74	43	30 (40.5%)	0.25	91.9	8.1	0.32	1.208	1.538
≥ 2 h	Static	96	42	58 (60.4%)	0.25	97.9	2.1	! LOD	0.538	1.098
< 2 h	Personal	22	18	12 (54.5%)	3.19	36.4	40.9	! LOD	+ 2.912	4.315

Table 11.3.21 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	55	35	7 (12.7%)	0.71	94.5	5.5	1.745	5.985	8.977
≥ 2 h	LEV = no	14	12	1 (7.1%)	0.71	71.4	28.6	2.73	13.7	15.16
Respirable dust										
≥ 2 h	LEV = yes	48	30	22 (45.8%)	0.25	95.8	4.2	0.26	1.142	1.232
≥ 2 h	LEV = no	13	11	3 (23.1%)	0.25	84.6	15.4	0.51	1.442	1.702

11.3.22 Assembly, disassembly

Table 11.3.22

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	160	98	70 (43.8%)	0.71	94.4	5.6	+ 0.45	5.53	13.8
≥ 2 h	Static	140	106	68 (48.6%)	7.58	98.6	1.4	+ 0.355	+ 1.75	+ 2.67
< 2 h	Personal	13	11	7 (53.8%)	3.57	92.3	7.7	! LOD	8.421	10.027
< 2 h	Static	22	8	1 (4.5%)	1.9	100	0	+ 0.95	3.358	3.43
Respirable dust										
≥ 2 h	Personal	173	104	112 (64.7%)	1.25	91.3	8.7	! LOD	+ 0.861	1.665
≥ 2 h	Static	204	124	120 (58.8%)	1.25	95.1	4.9	! LOD	+ 0.674	+ 1.032
< 2 h	Personal	10	9	5 (50%)	1.43	40	50	+ 0.715	5.22	5.815
< 2 h	Static	33	11	6 (18.2%)	0.67	48.5	51.5	1.265	2.357	2.689

Table 11.3.22 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	52	41	20 (38.5%)	0.71	98.1	1.9	0.74	5.322	7.288
≥ 2 h	LEV = no	95	61	44 (46.3%)	0.71	91.6	8.4	+ 0.385	6.865	25.35
Respirable dust										
≥ 2 h	LEV = yes	62	45	42 (67.7%)	1.25	88.7	11.3	! LOD	1.304	1.507
≥ 2 h	LEV = no	94	62	59 (62.8%)	1.25	92.6	7.4	! LOD	+ 0.816	2.906

11.3.23 Insulation, cladding

Mats made of artificial mineral fibres are used for insulation purposes in plant engineering, the construction of equipment, refrigeration and the manufacture of vehicle bodies. The fibres concerned are largely "unclassified". The GDLV (inhalable and respirable fraction) serves as the basis for evaluating the dust produced during processing.

The 90th percentile values for both dust fractions measured both on the person and statically over a sampling duration of ≥ 2 hours lie substantially below the limit value.

Table 11.3.23

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	25	13	15 (60%)	0.72	100	0	! LOD	3.525	5.155
≥ 2 h	Static	11	9	5 (45.5%)	0.72	100	0	+ 0,22	+ 0.359	+ 0.481
Respirable dust										
≥ 2 h	Personal	29	16	18 (62.1%)	0.25	96.6	3.4	! LOD	0.448	0.558
≥ 2 h	Static	12	10	10 (83.3%)	0,25	100	0	! LOD	+ 0.125	+ 0.171
< 2 h	Static	9 ***	3 **	2 (22.2%)	0.37	33.3	66.7	=-Values: 0.69 to 3.27		

11.3.24 Inspection, test benches

Table 11.3.24

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	72	49	34 (47.2%)	0.71	100	0	+ 0.355	2.226	3.38
≥ 2 h	Static	83	46	52 (62.7%)	0.71	100	0	! LOD	0.957	1.494
Respirable dust										
≥ 2 h	Personal	84	58	51 (60.7%)	1.22	91.7	8.3	! LOD	+ 1.058	1.806
≥ 2 h	Static	130	73	79 (60.8%)	1.25	97.7	2.3	! LOD	+ 0.57	+ 0.94

Table 11.3.24 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	LEV = yes	45	29	28 (62.2%)	0.25	93.3	6.7	! LOD	0.71	1.558
≥ 2 h	LEV = no	35	30	22 (62.9%)	1.22	88.6	11.4	! LOD	1.29	1.913

11.3.25 Cleaning of rooms and installations

The removal of deposited dust is by its nature associated with high dust levels, particularly when compressed air is used.

The 90th percentile values of dust fractions measured solely on the person lie substantially above the limit values. These are not time-weighted shift values however, but activity-specific exposures with a sampling duration of < 2 hours.

Table 11.3.25

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
< 2 h	Personal	16	11	6 (37.5%)	10.6	75	18.8	+ 2.475	14.78	23.42
Respirable dust										
< 2 h	Personal	11	10	7 (63.6%)	4.99	45.5	18.2	! LOD	+ 2.345	+ 2.443

11.3.26 Cleaning of parts and surfaces

Table 11.3.26

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	25	22	11 (44%)	0,71	96	4	+ 0.62	5.825	9.0975
≥ 2 h	Static	30	23	14 (46.7%)	0,74	96.7	3.3	+ 0.355	3.45	5.825
Respirable dust										
≥ 2 h	Personal	28	24	19 (67.9%)	1.25	92.9	7.1	! LOD	+ 1.21	1.334
≥ 2 h	Static	24	20	14 (58.3%)	0.25	95.8	4.2	! LOD	0.638	0.698
< 2 h	Personal	7 ***	7	5 (71.4%)	1.36	57.1	28.6	=-Values: 1.36 to 1.39		

12 Repair, maintenance and workshop work

12.1 Repair and maintenance of road and rail vehicles

Sector
Repair shop, motor vehicles
Transport, haulage, transport companies
Vehicle construction
Repair shop (service workshop), general
Metalworking and metal processing, general
Wholesale trade in motor vehicles, machinery, mechanical equipment and related technical supplies (excluding tyres and rubber articles)
Repair shop, railways
Training facilities
Construction of machinery and vehicles, general
Repair shop, trams, light rail vehicles
Vehicle detailing

Occupation
Vehicle mechanic
Vehicle fitter
Vehicle cleaner, valet
Vehicle mechanic (excluding repairs)
Car and other vehicle painter
Railway maintenance fitter
Bodywork and vehicle technician
Vehicle mechatronics technician
Locomotive fitter
Industrial crafts person, foreman/woman (metal, vehicles)
Agricultural machinery mechanic, general
Two-wheeled vehicle mechanic
Car washer, car valet

Area of activity
General areas of activity
Repair and maintenance, in the workshop
Vehicles, rail (tram, railway, underground)
Continuous maintenance (refuelling, servicing)
Assembly, general
Workshop work, general
Dry grinding
Processing, indoor
Storage sheds
Repair and maintenance, general
Vehicle shop
Laminating of moulded items
Vehicles and machines, closed cab
Surface treatment, general
Bulk material, closed (silo)
Sawing
Grinding
CNC machines
Surface treatment, indoor
Filling
Quality control
Finishing
Transport and service stations, general
Car parks
Repair shops, repair and maintenance
Maintenance, general
Test benches and service, general
Repair of drivetrains, running gear, general
Visual and functional inspection on or under vehicle lifts
Paint shop, paint preparation (surfacing, smoothing)
Removal and fitting of bodywork components and assemblies
Car body work, general
Oil changing, checking of operating fluids, filling up

Area of activity
Washing and valeting station
Body work, repair work on vehicle bodies
Paint shop, airless
Repair of engines, gearboxes, clutches
Exhaust emissions test
Wheel repair, tyre service (wheel change, tyre repair, balancing, removal and refitting)
Paint shop, general
Dynamometer
Electrics, fitting and removal of electrical and electronic components
Visual and functional testing in pits or underfloor systems
Brake test stand
Body work, repairs to plastic parts
Body work, sanding
Bodywork, polishing, waxing and dewaxing
Administration, sales, stores, work in the spare parts store
Electrics, general

Besides conventional car repair shops, measurements were also conducted in the area of repair/maintenance of road and rail vehicles, primarily maintenance shops for rail vehicles in public transport (suburban and underground trains). The repair and maintenance of road and rail vehicles involves a wide range of activities. Dust exposure may occur in particular during grinding and welding work on vehicle bodies. Another source of dust in rail vehicle maintenance is the cleaning and refilling of brake sandboxes. This can lead to very high dust concentrations for brief durations.

Table 12.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	42	33	7 (16.7%)	0.71	88.1	11.9	1.64	10.726	33
≥ 2 h	Static	95	70	44 (46.3%)	0.71	100	0	+ 0.14	1.28	2.212
< 2 h	Personal	36	24	9 (25%)	2.86	61.1	38.9	3.9	121.2	161.6
< 2 h	Static	26	12	4 (15.4%)	1.55	92.3	7.7	+ 1.38	5.61	14.236
Respirable dust										
≥ 2 h	Personal	71	53	31 (43.7%)	1.25	88.7	11.3	+ 0.27	1.301	4.859
≥ 2 h	Static	388	157	266 (68.6%)	1.25	99.2	0.8	! LOD	+ 0.18	+ 0.396
< 2 h	Personal	34	21	14 (41.2%)	5	47	47.1	+ 0.85	12.76	25.09
< 2 h	Static	67	27	26 (38.8%)	1.25	79.1	20.9	+ 0.335	1.553	1.718

12.2 Repair, maintenance, workshop work in other sectors

Areas of activity
General areas of activity
Workshop work, general
Repair and maintenance, general
Repair and maintenance, in the workshop
Repair and maintenance, in operation
Wood workshop (in the metal trade)
Continuous maintenance (refuelling, servicing)
Restoration workshop
Ceramics
Cleaning, repair, miscellaneous, repair of tunnel/furnace cars
Repair work on the furnaces
Repair of the furnace cars
Blast furnace
Mould repair shop, repair of the moulds
Fettling shop, moulding shop, billet grinding shop, repair, maintenance
Repair, maintenance, general
Foundries
Installation, electrical and repair work on the equipment
Mechanical workshop, fitter's shop, electrical workshop, indoor
Hollow glass
Cleaning, repair, miscellaneous, neck ring repair
Aluminium smelters
Foundry furnace repair, indoor
Production of mortar and ready-mixed plaster
Maintenance of ancillary equipment, site silos
Meat production and processing
Workshop, general
Repair shops, repair and maintenance
Dynamometer
Repair of engines, gearboxes, clutches
Body work, sanding
Body work, turning, shaping
Paint shop, paint preparation (surfacing, smoothing)
Electrics, fitting and removal of electrical and electronic components
Electrics, cleaning of electrical and electronic components
Waste incineration plants
Crane station in waste bunker, repair/maintenance of crane system
Boilers, general repair work
Flue gas cleaning systems, general repair work
Glass
Craft trade work, general
Repair shop

Besides the road and rail vehicle sector, a wide variety of repair, maintenance and fitting work is also carried out in various repair shops in other sectors. This work covers the maintenance of machinery, repair and cleaning of work equipment, and grinding and welding work on larger sheet metal parts such as containers or silos. High dust exposures arise above all during grinding and welding work, and also during repair work involving cleaning of the machinery or equipment.

Table 12.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	170	107	37 (21.8%)	0.71	88.8	11.2	1.45	10.2	15.35
≥ 2 h	Static	243	140	80 (32.9%)	0.72	95.5	4.5	+ 0.355	3.822	7.98
< 2 h	Personal	57	36	30 (52.6%)	3.43	78.9	21.1	! LOD	30.05	42.375
< 2 h	Static	64	26	10 (15.6%)	4	85.9	14.1	+ 3.15	15.78	23.88
Respirable dust										
≥ 2 h	Personal	187	126	81 (43.3%)	1.25	80.2	19.8	+ 0.313	1.965	3.159
≥ 2 h	Static	264	163	131 (49.6%)	0.63	93.2	6.8	+ 0.125	0.88	1.684
< 2 h	Personal	67	42	41 (61.2%)	5	64.2	31.3	! LOD	13.93	19.315
< 2 h	Static	72	34	26 (36.1%)	1.5	58.3	38.9	+ 0.82	4.822	6.41

13 Electrical and precision engineering industry and trades

13.1 Electrical engineering

Sector
Electrical engineering, general
Nickel-cadmium batteries, production
Production of insulated electrical cables, wires and conductors
Electrical panel building

In the electrical industry, powdered additives are filled, weighed and mixed in the most diverse of activities. These include the production of moulded and pressed parts, the formulation of casting resins containing powdered additives, and the production of cable and wire insulation with the use of powdered components. Dust exposure must be anticipated during most of these activities.

13.1.1 Filling, weighing

Table 13.1.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	37	16	10 (27%)	0.71	89.2	10.8	1.2	7.64	16.59
≥ 2 h	Static	22	13	17 (77.3%)	0.71	100	0	! LOD	1.124	1.697
< 2 h	Personal	15	10	9 (60%)	3.55	86.7	13.3	! LOD	7.61	12.6
Respirable dust										
≥ 2 h	Personal	31	13	16 (51.6%)	0.25	96.8	3.2	! LOD	0.965	1.089
≥ 2 h	Static	22	12	18 (81.8%)	0.25	100	0	! LOD	0.278	0.343
< 2 h	Personal	14	10	10 (71.4%)	2.73	78.6	14.3	! LOD	+ 1.506	2.878

13.1.2 Mixing

Table 13.1.2

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	21	12	11 (52.4%)	0.71	100	0	! LOD	5.413	6.24
≥ 2 h	Static	15	9	11 (73.3%)	0.71	100	0	! LOD	1.15	2.212
Respirable dust										
≥ 2 h	Personal	21	12	13 (61.9%)	0.25	100	0	! LOD	0.979	1.009
≥ 2 h	Static	16	9	10 (62.5%)	0.25	87.5	12.5	! LOD	0.862	1.556

13.1.3 Surface treatment

Some downstream production processes first require the surfaces of a wide variety of materials to be prepared by surface erosion techniques such as lasering.

Table 13.1.3

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	21	10	17 (81%)	0.71	95.2	4.8	! LOD	1.232	1.613
≥ 2 h	Static	28	20	27 (96.4%)	0.71	100	0	! LOD	! LOD	! LOD
Respirable dust										
≥ 2 h	Personal	15	10	14 (93.3%)	0.25	100	0	! LOD	! LOD	0.291
≥ 2 h	Static	30	21	29 (96.7%)	0.25	100	0	! LOD	! LOD	! LOD

13.1.4 Surface coating (excluding powder coating)

Surface coating processes in this context particularly include a range of painting processes. The use of powder coatings will be described separately in the next chapter.

13.1.5 Surface coating, powder coating

Powder coating is a coating process in which an electrically conductive material is coated by means of electrostatically charged paint particles. Exposure to dust may occur in particular during the application of the powder coatings.

Table 13.1.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	26	14	14 (53.8%)	0.71	100	0	! LOD	2.148	3.639
≥ 2 h	Static	24	23	20 (83.3%)	0.71	100	0	! LOD	0.978	1.314
Respirable dust										
≥ 2 h	Personal	25	14	18 (72%)	0.25	96	4	! LOD	0.425	0.51
≥ 2 h	Static	24	22	23 (95.8%)	0.25	100	0	! LOD	! LOD	! LOD

Table 13.1.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	14	12	7 (50%)	0.71	100	0	+ 0.46	2.31	3.987
≥ 2 h	Static	17	9	14 (82.4%)	0.71	100	0	! LOD	+ 0.509	2.037
< 2 h	Personal	5 ***	4 **	2 (40%)	1.86	80	20	=-Values: 3.79 to 18.7		
Respirable dust										
≥ 2 h	Personal	12	11	8 (66.7%)	0.25	91.7	8.3	! LOD	0.544	0.964
≥ 2 h	Static	18	9	14 (77.8%)	1.25	100	0	! LOD	+ 0.461	+ 0.626

13.1.6 Chip-forming machining processes

A wide variety of materials are processed mechanically in the electrical industry. These include various steels, metal alloys, cured resins and plastics. The processes used include chip-forming processes such as drilling, sawing, milling and punching, and also surface finishing processes such as polishing, grinding and blasting.

Table 13.1.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	70	40	43 (61.4%)	0.72	97.1	2.9	! LOD	6.07	9.675
≥ 2 h	Static	35	28	27 (77.1%)	0.71	100	0	! LOD	1.105	1.788
< 2 h	Personal	22	15	10 (45.5%)	1.43	90.9	9.1	+ 0.715	7.542	15.342
< 2 h	Static	11	8	7 (63.6%)	1.41	81.8	18.2	! LOD	15.255	18.06
Respirable dust										
≥ 2 h	Personal	71	40	54 (76.1%)	0.25	95.8	4.2	! LOD	0.615	1.044
≥ 2 h	Static	35	28	32 (91.4%)	0.25	100	0	! LOD	! LOD	+ 0.212
< 2 h	Personal	18	14	11 (61.1%)	1	77.8	22.2	! LOD	1.44	2.432
< 2 h	Static	14	9	12 (85.7%)	1	92.9	7.1	! LOD	+ 0.554	1.94

13.1.7 Polishing, grinding, blasting

Table 13.1.7

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	108	44	40 (37%)	0.71	90.7	9.3	1.02	8.292	13.84
≥ 2 h	Static	32	21	21 (65.6%)	0.71	100	0	! LOD	3.904	8.94
< 2 h	Personal	14	11	6 (42.9%)	2.86	85.7	14.3	+ 1.26	8.728	19.32
Respirable dust										
≥ 2 h	Personal	97	42	51 (52.6%)	0.25	92.8	7.2	! LOD	1.103	1.559
≥ 2 h	Static	35	23	25 (71.4%)	0.25	97.1	2.9	! LOD	0.72	0.995
< 2 h	Personal	8 ***	8	4 (50%)	1.43	50	37.5	=-Values: 0.76 to 2.22		

13.1.8 Cleaning of equipment and material

Dust deposits are often removed from parts of equipment or products by vacuuming or by means of cloths, brushes or similar. These activities are usually associated with dust exposure. Limit values are violated in particular when prohibited techniques are used, such as blasting with compressed air, or sweeping.

13.1.9 Assembly

Fibrous materials in the form of mats are used to insulate electrical components against external heat and to prevent heat being emitted from furnaces and ovens. Exposure to dust must be anticipated during the installation of such equipment.

Table 13.1.8

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	13	10	4 (30.8%)	0.72	92.3	7.7	0.865	4.884	21.5
< 2 h	Personal	28	17	16 (57.1%)	3.72	92.9	7.1	! LOD	7.908	9.848
Respirable dust										
≥ 2 h	Personal	12	10	9 (75%)	0.25	91.7	8.3	! LOD	0.94	2.856
< 2 h	Personal	20	14	18 (90%)	3	65	5	! LOD	+ 1.155	+ 1.5

Table 13.1.9

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	47	25	25 (53.2%)	0.71	97.9	2.1	! LOD	3.221	4.745
≥ 2 h	Static	86	38	73 (84.9%)	0.71	98.8	1.2	! LOD	+ 0.505	1.567
Respirable dust										
≥ 2 h	Personal	38	23	32 (84.2%)	0.25	97.4	2.6	! LOD	0.31	0.44
≥ 2 h	Static	86	35	79 (91.9%)	0.25	100	0	! LOD	! LOD	+ 0.241

13.1.10 Production of plastic parts, processing of plastics

Plastic parts are used in a variety of ways in electrical engineering. Production methods include injection moulding and extrusion and also the pressing of fibre mats pre-impregnated with reactive resins (prepregs). In the injection moulding process, plastic granulate is liquefied by an injection moulding machine and injected under pressure into a mould, the injection moulding die. The material cools down in the die, thereby reverting to the solid state, and is removed or ejected as a finished part when the die is opened. In the extrusion process, the liquefied plastic is formed into a continuous product, such as hose, in a die. Exposure to dust arises in all processes involving the mechanical finishing of workpieces and handling of the plastic granulate.

Table 13.1.10

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	23	13	11 (47.8%)	0.71	100	0	+ 0.497	2.109	2.505
≥ 2 h	Static	28	14	18 (64.3%)	0.71	100	0	! LOD	1.954	2.268
Respirable dust										
≥ 2 h	Personal	20	11	15 (75%)	0.25	100	0	! LOD	0.31	0.58
≥ 2 h	Static	28	13	18 (64.3%)	0.25	96.4	3.6	! LOD	0.534	0.874

13.1.11 Pressing, forming

Table 13.1.11

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	18	11	9 (50%)	0.72	100	0	+ 0.47	1.394	2.036
≥ 2 h	Static	33	16	18 (54.5%)	0.72	100	0	! LOD	1.206	1.621
Respirable dust										
≥ 2 h	Personal	15	11	14 (93.3%)	0.25	100	0	! LOD	! LOD	+ 0.174
≥ 2 h	Static	30	15	27 (90%)	0.25	100	0	! LOD	+ 0.17	+ 0.205

13.2 Jewellery, production and working

Sector
Jewellery, production and working
Gemstone polishing

In addition to metals and metal alloys, gemstones (precious and semi-precious stones) are worked mechanically during the production and working of jewellery. High dust exposures must be anticipated during activities such as cutting, grinding and polishing, particularly when gemstones are worked without adequate dust collection. The use of talcum powder during the mechanical production of jewellery chains may present a further source of dust. When the talcum powder is applied to the chains, the solder powder applied beforehand is removed again; the solder adheres only in the gaps within the individual chain links. This ensures that during the subsequent soldering process in the oven, only the gaps are fused, and the chain links are not soldered rigidly together.

Table 13.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	18	10	10 (55.6%)	0.71	83.3	16.7	! LOD	10.4	10.8
Respirable dust										
≥ 2 h	Personal	18	10	11 (61.1%)	0.25	88.9	11.1	! LOD	1.338	2.005
≥ 2 h	Static	8 ***	5	3 (37.5%)	0.63	87.5	12.5	=-Values: 0.27 to 1.26		

13.3 Solar technology, production

Sector
Solar technology, production

A wide variety of processes are used in the production of solar modules. These include cutting and parting processes, blasting processes, laser surface treatments and various surface cleaning processes.

Table 13.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	23	12	18 (78.3%)	0.72	95.7	4.3	! LOD	0.82	1.399
≥ 2 h	Static	64	18	50 (78.1%)	0.71	100	0	! LOD	+ 0.355	+ 0.355
< 2 h	Personal	11	8	11 (100%)	5.67	100	0	! LOD	! LOD	! LOD
Respirable dust										
≥ 2 h	Personal	21	12	18 (85.7%)	0.25	95.2	4.8	! LOD	0.282	0.423
≥ 2 h	Static	46	16	45 (97.8%)	0.25	100	0	! LOD	! LOD	! LOD
< 2 h	Personal	13	11	13 (100%)	1.99	69.2	0	! LOD	! LOD	! LOD

13.4 Grinding during the production of musical instruments, sheet and solid metal goods

Sector
Iron, sheet and solid metal goods, production
Musical instruments, production

A range of surface grinding methods are used in the production of various solid and sheet metal goods and of musical instruments. High dust exposures are to be anticipated, particularly during the grinding of large areas in the absence of effective dust collection equipment.

Table 13.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	84	36	9 (10.7%)	0.75	77.4	22.6	2.87	15.54	23.02
≥ 2 h	Static	29	11	13 (44.8%)	0.71	96.6	3.4	+ 0.35	1.423	2.478
Respirable dust										
≥ 2 h	Personal	92	36	36 (39.1%)	1.25	80.4	19.6	+ 0.53	1.828	2.842
≥ 2 h	Static	33	12	18 (54.5%)	1	93.9	6.1	! LOD	+ 0.939	1.681

13.5 Precision mechanics

Sector
Lamps, luminaires, production
Lamps containing mercury, including illuminated signage, production
Hearing aid manufacturers
Production of audio storage media
Precision mechanics, optics, production
Medical technology, production
Production of weapons and ammunition
Sports equipment, production
Outdoor advertising

The term "precision engineering" covers a large number of sectors. Measured values from the following sectors were considered here:

- Manufacture of lamps and luminaires, including illuminated signage and outdoor advertising
- Production of hearing aids
- Production of audio storage media
- Production of optical devices
- Medical technology
- Production of weapons and ammunition
- Production of sports equipment

13.5.1 Grinding, blasting, deburring

Table 13.5.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	41	23	12 (29.3%)	0.71	85.4	15.4	0.985	11.78	13.815
≥ 2 h	Static	22	13	19 (86.4%)	0.71	95.5	4.5	! LOD	+ 0.671	2.469
< 2 h	Personal	6 ***	6	4 (66.7%)	1.43	83.3	16.7	=-Values: 1.48 to 190		
< 2 h	Static	6 ***	3 **	1 (16.7%)	1.57	83.3	16.7	=-Values: 5.49 to 65.1		
Respirable dust										
≥ 2 h	Personal	42	21	18 (42.9%)	0.25	81	19	0.26	1.444	3.394
≥ 2 h	Static	22	13	19 (86.4%)	0.25	100	0	! LOD	+ 0.145	+ 0.177
< 2 h	Personal	6 ***	5	4 (66.7%)	0.58	83.3	16.7	=-Values: 0.35 to 43.4		

13.6 Dental laboratories

Sector
Dental laboratories

A wide range of materials are used in dental laboratories. Besides the use of investment materials containing quartz in model casting, various plastics are used in the production of models, and metals in the fabrication of crown and bridge frames. Dust exposure must be anticipated during handling of the raw materials of the investment materials and during mechanical processing, such as grinding of the models and frames.

Figure 38: Formulating investment material

Table 13.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	59	26	31 (52.5%)	0.72	100	0	! LOD	1.88	2.502
≥ 2 h	Static	26	14	22 (84.6%)	0.71	100	0	! LOD	1.016	1.154
< 2 h	Personal	13	12	8 (61.5%)	2.85	100	0	! LOD	2.987	3.509
Respirable dust										
≥ 2 h	Personal	58	28	38 (65.5%)	0.25	100	0	! LOD	0.424	0.689
≥ 2 h	Static	25	14	21 (84%)	0.83	100	0	! LOD	+ 0.398	+ 0.464
< 2 h	Personal	14	12	11 (78.6%)	1	92.9	7.1	! LOD	+ 0.712	1.364
< 2 h	Static	6 ***	5	5 (83.3%)	1	83.3	16.7	=-Values: 1.5 to 1.5		

13.7 Electrical installation work on construction sites

Sector
Electrical systems

Mineral dusts are released during work in the electrical trades on construction sites during chiselling off, the cutting of chases for electrical wiring, and the production of recesses for switches and distribution boxes. Different dust exposures must be anticipated, as a function of the type of machine and dust collection equipment used.

The exposure data presented here were obtained during the use of matched tool and dust collection systems. This refers to manufacturers' recommended combinations of electric tools, such as wall chasers, and the associated dust collection equipment. Such combinations have been designated as "low dust" following testing, and details of them can be found under the following link on the GISBAU website: https://www.bgbau.de/fileadmin/Gisbau/BG_Bau-Evaluation_of_dust_emission_2-2010.pdf

When combinations other than matched tool and dust collection systems are used, dust exposures of between 1.5 and 134 mg/m³ (mean: 42.8 mg/m³) for inhalable dust and 0.02 mg/m³ to 23.18 mg/m³ (mean: 4.43 mg/m³) for respirable dust may be anticipated [28].

Figure 39: Cutting of chases for electrical wiring

Table 13.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	13	7	3 (23.1%)	0.71	92.3	7.7	1.495	4.032	12.977
≥ 2 h	Static	7 ***	3 **	0	k. A.	85.7	14.3	=-Values: 0.35 to 14.1		
< 2 h	Personal	7 ***	4 **	0	k. A.	28.6	71.4	=-Values: 1.41 to 87.6		
< 2 h	Static	7 ***	3 **	1 (14.3%)	0.34	42.9	57.1	=-Values: 1.89 to 70		
Respirable dust										
≥ 2 h	Personal	12	6	4 (33.3%)	0.25	91.7	8.3	0.28	0.786	2.674
≥ 2 h	Static	7 ***	3 **	2 (28.6%)	0.25	85.7	14.3	=-Values: 0.16 to 3.03		
< 2 h	Personal	8 ***	4 **	1 (12.5%)	0.38	12.5	87.5	=-Values: 1.47 to 9.32		
< 2 h	Static	8 ***	3 **	2 (25%)	1.07	50	50	=-Values: 0.54 to 6.58		

13.8 Friction linings

Sector
Friction linings (brake and clutch linings), production, machining

During the production of friction linings, various friction materials in powder form are mixed with a binder, usually synthetic resin-based, and pressed onto a backing plate of steel or grey cast iron. In subsequent production steps, the blanks produced in this way are machined (by grinding, drilling).

13.8.1 Mixing

Table 13.8.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	66	11	15 (22.7%)	1.3	98.5	1.5	1.48	4.71	7.61
≥ 2 h	Static	23	8	6 (26.1%)	0.71	100	0	+ 0.58	1.706	3.445
Respirable dust										
≥ 2 h	Personal	63	11	18 (28.6%)	1.1	95.2	4.8	+ 0.35	+ 0.818	1.194
≥ 2 h	Static	24	8	5 (20.8%)	0.25	100	0	+ 0.2	0.492	0.508

13.8.2 Pressing

Table 13.8.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	40	8	8 (20%)	0.71	92.5	7.5	1.29	8.12	10.2
≥ 2 h	Static	17	5	9 (52.9%)	0.71	94.1	5.9	! LOD	2.227	11.861
Respirable dust										
≥ 2 h	Personal	38	7	14 (36.8%)	1.25	86.8	13.2	+ 0.36	1.372	1.723
≥ 2 h	Static	16	4 **	10 (62.5%)	0.83	93.8	6.3	! LOD	+ 0.616	5.624

13.8.3 Drilling, grinding

Table 13.8.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	18	7	11 (61.1%)	0.71	100	0	! LOD	1.094	2.297
≥ 2 h	Static	20	6	15 (75%)	0.71	100	0	! LOD	0.73	0.92
Respirable dust										
≥ 2 h	Personal	18	7	13 (72.2%)	0.76	100	0	! LOD	+ 0.402	+ 0.527
≥ 2 h	Static	20	6	16 (80%)	0.25	100	0	! LOD	0.27	0.27

14 Electroplating, hot dip galvanizing, surface coating

14.1 Electroplating

Sector
Electroplating
Electroplating/anodizing plant, waste water treatment plant
Electroplating, automatic rack/drum system
Electroplating, semi-automatic, manually guided rack/drum system
Electroplating, automatic strip processing line
Electroplating, manually operated system
Anodizing plant, automatic rack/drum system
Anodizing plant, semi-automatic, manually guided rack/drum system
Electroplating, intaglio printing, manually operated system
Electroplating, nickel plating, automatic rack/drum system
Electroplating, nickel plating, manually operated system
Electroplating, galvanizing, automatic rack/drum system

In the electroplating sector, high dust exposures generally occur only when substances in powder form are used, for example during formulation of electrolytes, or when lime is used in the treatment of waste water. These activities are usually of only brief duration. The results of the activity-related measurements (where sampling is usually of much less than two hours in duration) suggest that exposures for both dust fractions are particularly high.

Conversely, the 90th percentile shift-weighted values (sampling duration ≥ 2 hours) for both dust fractions, measured both on the person and statically, lie substantially below the limit values.

Table 14.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	118	69	79 (66.9%)	0.73	99.2	0.8	! LOD	1.642	2.9
≥ 2 h	Static	187	101	130 (69.5%)	0.72	100	0	! LOD	0.846	1.631
< 2 h	Personal	9 ***	9	3 (33.3%)	186	55.6	44.4	=-Values: 0.42 to 186		
Respirable dust										
≥ 2 h	Personal	65	38	46 (70.8%)	0.25	98.5	1.5	! LOD	0.44	0.78
≥ 2 h	Static	102	58	71 (69.6%)	2.41	99	1	! LOD	+ 0.478	+ 0.706
< 2 h	Personal	10	8	5 (50%)	2	40	50	+ 1	39.3	50.8

14.2 Hot-dip galvanizing plants

Sector
Galvanizing plant
Hot-dip galvanizing plants

During hot-dip galvanizing, coatings of zinc or zinc-iron alloys are produced by immersion of the steel or cast iron workpieces in a molten zinc bath at around 450 °C. A distinction is drawn according to whether the galvanizing bath is open (at ground level, with exhaust at the perimeter) or encapsulated (enclosed, with exhaust). Workers are exposed to respirable dust above the limit value primarily when working directly at the galvanizing bath, especially when regularly scraping the zinc ash off the surface of the molten zinc.

14.2.1 Galvanizing bath

The high temperature in the galvanizing bath causes fumes to be produced consisting largely of particles in the respirable fraction. The 90th percentile for inhalable dust lies substantially below the limit value in both static and personal measurements. Conversely, the 90th percentile for the respirable dust lies clearly above the limit value in the personal measurements. The results of activity-specific measurements of respirable dust on the person reveal particularly high exposure, for example when zinc ash is drawn off manually; the duration of sampling is usually much lower than two hours in this case.

Table 14.2.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	74	51	9 (12.2%)	0.71	100	0	0.98	2.576	2.946
≥ 2 h	Static	20	12	6 (30%)	0.71	100	0	+ 0.42	1.74	3.42
Respirable dust										
≥ 2 h	Personal	76	53	16 (21.1%)	1.24	81.6	18.4	+ 0.48	1.92	2.294
≥ 2 h	Static	16	12	6 (37.5%)	0.25	93.8	6.3	0.32	0.81	1.166
< 2 h	Personal	5 ***	4 **	0	n/a	40	60	=-Values: 0.34 to 12.7		
< 2 h	Static	11	2 **	0	n/a	0	100	2.25	2.669	2.773

14.3 Surface coating

Sector
Handling of liquid coating materials
Paint shops
Signage and glass painting
Car paint shop

14.3.1 Powder coating

Powder coating is used on electrically conductive material. The process may be performed on a continuous line or manually. The powder coating material is atomized by a nozzle on the spray gun. Powder coatings are usually based on epoxy or polyester resins; hybrid systems are also used, containing both epoxy and polyester resins as binders.

The 90% values for both dust fractions measured on the person lie substantially above the limit values.

Table 14.3.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	11	6	4 (36.4%)	0.71	81.8	18.2	1.045	14.899	19.345
Respirable dust										
≥ 2 h	Personal	12	6	8 (66.7%)	0.25	75	25	! LOD	2.654	8.49

14.3.2 Liquid coating by manual processes, paint spraying, dipping

During paint spraying, the surface coating agent (typically lacquer) is atomized in a spray gun by means of compressed air. The dust particles in this case are predominantly binder components and pigments. By its nature, dip coating gives rise to relevant solvent exposure; dust or aerosol formation is however negligible.

The 90th percentile value for inhalable dust measured on the person lies above the limit value, irrespective of the sampling duration. The value for respirable dust however lies well below the limit value.

Table 14.3.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	34	30	13 (38.2%)	0.71	88.2	11.8	1.1	10.488	15
≥ 2 h	Static	40	30	26 (65%)	0.72	95	5	! LOD	1.62	6.7
< 2 h	Personal	7 ***	6	3 (42.9%)	1.42	71.4	28.6	=-Values: 1.18 to 59.8		
< 2 h	Static	10	6	8 (80%)	1.43	90	10	! LOD	2.15	30.325
Respirable dust										
≥ 2 h	Personal	26	23	14 (53.8%)	1.25	96.2	3.8	! LOD	+ 0.631	+ 0.752
≥ 2 h	Static	28	21	23 (82.1%)	0.25	96.4	3.6	! LOD	0.418	0.744

14.3.3 Polishing, grinding, milling, blasting

Overall, these activities are associated with high dust levels. The crucial factors determining the level of exposure are the design of the workplace, the size and geometry of the workpieces, and the means provided for effective dust collection.

The 90th percentile values for both inhalable and respirable dust measured on the person over a sampling duration of ≥ 2 hours lie substantially above the limit value.

Table 14.3.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	72	47	11 (15.3%)	0.71	81.9	18.1	1.54	15.42	25.12
≥ 2 h	Static	18	12	3 (16.7%)	0.71	100	0	1.06	2.71	3.591
< 2 h	Personal	22	9	8 (36.4%)	1.49	90.9	9.1	+ 0.6	7.002	19.719
< 2 h	Static	11	4 **	7 (63.6%)	6.1	100	0	! LOD	+ 1.088	+ 1.988
Respirable dust										
≥ 2 h	Personal	66	50	36 (54.5%)	1.25	83.3	16.7	! LOD	1.784	2.367
≥ 2 h	Static	17	11	6 (35.3%)	0.83	94.1	5.9	+ 0.2	+ 0.428	+ 0.632
< 2 h	Personal	9 ***	5	3 (33.3%)	1	55.6	44.4	=-Values: 0.35 to 65.6		

Table 14.3.3 a

Duration of sampling	Collection	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	LEV = yes	46	32	10 (21.7%)	0.71	84.8	15.2	1.83	12.74	19.58
≥ 2 h	LEV = no	9 ***	8	0	n/a	66.7	33.3	=-Values: 0.62 to 50.5		
Respirable dust										
≥ 2 h	LEV = yes	49	35	31 (63.3%)	1.25	91.8	8.2	! LOD	+ 0.742	1.55
≥ 2 h	LEV = no	12	11	3 (25%)	0.43	66.7	33.3	+ 0.41	1.788	2.53

15 Services, transport, power generation, educational establishments

15.1 Services

15.1.1 Postal and parcel services

Sector
Postal services
Parcel services
Parcel centre
Parcel delivery depot
Mail services
Mail sorting office
Logistics centres for postal services

Dust measurements performed in postal and parcel services are primarily static dust measurements in the areas of storage and distribution of postal consignments. In consideration of the statistical evaluations of the respirable and inhalable dust measurements in postal services, parcel services and parcel and mail sorting offices, workplaces in this group of sectors may be regarded as dust-free.

15.1.2 Research and testing institutes, laboratories, design offices

Sector
Design offices
Research and testing institutes, laboratories
Teaching and experimental farms (research stations)
Engineering offices for technical planning
Geophysical soil studies
Environmental services, consulting and testing

Exposure measurements were performed in research and testing institutes, laboratories and design offices in a wide variety of areas. Particularly high dust exposures were observed wherever mechanical comminution or sorting/screening processes occurred during test activity. This is the case for example in building materials testing laboratories and geological research facilities. Another source of elevated dust exposure is the machining of test specimens by dry grinding, sawing, etc.

Table 15.1.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	30	13	25 (83.3%)	1.25	100	0	! LOD	+ 0.28	+ 0.32
≥ 2 h	Static	98	35	66 (67.3%)	0.18	100	0	! LOD	+ 0.162	0.211
Respirable dust										
≥ 2 h	Personal	17	8	7 (41.2%)	0.25	100	0	+ 0.21	0.618	0.759
≥ 2 h	Static	69	27	22 (31.9%)	0.36	100	0	+ 0.15	+ 0.331	0.465

Table 15.1.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	53	29	23 (43.4%)	0.83	92.5	7.5	+ 0.76	9.462	10.93
≥ 2 h	Static	82	35	46 (56.1%)	0.71	98.8	1.2	! LOD	1.254	2.578
< 2 h	Personal	19	11	10 (52.6%)	1.43	89.5	10.5	! LOD	7.68	17.48
< 2 h	Static	27	13	17 (63%)	1.43	92.6	7.4	! LOD	3.667	11.618
Respirable dust										
≥ 2 h	Personal	49	29	23 (46.9%)	0.25	83.7	16.3	+ 0.215	1.703	2.249
≥ 2 h	Static	64	31	42 (65.6%)	0.25	98.4	1.6	! LOD	0.682	0.856
< 2 h	Personal	23	14	11 (47.8%)	1.43	56.6	39.1	+ 0.45	2.15	6.669
< 2 h	Static	21	12	19 (90.5%)	2.08	81	9.5	! LOD	! LOD	+ 1.734

15.1.3 Services – other sectors

Sector
Cold storage
Restaurants, hotels, night clubs, kitchens
Car washes
Radio and television stations
Filmmaking
Theatres, opera houses, orchestras, bands
Museums
Hospitals and teaching hospitals, specialist and university hospitals
Hospitals
Animal treatment businesses (veterinary practices, hoof trimmers, etc.)
Advertising
Security companies
Temping agencies
Services, general
Building services
Police services
Fire services
Fire stations
Civil defence, civil protection
Correctional facilities
Public utilities
Cemeteries
Builder's yards, depots
Vehicle fleet sites

This section summarizes dust measurements performed in other service sector/public sector industries. As in the case of research facilities, dust exposure is also to be anticipated here in particular during mechanical or chip-forming working of the products used or manufactured.

The high number of respirable dust measurements with a sampling duration of < 2 hours in which observance the limit value could not be determined (almost 40% of the measurements) is found in a measurement campaign intended to study dust exposure at police firing ranges.

Table 15.1.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	29	20	11 (37.9%)	0.71	93.1	6.9	0.765	7.644	13.92
≥ 2 h	Static	44	26	18 (40.9%)	0.73	100	0	+ 0.355	1.14	3.244
< 2 h	Personal	15	11	5 (33.3%)	1.88	86.7	13.3	+ 1.905	10.475	13.85
Respirable dust										
≥ 2 h	Personal	32	21	23 (71.9%)	1.25	90.6	9.4	! LOD	+ 0.866	1.91
≥ 2 h	Static	79	34	60 (75.9%)	1.25	100.0	0.0	! LOD	+ 0.4651	+ 0.5425
< 2 h	Personal	17	9	14 (82.4%)	2.5	52.9	5.9	! LOD	+ 1.25	+ 1.26
< 2 h	Static	18	9	10 (55.6%)	2	83.3	5.6	! LOD	+ 0.952	+ 1.209

15.2 Workshops for persons with disabilities

Sector
Workshops for persons with disabilities (sheltered workshop), general
Workshop for persons with disabilities, metalworking

Workshops for persons with disabilities offer a wide range of services and commissioned production activities that are comparable to those in commercial enterprises. Dust is generated during dry chip-forming operations such as grinding and sawing in the working of metals, plastics and stone. Woodworking is also significant, but is not considered in the present analysis. Many of these activities are performed manually and often in larger groups, as a result of which dust exposure may increase. Dust is also generated during paper and plastics recycling, especially during the shredding and recycling of electronic waste. The dust concentrations stated in the evaluation of the results relate to a cross-section of activities in sheltered workshops that cannot be assigned to other sectors. The measurement data concerned are a small selection of data from individual cases, and cannot be considered representative. Certain basic conclusions can however be drawn. Most of the values measured on the person lay below the limit values for the inhalable and respirable concentrations. Violations of the limit value or concentrations close to it were determined for respirable dust concentrations during paper recycling, in particular during the shredding of paper and destruction of files. The permissible respirable dust concentration was also exceeded during sandstone working. The above assessments refer to averages over an eight-hour shift. Shorter durations of exposure result in lower shift averages. For sheltered workshops, exposure durations of between four and six hours can be assumed.

Since the data presented concern the cross-section referred to above of certain typical activities in sheltered workshops, the data for the specific activities referred to in the other chapters of this report should be consulted.

Table 15.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	11	10	0	n/a	90.9	9.1	1.595	2.528	7.517
≥ 2 h	Static	35	19	6 (17.1%)	0.32	100	0	0.855	4.35	7.487
< 2 h	Static	8 ***	5	2 (25%)	0.95	100	0	=-Values: 1.1 to 7.58		
Respirable dust										
≥ 2 h	Personal	19	11	7 (36.8%)	0.25	84.2	15.8	0.36	1.602	2.649
≥ 2 h	Static	33	19	15 (45.5%)	0.62	90.9	9.1	+ 0.25	1.097	1.559
< 2 h	Static	8 ***	4 **	4 (50%)	0.38	100	0	=-Values: 0.42 to 1.18		

15.3 Vocational schools and training centres for the building trade

Sector
Schools for vocational education and training
Training facilities

During their practical training for vocations in the building trade (bricklaying etc.), trainees carry out typical activities such as masonry and concreting work. The practice structures created are then dismantled again and the training premises cleaned. These activities take place in larger, enclosed training rooms or halls and are usually carried out by several trainees at the same time.

In general, relatively high dust concentrations were measured, particularly in personal measurements on the trainees or instructors. The high values for respirable and inhalable dust exposure measured over brief durations of sampling occur mainly during sweeping of classrooms and demolition of the practice structures.

Table 15.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	19	9	0	n/a	73.7	26.3	3.665	18.74	22.05
≥ 2 h	Static	16	9	0	n/a	93.7	6.3	3.01	8.236	10.508
< 2 h	Personal	11	4 **	0	n/a	45.5	54.5	9.715	32.84	38.485
Respirable dust										
≥ 2 h	Personal	24	10	2 (8.3%)	0.25	70.8	29.2	0.91	3.038	3.706
≥ 2 h	Static	14	9	1 (7.1%)	0.18	92.9	7.1	0.5	1.174	1.326
< 2 h	Personal	12	4 **	1 (8.3%)	0.46	41.7	58.3	1.89	7.292	8.978
< 2 h	Static	14	6	1 (7.1%)	0.7	35.7	64.3	1.42	3.598	5.485

15.4 Power generation

Sector
Electricity, gas, water supply (excluding coal-fired power plants)
Coal-fired power plants
Biogas plants
Combined heat and power plants
Heating plants
Crude oil and natural gas, extraction and processing

15.4.1 Steam generation

Different fuels, according to the type of power plant, are fed into the combustion process for the generation of steam. In addition to coal, crude oil and natural gas are also used as fuel. As a rule, the combustion process and steam generation take place in areas of activity associated with the boiler house. The combustion process and also handling and transport processes may give rise to dust exposure in the boiler house.

Table 15.4.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	13	8	9 (69.2%)	0.71	100	0	! LOD	2.939	4.173
≥ 2 h	Static	37	19	26 (70.3%)	0.71	100	0	! LOD	1.11	1.386
Respirable dust										
≥ 2 h	Personal	15	8	13 (86.7%)	0.25	100	0	! LOD	0.268	0.443
≥ 2 h	Static	35	20	26 (74.3%)	1.25	100	0	! LOD	+ 0.3	+ 0.464

15.4.2 Inspection

A wide range of plant components are inspected during inspection rounds in power plants. These involve inspection of the various areas of the plant by employees. This not infrequently requires flaps or shafts to be opened, which can lead to high dust exposures for brief periods.

15.4.3 Conveying, filling

A number of conveying and filling processes take place in power plants. They include the conveying of fuel such as coal on conveyor belts and chutes, and the filling of tank wagons. Fuels and ash are also stored in bunkers or silos. Exposure to dust must be anticipated during activities in these areas of activity. In most cases however, the workplaces concerned are not manned continuously.

Table 15.4.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	53	19	5 (9.4%)	0.71	94.3	5.7	0.895	5.424	14.643
Respirable dust										
≥ 2 h	Personal	53	19	30 (56.6%)	0.25	92.5	7.5	! LOD	0.782	1.5

Table 15.4.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	54	15	8 (14.8%)	0.39	96.3	3.7	0.96	5.156	6.74
≥ 2 h	Static	129	27	25 (19.4%)	0.71	94.6	5.4	1.03	7.065	9.908
Respirable dust										
≥ 2 h	Personal	57	17	17 (29.8%)	0.2	93	7	0.205	0.969	1.615
≥ 2 h	Static	115	25	39 (33.9%)	1.25	80.9	19.1	+ 0.31	1.91	2.578
< 2 h	Static	9 ***	2 **	1 (11.1%)	0.33	22.2	77.8	=-Values: 1.09 to 2.73		

15.4.4 Storage

Table 15.4.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	9 ***	4 **	2 (22.2%)	0.71	77.8	22.2	=-Values: 0.99 to 14.9		
≥ 2 h	Static	28	7	16 (57.1%)	0.71	96.4	3.6	! LOD	1.396	1.69
Respirable dust										
≥ 2 h	Personal	10	5	4 (40%)	0.25	90	10	+ 0.14	0.91	1.43
≥ 2 h	Static	17	9	8 (47.1%)	0.25	100	0	+ 0.147	0.829	0.855

15.4.5 Cleaning of indoor areas, material and equipment

Dust deposits are often removed from parts of equipment or products by vacuuming or cleaning with brooms or similar. These activities are usually associated with dust exposure. Limit values are violated in particular when prohibited techniques are used, such as blasting with compressed air, or sweeping.

Table 15.4.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	10	5	1 (10%)	0.25	50	50	6.82	55.5	95.25
Respirable dust										
≥ 2 h	Personal	10	5	4 (40%)	0.25	90	10	0.47	1.09	1.18

15.5 Transport

Sector
Transport, haulage, transport companies
Wet concrete and wet mortar, transport
Bulk goods from the minerals and earths industry, transport
Container services
Railways
Trams
Road traffic, car parks
Inland shipping
Maritime shipping, passenger shipping
Maritime shipping, goods and tanker shipping (shipping companies)
Maritime shipping, special vessels such as tugs, supply vessels, salvage vessels
Maritime shipping, ferries, service barge companies (passengers and freight)
Inland shipping, ferries, service barge companies (passengers and freight)
Transshipment, stevedoring
Aviation
Helicopters
Airports, airfields
Maintenance bases

Areas of activity in the "transport" group comprise areas associated with various means of water, land and air transport. This broad spectrum covers maritime and inland waterway and port operations, aircraft, helicopters and airports, railways and tramways, and the operation of cars, trucks and special vehicles in various transport sectors.

For the purpose of further evaluation, the group was subdivided into the two variants of "conveying, transshipment, storage, packaging" and "vehicles, industrial trucks, transport", no distinction being made between modes of transport. The two tables thus contain a wide mixture of different jobs. They include jobs both in or on the mode of transport itself (such as driver, seaman) and in the area associated with it (such as airport apron, multi-storey car park, unloading point).

How do dust emissions arise in the "transport" sub-sector?

1) Bulk goods and processes
Transport on company premises in particular also takes place where freight is loaded, unloaded or conveyed. Depending on the particle size, wind direction, loading/unloading method and other influencing factors, parts of the freight are released into the environment and remain in the breathed air for a certain time before they settle again. Peak values may be reached when a number of underlying conditions coincide. Since these processes can be attributed to the transport sector, particular attention must be paid to them. In many cases however, the transport company has only limited influence on the underlying conditions that favour the release of dust.

2) Exposure caused by the raising of dust deposits
In many companies, dust deposits accumulate continually on the traffic areas. Sources of this dust include environmental dust, loss of cargo (particularly waste and bulk materials) when inadequately covered, and operating processes that release dust, such as screening, separation and surface treatment processes. The deposits are raised by traffic (when they are driven over) and are thus measurable in some cases as an inhalable or respirable fraction. Effective cleaning of the traffic areas therefore contributes directly to the reduction of dust in the air.

3) Emissions from vehicle engines
Power to propel vehicles and drive machines is generated primarily by the combustion of fossil fuels, often diesel. The resulting emissions contain gaseous and particulate components. Owing to agglomeration processes, the latter are in the order of magnitude of ultrafine particles, approximately in the range between 50 and 100 nm. They are thus included nominally within the respirable dust fraction. However, the emitted particles are unlikely to reach masses that are in the order of magnitude (in terms of mass) of other emission sources. This component can therefore be ignored.

In summary, it can be concluded that high measured dust values and violations of the limit values may occur in tasks that primarily involve operational processes and transshipment. The mere driving of a vehicle on the public highway does not pose a hazard of exposure levels in the order of magnitude of the GDLV.

Preventive measures are geared to the hazards referred to above and assessment of the associated risk in the various areas of activity. Possible measures include, for example, encapsulation of transport processes, regular cleaning of traffic areas by means of non-dust-raising methods, and protection of drivers' workplaces by means of dust protection systems/protective ventilation systems for drivers' cabs.

15.5.1 Conveying, transshipment, storage, packaging

Measurements on the person reveal violations of the limit values in 18.5% and 17.2% of the mean shift-based values for inhalable and respirable dust respectively. This indicates a major need for action in the areas concerned.

Table 15.5.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	27	16	9 (33.3%)	0.62	81.5	18.5	+ 0.435	17.5	28.65
≥ 2 h	Static	93	30	45 (48.4%)	0.25	98.9	1.1	+ 0.125	0.987	2.427
< 2 h	Personal	7 ***	5	2 (28.6%)	10	57.1	42.9	=-Values: 0.25 to 95		
< 2 h	Static	14	7	6 (42.9%)	2.94	100	0	+ 0.9	+ 1.844	+ 2.257
Respirable dust										
≥ 2 h	Personal	29	15	9 (31%)	0.25	82.8	17.2	+ 0.15	2.689	5.576
≥ 2 h	Static	197	69	133 (67.5%)	0.25	98	2	! LOD	+ 0.153	0.332
< 2 h	Personal	5 ***	3 **	2 (40%)	10	40	40	=-Values: 0.7 to 32.7		
< 2 h	Static	18	10	11 (61.1%)	0.53	94.4	5.6	! LOD	+ 0.392	6.294

15.5.2 Vehicles, industrial trucks, transport

Table 15.5.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	23	13	4 (17.4%)	0.25	78.3	21.7	1.6	15.51	30.265
≥ 2 h	Static	32	18	24 (75%)	0.29	100	0	! LOD	+ 0.248	0.714
< 2 h	Personal	27	13	3 (11.1%)	1.11	55.6	44.4	6.77	107.8	134.75
< 2 h	Static	14	6	3 (21.4	0.27	92.9	7.1	0.67	1.92	6.234
Respirable dust										
≥ 2 h	Personal	34	19	15 (44.1%)	0.25	88.2	11.8	0.32	1.29	1.747
≥ 2 h	Static	88	33	60 (68.2%)	0.25	100	0	! LOD	+ 0.202	0.342
< 2 h	Personal	30	15	14 (46.7%)	1.5	50	46.7	+ 0.75	13.2	26.35
< 2 h	Static	34	11	18 (52.9%)	0.85	97.1	2.9	! LOD	+ 0.682	0.89

The high values measured in the personal spot measurements (measurement duration of < 2 hours) are noteworthy. For both fractions, almost half of the values measured lay above the GDLV, with peak values of 134 mg/m³ for inhalable dust and 26.4 mg/m³ for respirable dust. Owing to the diversity of the conditions under which the measured values were obtained, a detailed discussion of the figures is of no benefit. It is clear however that particular attention must be paid to the workplaces associated with vehicles, industrial trucks and transport in the waste management sector.

16 Agriculture, animal feed production

This chapter provides guidance on assessing exposure to the inhalable and respirable dust fractions in animal husbandry. According to the GefStoffV, dusts constitute hazardous substances. However, airborne dusts may also contain biological substances such as mould fungi, bacteria or viruses in accordance with the German Ordinance on Biological Substances (BioStoffV). Biological substances pose a threat to human beings in the form of infections, transmissible diseases, formation of toxins, and sensitizing or other effects harmful to health (BioStoffV). Attention is drawn to the TRBA 230 technical rules on biological substances concerning protective measures for activities involving biological substances in agriculture and forestry and comparable activities.

The GDLV in accordance with the TRGS 900 technical rules concerning occupational exposure limits, which served as the assessment benchmark in the statistical evaluations presented here, does not apply to allergenic dusts or to dusts from which other toxic effects must be anticipated. In accordance with the TRGS 907 technical rules listing sensitizing substances and activities involving sensitizing substances and the TRBA/TRGS 406 technical rules concerning substances with a sensitizing effect upon the respiratory tract, a sensitizing effect upon the respiratory tract must be anticipated from animal matter (hair, bristles, feathers, horn, faeces, urine).

In accordance with TRGS 900, the GDLV applies as a general upper limit for allergenic dusts and for dusts from which other toxic effects may be anticipated. No limit values are currently set for biological substances (TRBA/TRGS 406).

The results of measurements show that the GDLV is exceeded on occasions in poultry, cattle and pig husbandry. The dust measurements carried out and statistically evaluated here thus serve as guidance and indicate that the effectiveness of the protective measures must be reviewed and improved without delay. Additional protective measures must be taken if necessary. These must however be specific to the area of activity and particular activity in the enterprise, and must be selected in consideration of the results of risk assessment.

16.1 Animal feed production

Sector
Animal feed (of non-animal origin), production
Animal feed, production
Animal feed, other (of non-animal origin), production

The production of feed for domestic and farm animals involves the processing of primary ingredients, in some cases in powder form, such as various types of starch, wheat, rice, maize and yeasts, and also a vast number of additives such as mineral mixtures, vitamins, β-Carotene, copper, zinc, selenium and cobalt. The raw materials are delivered by silo vehicles, packed in FIBCs or sacks, transferred in the plant, transported, weighed, metered, mixed, pelletized and filled again into various containers for the customer. Processing is generally carried out in enclosed installations equipped with aspirators, but in some cases also open with the use of hand shovels. The various kinds of dust which are released may have toxic or sensitizing effects.

The measurements were carried out as part of preventive activity in accordance with the German Social Code (SGB) Vol. VII. The scale of the measurements permits only general conclusions regarding the level of exposure.

The development of dust, and exposure to it, that was frequently observed was not necessarily linked to the technical process, but attributable to the following:

- Transfer points, dust deposits on machines, luminaires and ledges
- Large drop heights in loading and other transport operations
- Manual cleaning of machinery and rooms with a broom, without the use of dust binder
- Generation of secondary dust from dust deposits, for example by vehicle traffic in production areas
- Unsuitable work equipment (loaders without a suitable driver's cab)

A lack of suitable dust removal equipment was however often also a factor.

Personal measurements may reveal violations of the limit values for respirable and inhalable dust, for example during manual activities in the area of activity. Higher levels of exposure to inhalable dust observed in static measurements are also evidence of the incidence of dusts in this area of activity. An example is the production of compound feeds for animal husbandry in a drying system. The workers perform various tasks during a shift. In the drying system, employees also monitor the equipment and the quality of the relevant process such as cooling, drying and sorting of the pressed material. The pelletized feed drops unshrouded onto belts and vibrators at various drop points. A person performing an inspection round is exposed to dusts on the open belt conveyor.

In some plants, pellets are bagged manually. A person is located directly at the point at which the product is bagged. Bagging the feed generates abraded material and dust.

Protective measures include processing in enclosed systems wherever possible, and the use of suitable dust removal equipment, such as mobile dust capture hoods, when open products are handled. Generation of dust and exposure to it must be reduced to a minimum by the following measures:

- Regular maintenance of the dust removal systems
- Checking of conveyor systems and transfer points for egress points
- Keeping machines, luminaires and ledges free of dust
- Avoidance of large free drop heights in loading and other transport operations
- Prevention of dust deposits from giving rise to secondary dust, caused for example by vehicle traffic in production areas
- Use of vehicles with a driver's cab that provides protection against dust
- Removal of dust deposits by vacuuming

Where the technical and organizational protective measures are not sufficient, personal protective equipment must be worn.

Figure 40: Loading a mixer: the worker adds various ingredients of the feed, supplied in bags, into the mixer. A vacuuming element is located behind the feed hopper

Table 16.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV# (%) $	> LV# (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	39	n/a	4 (10.3%)	n/a	84.6	15.4	4.55	12.22	16.235
≥ 2 h	Static	47	n/a	6 (12.8	n/a	100	0	1.45	4.271	6.68
< 2 h	Personal	36	n/a	0	n/a	61.1	38.9	7.64	23	25.56
< 2 h	Static	43	n/a	3 (7.0%)	n/a	74.4	25.6	2.885	25.61	32.607
Respirable dust										
≥ 2 h	Personal	13	n/a	3 (23.1%)	n/a	92.3	7.7	0.5	1.051	1.3075
≥ 2 h	Static	13	n/a	2 (15.4%)	n/a	100	0	+ 0.265	0.82	0.883

No OEL is specified for this type of dust. The reason for this is that the GDLV does not apply to allergenic dusts or to dusts from which other toxic effects must be anticipated. For allergenic dusts and for dusts presumed to have other toxic effects, the GDLV serves as a general upper limit.

16.2 Poultry farming: broilers and laying hens

Sector
Poultry farming, laying hens
Broilers

The measurements were carried out as part of preventive activity in accordance with the German Social Code (SGB) Vol. VII. The scale of the measurements permits only general conclusions regarding the level of exposure. Bedding, feed, stored vegetable elements and animals may constitute significant sources of airborne dust. Violations of the limit values for respirable and inhalable dust may be measured on the person, for example during manual activities in the areas of activity of broilers (such as checking of drinking troughs) or laying hens (such as retrieval of eggs).

The dusts released in poultry stalls may differ widely in their type and may include dusts with toxic or sensitizing effects, in addition to infectious biological substances.

Optimized ventilation is very important in poultry farming. Regular maintenance and care of the ventilation system must be carried out based upon inspection and maintenance plans, and documented. The ventilation systems must be inspected by a competent person as required and at least once a year. Records must be kept of the results of the inspections.

Organizational protective measures, including hygiene measures such as regular and thorough observance of the cleaning plan, support the technical protective measures and considerably reduce the levels of dust in the air breathed at workplaces in poultry farming. Performance of the measures must be documented on an ongoing basis. The animals should be handled calmly.

Cleaning methods must be used that involve minimum exposure to dust, such as vacuuming with use of a Class H vacuum cleaner.

Table 16.2

								Concentrations (mg/m^3)		
Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV# (%) $	> LV# (%) $	50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	11	3 **	0	n/a	36.4	63.6	13.92	25.46	25.79
≥ 2 h	Static	38	5	2 (5.3%)	0.71	92.1	7.9	3.93	8.22	10.429
< 2 h	Personal	25	8	0	n/a	32	68	14.375	62.6	69.675
< 2 h	Static	6 ***	5	0	n/a	83.3	16.7	=-Values: 0.47 to 16.1		
Respirable dust										
≥ 2 h	Personal	8 ***	1 **	0	n/a	25	75	=-Values: 0.54 to 2.62		
≥ 2 h	Static	10	2 **	0	n/a	100	0	0.62	0.69	0.75

[#] No OEL is specified for this type of dust. The reason for this is that the GDLV does not apply to allergenic dusts or to dusts from which other toxic effects must be anticipated. For allergenic dusts and for dusts presumed to have other toxic effects, the GDLV serves as a general upper limit.

Thorough hygiene measures must be observed. These include washing and where necessary disinfecting hands before breaks and after completing activities; furthermore, the workplace must be cleaned and work clothing and personal protective equipment cleaned/replaced, both regularly and as and when necessary. The measures must be set out in a cleaning, skin protection and hygiene plan. Contact between the hands and face must be avoided during work in the poultry stalls.

The work areas must be cleaned and, if necessary, disinfected regularly, in accordance with the risk assessment and the specifications of the cleaning and hygiene plan. Protective measures for cleaning and disinfection of work areas and equipment must be laid down in writing in accordance with the risk assessment, and their observance monitored.

For low-dust sweeping, a battery powered, manually guided sweeping machine with dust filter and circumferential sealing lip around the fine dust roller brush is recommended. The dust filters can be washed out.

Activities in free-run indoor poultry husbandry and work involving direct contact with poultry are currently assumed to be associated with high levels of exposure to dust and bioaerosols. Respiratory protection must therefore be worn.

16.3 Pig farming: fattening pigs

Sector
Pig fattening

The discussion below reflects average exposure values. At the same time, the values measured only ever represent a brief snapshot of the exposure. The values are subject to constant fluctuations caused by the climate, premises, season and other conditions (such as ventilation systems, preparatory feeding or final fattening). An unfavourable air flow in the fattening shed for example is evident in the measured values. If, for example, the air in the fattening shed is exhausted from above and fresh air is also supplied from above, the shed will be more heavily contaminated with dust and gases than a sty with underfloor air exhaust, in which the hazardous substances are exhausted before they are released into the air of the shed. Consideration must be given to the time, generally short, spent in the shed each day by personnel, for example during inspection rounds.

The discussion of the measurement results is based on measurements of hazardous substances taken over the past 15 years, in fattening sheds typical of this period but differing in their dimensions, ventilation arrangements and housing systems. The measurements were taken during the normal times of sty access and during performance of the usual tasks. The following conclusions can be drawn with respect to the values for the inhalable dust. The limit value is exceeded conspicuously in one third of the personal measurements; this violation is not observed in the static measurements. This phenomenon can be explained by the fact that the worker distributes straw, for example, by hand, prepares concentrate/dry feed, mixes it and distributes it into the feed troughs. Higher measured values are also a result of fattening pigs being kept in sties with outdoor climate, in which case the animals have more hair. This results in the air in the sty being more heavily contaminated with animal epithelium. Furthermore, straw or other products such as spelt husks are often spread in these sties in the areas in which the animals lie.

In sties in which the fattening pigs are kept on slatted floors (liquid manure) and with good sty hygiene, lower values are measured for the respirable dust. As soon as bedding or dry feed is used, the measured values rise. The values measured for respirable dust are, like those for inhalable dust, higher in sties with outdoor climate.

Table 16.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV[#] (%) $	> LV[#] (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	6 ***	6	0	n/a	66.7	33.3	=-Values: 2.43 to 22		
≥ 2 h	Static	110	56	0	n/a	97.3	2.7	3.34	6.08	8.64
< 2 h	Personal	58	51	3 (5.2%)	3.33	77.6	22.4	5.74	16.14	17.15
< 2 h	Static	6 ***	5	0	n/a	66.7	33.3	=-Values: 0.7 to 43.2		
Respirable dust										
≥ 2 h	Static	114	56	45 (39.5%)	0.25	98.2	1.8	0.29	0.598	0.686
< 2 h	Personal	57	50	46 (80.7%)	3.33	75.4	3.5	! LOD	+ 0.979	+ 1.665

[#] No OEL is specified for this type of dust. The reason for this is that the GDLV does not apply to allergenic dusts or to dusts from which other toxic effects must be anticipated. For allergenic dusts and for dusts presumed to have other toxic effects, the GDLV serves as a general upper limit.

16.4 Pig farming: breeding sows

Sector
Pig farming, breeding sows

16.4.1 Farrowing stall

Table 16.4.1

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV# (%) $	> LV# (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Static	20	2 **	2 (10%)	0.71	100	0	1.51	2.62	2.69
< 2 h	Personal	10	1 **	0	n/a	100	0	2.87	3.52	3.555
Respirable dust										
≥ 2 h	Static	20	2 **	12 (60%)	1.25	100	0	! LOD	+ 0.44	+ 0.625
< 2 h	Personal	10	1 **	6 (60%)	0.5	100	0	! LOD	+ 0.38	+ 0.39

No OEL is specified for this type of dust. The reason for this is that the GDLV does not apply to allergenic dusts or to dusts from which other toxic effects must be anticipated. For allergenic dusts and for dusts presumed to have other toxic effects, the GDLV serves as a general upper limit.

16.4.2 Warm and outdoor climate sties

Table 16.4.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV[#] (%) $	> LV[#] (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	6 ***	5	0	n/a	83.3	16.7	=-Values: 2.83 to 25.2		
≥ 2 h	Static	54	28	4 (7.4%)	0.71	96.3	3.7	2.34	5.034	6.963
< 2 h	Personal	26	21	1 (3.8%)	1.71	84.6	15.4	4.77	10.88	13.784
< 2 h	Static	22	4 **	13 (59.1%)	5.04	100	0	! LOD	+ 2.445	+ 4.059
Respirable dust										
≥ 2 h	Static	50	28	29 (58%)	1.25	96	4	! LOD	+ 0.76	+ 0.975
< 2 h	Personal	23	20	17 (73.9%)	1	91.3	8.7	! LOD	1.101	1.314

[#] No OEL is specified for this type of dust. The reason for this is that the GDLV does not apply to allergenic dusts or to dusts from which other toxic effects must be anticipated. For allergenic dusts and for dusts presumed to have other toxic effects, the GDLV serves as a general upper limit.

16.5 Cattle farming: beef cattle and dairy cattle

Sector
Dairy farming, cattle
Beef cattle husbandry
Insemination station, cattle

The measurements were carried out as part of preventive activity in accordance with the German Social Code (SGB) Vol. VII. The scale of the measurements permits only general conclusions regarding the level of exposure. Bedding, feed, stored vegetable elements and animals may constitute significant sources of airborne dust. Violations of the limit values for respirable and inhalable dust measured on the person may occur for example during manual tasks in the areas of activity of cattle fattening and dairy cattle, such as offering of the feed with a fork in beef cattle husbandry or cleaning the cubicles of dairy cattle.

The dusts released in cowsheds may be very diverse in type and may include dusts with toxic or sensitizing effects as well as biological substances with infectious effects. In cowsheds without natural ventilation, optimization of the ventilation is very important. Natural ventilation is preferable for both cattle and human beings. Most cowsheds have natural ventilation (loose housing). Many cowsheds are also equipped with fans that support natural ventilation in the summer. All doors are normally open in the summer.

Organizational protective measures, including hygiene measures such as regular and thorough observance of the cleaning plan, support the technical protective measures and bring about a significant reduction in the incidence of dust in the air breathed at workplaces in cattle husbandry. Performance of the measures must be documented on an ongoing basis. The animals should be handled calmly. Cleaning work must be carried out in such a way that exposure to dust is minimized. Dust deposits should be removed regularly by vacuuming. Attention must be paid to the quality of the feed.

Thorough hygiene measures must be observed. These include washing and where necessary disinfecting hands before breaks and after completing activities; furthermore, the workplace must be cleaned and work clothing and personal protective equipment cleaned/replaced both regularly and as and when necessary.

The work areas must be cleaned and, if necessary, disinfected regularly, in accordance with the risk assessment and the specifications of the cleaning and hygiene plan. Protective measures for cleaning and, where necessary, disinfection of work areas and equipment must be laid down in writing in accordance with the risk assessment, and their observance monitored.

Table 16.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV# (%) $	> LV# (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	7 ***	4 **	0	n/a	42.9	57.1	=-Values: 0.64 to 11.5		
≥ 2 h	Static	56	27	24 (42.9%)	0.71	100	0	+ 0.6	1.854	3.004
< 2 h	Personal	26	17	2 (7.7%)	1.43	69.2	30.8	4.62	23.54	38.16
Respirable dust										
≥ 2 h	Static	48	25	45 (93.8%)	1.25	100	0	! LOD	! LOD	+ 0.625
< 2 h	Personal	16	13	12 (75%)	1	100	0	! LOD	+ 0.656	+ 0.772

No OEL is specified for this type of dust. The reason for this is that the GDLV does not apply to allergenic dusts or to dusts from which other toxic effects must be anticipated. For allergenic dusts and for dusts presumed to have other toxic effects, the GDLV serves as a general upper limit.

17 Food industry

This chapter provides guidance on assessing exposure to the inhalable and respirable dust fractions in the food industry. The summary provided below lists only dusts which are not classified. Grain flour dusts in mills and bakeries are excluded. The sectors of coffee roasting and mustard and spice production are also excluded, as their dusts lie within the scope of TRGS 406.

Specific dusts are caused in the food industry by abrasion from the products used, and even more so by the use of a large number of powdered ingredients. These ingredients are typically cereal flours, which are potentially sensitizing, or ground spices with irritant properties, which however lie outside the scope of the GDLV. In addition, a large number of other powdered foods or food ingredients are processed in special processes. Owing to the requirements concerning convenience foods, many types of food are now also available in granular or powder form; examples are butter powder and wine powder.

During the processing of these powders, dusts may be released into the work areas during transfer processes, weighing out (in some cases manual), grinding, mixing and packing. As a rule, the particle size range of the powders is such that the respirable fraction is of secondary importance. However, silicon dioxide is also used as a flow aid and release agent and titanium dioxide as a colouring, with particle size spectra extending into the nanoscale range of < 100 nm.

Dust measurements are generally taken on an ad hoc basis, usually at the instigation of the labour inspectors. Points of measurement are work areas at which the workers are subject to high dust exposures. In some cases, measurements are also carried out following implementation of measures, for assessment of their efficacy.

The values presented below should not therefore be regarded as representative exposures of workers in the food industry. Peak values may occur during the manual transfer of powdered stock or during the cleaning of equipment. The measured values shown are in many cases not mean shift-based values, but measured values of exposures occurring over only a limited part of the shift.

17.1 Production of processed foods and pasta

Sector
Pasta, production
Baking
Processed foodstuffs, production

This sector encompasses numerous different forms of processing of foods and food ingredients, often in powder form, such as baking agents and coffee substitutes, and also powdered base materials for the food and pharmaceutical industries, such as vitamins, minerals, trace elements and other functional ingredients. The processes and areas of activity are broadly similar to those in the animal feed industry, the difference being that much stricter criteria are placed on the products in this case. This extends to underlying conditions of production, which may even resemble those for the pharmaceutical sector. In some cases, substances classified as hazardous are also processed, such as vitamin A, vitamin D3, iron, copper and selenium.

Raw materials in dust form are also used in pasta production. Besides the main ingredient, ground cereals (such as semolina made from durum wheat) and other powdered ingredients are used. These include egg powder and egg white powder, and for more exotic products also beetroot, tomato or red wine powders.

Table 17.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	31	n/a	1 (3.2%)	n/a	71.0	29.0	4.1	22.12	26.52
≥ 2 h	Static	22	n/a	1 (4.5%)	n/a	100.0	0	1.4	3.126	4.91
< 2 h	Personal	10	n/a	0	n/a	60.0	40.0	6.32	15.8	17
< 2 h	Static	12	n/a	1 (8.3%)	n/a	83.3	16.7	1.9	11.782	15.52
Respirable dust										
≥ 2 h	No differentiation	19	n/a	12 (63.2%)	n/a	100.0	0	! LOD	+ 0.625	+ 0.6258
< 2 h	No differentiation	8***	n/a	5 (62.5%)	n/a	50.0	25.0	=-Values: 1.2 to 10.9		

17.2 Production of essences

Sector
Food, beverages and tobacco, production
Mustard and spices, production

The production of essences encompasses the production of flavours for the food industry and also for trade food producers such as bakers, confectioners and ice cream producers. Both the raw materials and the products themselves may take the form of powders. Dust may be released into the work area during the processes of transfer, weighing, mixing, portioning and packaging. The powders used may have effects on the organism even in small quantities, as is the case with the stimulants of caffeine powder and taurine.

Table 17.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	18	n/a	0	n/a	55.6	44.4	8.6	32.844	35.61
≥ 2 h	Static	20	n/a	0	n/a	65.0	35.0	2.15	19.8	19.8
< 2 h	No differentiation	12	n/a	1 (8.3%)	n/a	58.3	41.7	4.48	35.44	47.32
Respirable dust										
≥ 2 h	Personal	12	n/a	2 (16.7%)	n/a	100.0	0	0.32	0.688	0.844
≥ 2 h	Static	18	n/a	2 (11.1%)	n/a	77.8	22.2	0.41	2.212	2.38
< 2 h	No differentiation	11	n/a	6 (54.5%)	n/a	63.6	36.4	LOD	4.429	5.9915

Figure 41: Weighing out of raw materials in powder form: various raw materials in powder form are weighed out on a scale with dust exhaust (not shown in the image) and then manually fed into the mixer. An exhaust hose is located to the right of the mixer; the lid of the mixer is also exhausted. A further exhaust facility is located at the outlet (bottom left).

17.3 Fish-processing industry and gourmet food production

Sector
Fish industry

In the fish industry and gourmet food production, dusts originate mainly from breadcrumbs applied by machine. The excess breadcrumbs that do not adhere to the product are blown off again with compressed air in a final step. This is intended to prevent carry-over into subsequent processing steps, such as a breading line. Despite encapsulation and exhaust of the machinery, breadcrumb dust is dispersed into the work area. Further powdered ingredients such as spices are also used, the handling of which leads to dust emissions in the work area during transfer, weighing and metering processes. The respirable dust components are low, however.

Table 17.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	No differentiation	34	n/a	0	n/a	41.2	58.8	11	25.9	31.44
< 2 h	No differentiation	8***	n/a	0	n/a	12.5	87.5	=-Values: 0.6 to 112.7		
Respirable dust										
No differentiation	No differentiation	11	n/a	2 (18.2%)	n/a	92.3	7.7	0.5	1.051	1.3075

Figure 42: Breading of vegetable burgers: the product is first pressed into slices, after which it undergoes wet and dry breading. Dry breading not adhering to the product is blown off. This results in dry breading escaping from the machine into the surrounding work areas, despite the exhaust equipment and partial encapsulation. The same process is also used to bread fish, such as fishcakes or fish fingers, and in meat processing, for example for breading cutlets for the convenience foods sector.

17.4 Grist mills

Sector
Oil mills

The respirable fraction is of lesser importance in grist mills; the dusts arising in this case are largely confined to the inhalable fraction. Their measured values may be particularly high on tipping chutes into which large quantities of product are transferred in various ways. These include chutes for the unloading of trucks or manual emptying of bags. Mixtures containing additives are also produced, some of which are labelled as irritant or sensitizing substances. Personal protective equipment must then be worn during the processing of these mixtures.

High values were also measured during the unloading of shipping vessels when workers are required to enter the hold in order to gather product residues together for unloading. The dust exposure is lower during processing of the product in the mills themselves, as in this case work is carried out on installations equipped with aspirators.

Table 17.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	No differentiation	19	n/a	1 (5.3%)	n/a	78.9	21.1	3.82	11.22	13.33
< 2 h	No differentiation	9***	n/a	2 (22.2%)	n/a	66.7	33.3	=-Values: 0.91 to 49.84		
Respirable dust										
No differentiation	No differentiation	9***	n/a	6 (66.7%)	n/a	77.8	0	=-Values: 0.04 to 0.71		

17.5 Cigar and cigarette production

Sector
Tobacco processing

Tobacco dusts are the dominant form of dust in cigar and cigarette production. These dusts are material abraded from the dried tobacco leaves. This material is released throughout the manufacturing process, beginning with removal of the pressed tobacco leaves from the delivery cartons. Dust is also released when tobacco leaves are cut to the sizes needed for cigarette production, and as a result of mechanical abrasion during the transport and transfer processes on conveyor belts. As much of the dust as possible is collected, recovered and processed with the addition of liquid to make reconstituted tobacco leaves (sheet). The sheet is manufactured as a continuous product and must therefore be cut, which once again releases dust.

The release of dust into the work areas is prevented as far as possible by self-contained systems with aspiration equipment, and also by wetting of the product, where permitted by the production process. However, the primary purpose of wetting is to apply flavours. Not least owing to the high price of the raw material, the abraded material is collected and recovered as far as possible, ground if necessary and processed into sheets which can then be used in production.

Table 17.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	13	n/a	4 (30.8%)	n/a	76.9	23.1	+ 1.2	28.07	41.98
≥ 2 h	Static	20	n/a	1 (5.0%)	n/a	100.0	0	0.7	5	6.6
< 2 h	Personal	18	n/a	4 (22.2%)	n/a	83.3	16.7	5.2	15.48	29.3
< 2 h	Static	31	n/a	1 (3.2%)	n/a	93.5	6.5	+ 1.5	6.29	10.26
Respirable dust										
No differentiation	No differentiation	15	n/a	12 (80.0%)	n/a	100	0	! LOD	+ 0.365	0.4725

Figure 43: Unpacking of Oriental tobacco from jute wrapping during dust measurements in 2008: at that time, the tobacco bales were cut open and the content recovered by an industrial robot. A worker also removed final residues manually from the jute wrapping. The job no longer exists in this form (see Figure 44).

Figure 44: Unpacking of Oriental tobacco in 2018: the tobacco is now delivered in a box and the worker merely releases the plastic strapping on the box, whilst it is still closed. The robot opens the box five metres away from the employee, and allows the content to slide gently onto the conveyor belt from a low drop height. The worker is now exposed to hardly any dust.

17.6 Chocolate and confectionery production

Sector
Sugar, raw and consumable, production

A large proportion of the powders used in chocolate and confectionery production which are able to enter workers' breathing zones in dust form are water-soluble and unclassified. Examples are various types of sugar or milk powder. Spices, and baking agents with a wide variety of ingredients, both of which may present a hazard, also occur in smaller quantities however. Starch and cocoa powder are also used in larger quantities. Almost all of these substances lie within the inhalable dust fraction; respirable dusts occur only in spices. The main components are usually conveyed and processed in enclosed systems. Only the trace components are loaded manually into relevant silos and in some cases weighed, processed and added to the production process manually. Production facilities are increasingly automated, in which case dust exposure occurs only during cleaning and maintenance of the systems.

Table 17.6

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	34	n/a	5 (14.7%)	n/a	76.5	23.5	3.5	14.3	16.58
≥ 2 h	Static	33	n/a	3 (9.1%)	n/a	84.8	15.2	+ 1.3	15.9	28.135
< 2 h	Personal	7***	n/a	0	n/a	71.4	28.6	=-Values: 1.7 to 88.2		
< 2 h	Static	18	n/a	1 (5.6%)	n/a	33.3	66.7	14.9	41.862	50.479
Respirable dust										
No differentiation	No differentiation	9	n/a	3 (33.3%)	n/a	77.8	22.2	=-Values: 0.1 to 1.6		

17.7 Soup, pudding, blancmange and starch production

Soup, pudding and starch manufacturing are industries in which powdered ingredients and products are generally used. The quantities processed range from a few grammes, as in the case of spices, to the order of tons, for example starch. Dust is released at delivery of raw materials, for example potatoes for starch production, in tipping chutes, during transport, transfer and mixing processes, during manual weighing out of trace components, and on bagging machines or packing machines for small unit packaging. Respirable dusts are less of a factor.

Measures taken to prevent dusts being released into work areas are the dust-tight design of the machines where this is technically possible, enclosed silo and metering systems, including for trace components, dust exhaust systems, and air purifiers in the premises. Personal protective equipment is worn during activities associated with high dust levels or classified products such as irritant spices.

Figure 45: Manual input, e.g. of garlic and onion granulate supplied in bagged form, into a metering vessel during soup production. To prevent the entry of foreign bodies, the metering vessels are covered with mesh. As a result, the drop heights during input are high, leading to significant dust emissions.

Table 17.7

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	30	n/a	5 (16.7%)	n/a	56.7	43.3	6	26.9	52.3
≥ 2 h	Static	35	n/a	3 (8.6%)	n/a	80.0	20.0	+ 2.25	13.7	16.625
< 2 h	Personal	6***	n/a	1 (16.7%)	n/a	66.7	33.3	=-Values: 3.48 to 27		
< 2 h	Static	22	n/a	3 (13.6%)	n/a	86.4	13.6	+ 1.23	13.876	23.507
Respirable dust (only static measurements on respirable dust)										
No differentiation	No differentiation	15	n/a	11 (73.3%)	n/a	100	0	! LOD	+ 0.2225	+ 0.2425

17.8 Preserved foods, production

Dust emissions arise in the preparation of preserved foods mainly in relation to the preparation and addition of spices. The entire spectrum of powdered foodstuffs and food ingredients, from cereal flours and starches to preservatives, is also used. Other sources of dust include material abraded from products such as freeze-dried fruits and vegetable granulate. Typical points of emission are the product input point and the packing of finished products, which in some cases is still performed manually.

Respirable dusts are less of a factor.

Figure 46: Semi-automatic filling of dry products such as soups, sauces, stock or seasoning for bulk consumers into tubs on a packaging line. Raised dust is exhausted in some cases through an exhaust funnel (to the right above the tub). The worker places the tubs in position, checks that they are filled correctly and closes the lid manually.

Table 17.8

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	21	n/a	0	n/a	76.2	23.8	5	17.92	22.09
≥ 2 h	Static	25	n/a	1 (4.0%)	n/a	92.0	8.0	0.95	4.765	14.733
< 2 h	Personal	11	n/a	3 (27.3%)	n/a	36.4	63.6	19.7	53.193	59.659
< 2 h	Static	20	n/a	2 (10.0%)	n/a	65.0	35.0	6.7	12.17	23.53
Respirable dust										
No differentiation	No differentiation	23	n/a	11 (47.8%)	n/a	100	0	+ 0.2	+ 0.57	0.94

17.9 Dairies and cheeseries

Only inhalable dusts were detected in dairies and cheeseries. These dusts are milk powders, ingredients such as corn starch (serving as a release agent for grated cheese), sugar, cocoa, starch and gelatine powders for milk products, and other powdered ingredients such as flavourings.

Violations of the limit values can be observed mainly during individual sampling during direct handling of the products in powder form. These tasks often take the form of manual filling and transfer and the clearing of faults on automatic filling systems, which also involves cleaning operations.

Table 17.9

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	9***	n/a	0	n/a	44.4	55.6	=-Values: 0.7 to 31.6		
≥ 2 h	Static	21	n/a	6 (28.6%)	n/a	95.2	4.8	+ 0.9	4.05	7.045

17.10 Beverages industry (mineral springs, soft drink production, fruit wineries, malthouses, breweries)

The measurements of the inhalable fraction are largely associated with the malthouses. Violations of dust limit values for the brewing cereals may occasionally occur during cleaning work.

In the beverages industry, measured values of the respirable dust fraction are often obtained as a secondary outcome of diesel engine emissions measurements. These respirable dust values from areas in which vehicle traffic occurs are however generally very low, considerably below the limit value. Higher values for respirable dust may occur in filtration processes during the metering of filter aids. Substances containing quartz are also used in this process. The measured values for quartz and cristobalite can be found in the Quartz Report.

Figure 47: Filling a lined 20-foot container with brewer's malt in the partially encapsulated outdoor area. The product's drop height of up to several metres releases considerable quantities of dust. During filling, the entire truck and the container mounted on it is tilted on a platform by approximately 40°. One worker is present here intermittently to check correct filling and to take product samples for quality assurance.

17.10.1 Filtration in breweries and during beverage production

Table 17.10.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Respirable dust										
≥ 2 h	Personal	32	30	6 (19.0%)	0.40	97.0	3.0	0.36	0.90	1.06
≥ 2 h	Static	34	30	1 (3.0%)	0.05	94.0	6.0	0.24	1.10	1.26

18 Wholesale, retail, warehousing

No distinction was made in Chapter 18 with respect to the presence of dust collection equipment.

Figure 48: Warehouse in the wholesale trade

18.1 Warehousing, bottling and packaging industry

Sector
Warehousing
Bottling and packing trade

Measurements in this sector were performed largely in storage areas in which activities directly causing dust emissions did not occur. Measurements were performed in both manually operated and automated warehouses. Placing in storage, retrieval and order picking generally also involves the use of industrial trucks. However, the workplaces and packing equipment may frequently be located within or in the vicinity of areas in which dust is emitted and from which it may be carried over. Elevated exposure to inhalable and respirable dust can be avoided by regular cleaning of storage and handling areas.

Table 18.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	28	18	16 (57.1%)	0.71	100	0	! LOD	5.408	6.268
≥ 2 h	Static	57	35	24 (42.1%)	0.71	100	0	+ 0.193	1.027	1.627
< 2 h	Static	21	9	5 (23.8%)	0.95	100	0	+ 0.273	3.003	3.39
Respirable dust										
≥ 2 h	Personal	34	25	26 (76.5%)	0.25	100	0	! LOD	+ 0.212	0.472
≥ 2 h	Static	87	55	53 (60.9%)	0.25	100	0	! LOD	0.252	0.317
< 2 h	Static	13	9	10 (76.9%)	0.5	92.3	7.7	! LOD	0.921	1.488

18.2 Wholesale trade in iron, steel and non-ferrous metals, steel and non-ferrous metal semi-finished products

Sector
Wholesale trade in iron, steel and non-ferrous metals, steel and non-ferrous metal semi-finished products

Many different products such as steel profiled sections, tubes, rods, sheets and coils are handled in the steel trade. Basic working of these products is also performed, such as sawing of the material to the length required by the customer. Other processes are also performed however, such as surface treatment by blasting, and cutting to size and burning off by oxy-acetylene torch, plasma gas or laser beam. These processes may also generate dust. The dusts arising are generally collected effectively in the plants.

Cranes and industrial trucks are generally used in the steel trade for internal transport and for loading and unloading road trucks or railway wagons.

Elevated exposure to inhalable and respirable dust can be avoided by regular cleaning of storage and handling areas.

Table 18.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	47	31	17 (36.2%)	0.71	93.6	6.4	+ 0.585	6.807	9.241
≥ 2 h	Static	17	13	5 (29.4%)	0.71	100	0	+ 0.328	1.479	1.806
Respirable dust										
≥ 2 h	Personal	41	30	23 (56.1%)	1.25	95.1	4.9	! LOD	+ 0.792	+ 1.243
≥ 2 h	Static	38	25	24 (63.2%)	1.25	100	0	! LOD	+ 0.3	+ 0.407
< 2 h	Personal	5 ***	4 **	1 (20%)	0.29	60	40	=-Values: 0.64 to 2.63		

18.3 Wholesale and retail trade in food, agricultural products

Sector
Wholesale trade in cereals, seeds, animal feed, fertilizers, mill products, potatoes, hops
Wholesale trade in fruit, vegetables, flowers and plants
Wholesale trade in coffee, tea, cocoa, tobacco, drugs, spices, flavours, essences
Wholesale trade in foodstuffs, other
Wholesale trade in wine, beer, spirits, non-alcoholic beverages
Retail trade in pet shop goods, live animals, seeds, fertilizers

18.3.1 Filling, mixing, grinding, weighing, packing

In the wholesale trade in foodstuffs and agricultural produce, goods as diverse as lettuce, carrots, apples and citrus fruits are handled, as are packaged goods such as pasta and preserved foods. However, dust exposure generally occurs only where dry agricultural produce is traded on a wholesale scale. Examples of such produce are potatoes, cereals and onions. Extensive measurements relating to this section were taken in the area of activity of grain stores. Elevated exposure to dust may occur during bagging; this is however now rare. The use of modern technology has significantly reduced exposure.

Elevated exposure to dust also occurs during the sorting and packing of onions and unwashed potatoes. With the rising use of automated sorting systems and the decreasing proportion of unwashed potatoes, exposures are also decreasing here.

Table 18.3.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	43	23	3 (7%)	0.71	62.8	37.2	6.365	42.04	51.985
≥ 2 h	Static	48	28	6 (12.5%)	0.71	85.4	14.6	1.93	13.52	19.32
Respirable dust										
≥ 2 h	Personal	44	25	10 (22.7%)	0.42	70.5	29.5	+ 0.36	2.582	3.69
≥ 2 h	Static	33	20	11 (33.3%)	0.25	87.9	12.1	+ 0.19	1.283	2.316
< 2 h	Static	9 ***	5	4 (44.4%)	0.79	88.9	11.1	=-Values: 0.23 to 4.48		

18.3.2 Warehousing and storage/handling activity

In warehousing and handling activity, exposure to dust occurs wherever dry produce such as grain or potatoes is handled open or transported within a business. This includes, above all, the tipping of grain, potatoes or onions into the tipping chute, and the placing of grain in storage by means of a grain thrower or in open boxes in flat-bottomed stores. The use of modern technology has significantly reduced the time spent by workers in areas associated with dust exposure. The tipping process for example can be monitored from within the enclosed control room.

Transshipment operations on shipping vessels may also give rise to high levels of dust exposure. Here, technical protective measures such as Bobcats with enclosed and ventilated cabins should be used.

Table 18.3.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	44	24	5 (11.4%)	0.71	84.1	15.9	3.62	12.82	17.76
≥ 2 h	Static	25	17	7 (28%)	0.71	88	12	+ 0.305	7.615	14.55
< 2 h	Personal	12	8	0	n/a	50	50	9.78	109.46	438.2
< 2 h	Static	17	6	0	n/a	88.2	11.8	1.765	6.555	17.13
Respirable dust										
≥ 2 h	Personal	43	23	16 (37.2%)	1.25	90.7	9.3	+ 0.355	+ 0.957	1.482
≥ 2 h	Static	27	21	8 (29.6%)	0.25	85.2	14.8	+ 0.145	1.475	3.699
< 2 h	Personal	12	8	4 (33.3%)	1.9	75	16.7	+ 0.57	+ 1.284	108.38
< 2 h	Static	12	7	3 (25%)	0.51	83.3	16.7	+ 0.27	2.984	3.892

18.3.3 Sorting, manual

Sorting activities involving exposure to dust primarily concern unwashed potatoes and onions. Wide fluctuations in the dust exposure levels are observed, due in part to the prevailing weather conditions during the harvest. Soil adheres to both potatoes and onions when they are harvested under damp to wet conditions. When these vegetables have dried, this soil may lead to high dust exposure during sorting. The ventilation of the workplaces must also be geared to such conditions.

Table 18.3.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	18	8	2 (11.1%)	0.1	61.1	38.9	9.49	24.1	45.21
< 2 h	Static	24	4 **	3 (12.5%)	0.5	95.8	4.2	3.85	8.172	8.476
Respirable dust										
≥ 2 h	Static	13	7	5 (38.5%)	0.17	61.5	38.5	0.77	3.196	6.399

18.4 Wholesale and retail trade in a range of building materials

Sector
Wholesale trade in building materials
Wholesale trade in wood, wooden construction elements, semi-finished wood products, flat glass
Retail trade in building and do-it-yourself supplies

DIY stores are usually very large-scale retail operations. They can be divided broadly into two areas: sales (customer area), possibly with a drive-in area, and the warehouse with a goods inwards area. The stores have various departments, for example for building elements, building materials, wood, paints, wallpaper and carpets, plumbing and heating, tools and machinery, ironmongery, gardening, and electrical installation supplies and lamps. Owing to the product diversity, workers are exposed here to a greater number of hazards than in many other retail companies with direct customer contact.

In the building materials trade, the building materials are stored temporarily following delivery on pallets, either individually or in bulk form, and delivered to/collected by construction companies or private customers. Workers in the building materials trade make up orders comprising a wide variety of building materials for delivery or collection. Entire pallets of these goods are transported by fork-lift truck. The goods are also picked and lifted, carried or handled by hand.

Dust may be generated in DIY and home improvement stores, for example in the form of wood dust when wood is sawn to size, during the bagging of products such as sand, or as a result of leaks from bags and containers.

Effective collection of the dust must be ensured during the sawing or bagging of products. Exposure, possibly considerable, to inhalable or respirable dust may otherwise arise. Overall, exposure to inhalable and respirable dust can be avoided effectively by regular cleaning of the affected work areas. Industrial vacuum cleaners (dust class H) or wet methods should preferably be used for cleaning. The use of compressed air to clean floors is not permitted.

Table 18.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	25	19	3 (12%)	0.71	88	12	1.63	11.155	45.1
< 2 h	Static	24	15	6 (25%)	0.71	100	0	[+] 0.355	4.124	5.256
< 2 h	Personal	9 ***	5	0	n/a	77.8	22.2	=-Values: 1.48 to 94.9		
Respirable dust										
≥ 2 h	Personal	36	27	8 (22.2%)	0.63	77.8	22.2	[+] 0.49	1.836	2.754
< 2 h	Static	40	30	15 (37.5%)	1.25	100	0	[+] 0.18	[+] 0.625	[+] 0.71
< 2 h	Personal	10	6	0	n/a	50	50	0.96	4.63	15.865
< 2 h	Static	13	5	3 (23.1%)	0.36	61.5	38.5	1.02	2.774	3.948

18.5 Wholesale trade in end-of-life materials, residual materials and scrap

Sector
Scrap wholesale trade, shredding plants
Wholesale trade in end-of-life and residual materials (excluding scrap)

The scrap trade covers a range of different workplaces, work equipment and activities. Extensive information on the scrap trade can be found in the sectoral rule governing the trade [29].

Scrap is delivered either unsorted or already sorted. Where only very small quantities are delivered, they may be sorted (possibly manually) immediately upon delivery. Sorting otherwise takes place in one or more downstream processes. Manual sorting takes place outdoors, in sheds or on conveyor systems. The scrap may be fully sorted manually, or only the impurities removed from a fraction.

Scrap is stored outdoors or in buildings. The storage methods used depend on the material and state of processing. Scrap may for example be stored in bulk in a range of bay systems, or packaged for block storage, with or without stacking equipment.

A wide variety of methods and equipment are used for the processing of scrap. Drop balls for example may be used in scrap metal businesses to break cast metal scrap into small pieces. Large pieces of scrap that are not of cast material can be processed effectively only in a blasting pit, a buried monolithic structure of reinforced concrete, into which the scrap items to be broken down (rolling rolls, pig iron skull) are placed by crane. Blast holes are first lanced in the scrap items by means of torches. The holes are then filled with explosives and fuse, and the blasting pit closed by a mobile cover. Simple and robust crushers are also used for pre-crushing. The material is crushed by compressive stress between two crushing jaws, one fixed and the other moving.

Flame cutting is a time-consuming process and is used mainly where larger pieces of scrap cannot be broken up by other methods. This method is used to break up larger structural items which are either delivered to the scrapyard, or broken up directly on site in the course of demolition work. Oxygen and fuel gases for flame cutting, such as acetylene or propane, are supplied in mobile cylinder systems, or in less frequent cases from a stationary gas supply. The pressure of the gas is reduced and the gas supplied to the cutting torch through hoses.

During scrap processing, hydraulic presses are used to compact scrap, normally sorted by type, to reduce its volume. The scrap is pressed into compact bales that take up little space and are easy to stack and transport. In addition to stationary baling presses for large quantities of scrap, which are charged by a loader, manually charged mobile baling presses and special presses for the scrapping of car bodies are also used.

Hammer mills and crushers are able to grind different materials to different degrees of comminution. Hammer crushers for example form the heart of a shredder. In the recycling industry, the focus lies primarily on breaking up mixtures of materials, and also on comminution. Material mixtures are produced as a preliminary step for subsequent further comminution or separation by type. By contrast, cutting mills are used for pre-comminution or fine comminution and homogenization of medium-hard to soft and elastic materials. During scrap treatment, shredders are used for the comminution of primarily light to medium-weight mixed and collected scrap and for the processing of material composites.

Hydraulic guillotine shears are used to reduce light to medium-weight, bulky and long scrap to chargeable dimensions. The shear bed is filled by means of handling plant, such as an excavator. The material is then compacted by the press lid and the side compactor. The resulting scrap log is transported to the cutting equipment by a feeding mechanism. The cutting equipment holds the log down and compresses it again before it is cut by the knife, which is also guided in the yoke. Manually fed shears are also used to prepare ferrous and non-ferrous scrap for further processing. Owing to their design and mode of action, they are termed alligator shears.

Processes for separating scrap can be divided into the groups of sizing (separation by particle size) and sorting (separation by material type). Separation processes include dry and wet processes, comminution, vibrating and screening equipment, magnetic processes and sensor technology. The diversity of the separation equipment reflects the range of processes.

Dust may be generated during almost all processes in the scrap trade. Dust generation, in some cases considerable, must be expected for example during the emptying of containers or the various crushing and separation processes. Water mist or other agents may be used to bind the dust, depending upon the process. Particular attention should be paid to the removal of dust deposits. Sweeping is not permissible, as it raises the dust. These dust deposits must be vacuumed by means of a suitable vacuum cleaner, not least to prevent dust explosions.

Flame cutting also generates dust, as well as fumes and gases. The composition of the fumes depends on the base material and any coating or contamination that may be present; consideration must therefore be given during flame cutting to further possible hazardous substances, besides the dust exposure. During cutting of alloy steels with a nickel or chromium content of over 5% by weight and steels with a high cobalt content, dusts are produced that may cause cancer. Health hazards also arise during flame cutting of galvanized or leaded scrap parts and of parts coated with red lead (lead oxide). The GDLV may be exceeded even during flame cutting of unalloyed scrap, however. The particles contained in the fumes are primarily in the respirable fraction. Suitable personal protective equipment is therefore generally required during flame cutting work. Preference should be given to respiratory protection in the form of fan-assisted filtering devices (Airstream helmets).

Table 18.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	43	26	2 (4.7%)	0.71	93	7	1.975	7.43	11.05
≥ 2 h	Static	52	29	9 (17.3%)	0.71	100	0	1.06	5.102	6.502
< 2 h	Personal	8 ***	3 **	1 (12.5%)	0.82	75	25	=-Values: 2.96 to 16.1		
< 2 h	Static	15	5	1 (6.7%)	0.13	93.3	6.7	1.65	5.19	7.197
Respirable dust										
≥ 2 h	Personal	35	23	16 (45.7%)	1.25	88.6	11.4	+ 0.33	1.445	3.188
≥ 2 h	Static	33	28	12 (36.4%)	0.25	93.9	6.1	+ 0.155	0.733	1.107
< 2 h	Static	12	6	8 (66.7%)	0.36	83.3	16.7	! LOD	1.76	11.922

18.6 Wholesale trade in chemical products

Sector
Wholesale trade in chemicals
Wholesale trade in paints, adhesives and coatings
Wholesale trade in plastic granulates and semi-finished products
Wholesale trade in pharmaceutical and cosmetic products and medical supplies
Wholesale trade in detergent, cleaning and care products

18.6.1 Production and bottling/packaging of mixtures

Chemicals and hazardous substances are present in all areas of the economy and everyday life. Trade – in this case, the chemicals trade – has the function of ensuring that these substances are available wherever their use, processing or consumption is intended. Chemicals are packed, stored and transported as solids (granulates, pellets, powders, etc.), pastes, liquids and gases.

Besides hazards of a general nature, workers are subject to particular exposures and hazards during activities involving the chemicals, as a function of their toxic, physical and chemical properties. The specific properties of the chemicals concerned must therefore always be taken into account when dusts arise in affected areas of activity.

Dusts may arise in particular during the production and packing of solids in powder, granulate or pellet form. For these activities, which are carried out both manually and automatically/semi-automatically, care must be taken to ensure effective collection of any dust that may be generated, and regular cleaning of the relevant work areas.

Table 18.6.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	41	16	9 (22%)	0.71	80.5	19.5	2.01	18.47	26.78
≥ 2 h	Static	14	11	4 (28.6%)	0.71	100	0	+ 0.355	1.946	2.124
< 2 h	Personal	7 ***	7	2 (28.6%)	0.95	57.1	42.9	=-Values: 1.41 to 71.1		
Respirable dust										
≥ 2 h	Personal	37	15	12 (32.4%)	0.25	75.7	24.3	0.63	1.63	2.292
≥ 2 h	Static	19	11	7 (36.8%)	1.25	84.2	15.8	+ 0.155	1.457	2.247
< 2 h	Personal	7 ***	6	5 (71.4%)	0.5	85.7	14.3	=-Values: 0.59 to 6.84		
< 2 h	Static	8 ***	4 **	5 (62.5%)	0.36	87.5	12.5	=-Values: 0.36 to 1.79		

19 Waste disposal, recycling

19.1 Waste collection, disposal, incineration and recycling (excluding glass recycling); waste water disposal

Sector
Waste and waste water disposal
Waste disposal
Waste incineration
Hazardous waste, collection points for landfill
Waste collection
Waste sorting plant
Composting plants
Sewage sludge recycling
Waste water disposal
Waste water treatment plants
Packaging material recycling (e.g. recyclables in Germany's DSD system)
Thermal recycling plants (process for separating combined plastic and metal products)
Plastics recycling
Paper recycling
Scrap tyre recycling

Numerous processes in the waste management sector are associated with the release of dust. For example, dust emissions must be anticipated when household waste is emptied from the collection containers (dustbins) into the collection vehicles, during unloading operations in processing/incineration plants, and during separating, sorting or comminution steps.

In addition to disposal of waste in landfills or by incineration, recycling of various raw materials such as paper, plastics and packaging materials is also common.

Paper recycling
Waste paper is collected both from commercial sources and from private households. A distinction is drawn between systems for collection and delivery. Treatment of waste paper constitutes a change in its quality and is carried out manually and partly or fully automatically. In the process, contaminants such as metals, cord, glass, textiles or plastics are removed as completely as possible, and the waste paper classified according to defined waste paper grades.

The process steps are independent of the origin of the collected waste paper.

- **Incoming material:**
  Following weighing, the paper is dumped loose in the delivery area, which is often covered, such as a sorting shed or delivery bays. Workers may inspect the material visually before and during tipping to remove larger non-paper components.

- **Sorting:**
  The paper is placed on the infeed belt by a wheel loader or forklift. Non-paper components and unwanted paper and paperboard are separated out. The system may include an automatic sorting module which is covered and equipped with dust exhaust. During visual sorting, materials specified beforehand (brown, grey and multi-colour paperboard, fully dyed paper, etc.) are recognized by their colour and ejected by means of compressed air. Paper and paperboard can then be manually re-sorted in a sorting cabin if required. Any residual non-paper components and unwanted paper and paperboard is separated out at this point.

- **Baling**:
  The sorted paper fractions are often pressed into bales by means of a press and tied with high-tensile wire. The bales are then transported away, for example by means of a forklift with bale clamp attachment, and stored temporarily in the storage area.

Inhalable and respirable dusts may be released during the processing of paper and paperboard. Depending on the origin of the paper, paper dust may contain small quantities of substances such as fillers, pigments, surface finishing and coating materials, and adhesives from adhesive backing. Other possible dust components include soiling residues from the use, transport and storage of paper and paperboard. The dusts are therefore generally of mixed composition and may contain paper dust and other constituents such as abraded material from vehicle tyres, impurities such as sand, and adhering dirt. This applies in particular to delivery and input of the material and to the various activities in the shed, as it can always be assumed that the dust arising during these activities is substantially contaminated.

Conversely, during activities in the sorting cabin and on the baler, the paper dust can be presumed "clean", since pre-sorting/final sorting has already taken place at this point.

The work processes and activities described above release dusts differing in their particle size. In addition, dust exposure may arise on open conveyor systems or transport equipment. Cleaning work leads to above-average exposure to dust, particularly when performed with the use of compressed air, which is not permissible.

The release of dust on stationary machines and at input and transfer points can be minimized effectively by technical measures such as exhaust, encapsulation and spraying with water mist. Reducing drop heights to a minimum leads to a reduction in dust emissions at the transfer points.

Dust deposits must be removed by regular cleaning. This applies in particular to the floor in the delivery area, where dust can be raised by the delivery traffic. Industrial vacuum cleaners (dust class H) or wet methods should preferably be used for cleaning. The use of compressed air to clean floors is not permitted. The use of compressed air to blow off dust is permissible only in exceptional cases in which the areas to be cleaned are not accessible for cleaning by an industrial vacuum cleaner, for example when they are obstructed by permanent plant components. In these cases, basic cleaning with the use of an industrial vacuum cleaner must always be performed first. Should the use of compressed air be unavoidable, employees must wear at least Class 2 particle-filtering respiratory protection.

The tables below show exposure values for different recycling areas. Exposure data relating exclusively to the field of paper recycling can be found in: Paper recycling – activities involving hazardous substances and biological agents in the treatment of waste paper and paperboard (May 2014; https://www.baua.de/dok/2731428).

Figure 49: Delivery area for paper recycling

19.1.1 Delivery, conveying, material input, handling, weighing

High dust concentrations must be anticipated in the delivery areas and at charging points of waste treatment plants and recycling plants. A typical unloading situation is tipping onto on a flat shed floor. In this process, dust deposits on the floor are raised and dusts contained in the waste released.

In conveying processes (continuous conveyors), emissions must be anticipated in particular at transfer points that are not encapsulated or equipped with dust exhaust, or at large drop heights at the end of belts. In many places, bucket wheel loaders are used for handling operations. The working practice may also influence the release of dust, as well as the material properties.

Although it is difficult to turn delivery areas in waste management into "clean" areas comparable to those of other areas of activity, a wide range of possible measures exist by which the release of dust can be reduced to a minimum and workers protected. Comprehensive guidance can be found in the TRBA 214 technical rules concerning facilities for the treatment and recycling of waste. Proven measures include:

- Spatial separation of work areas
- Moistening of waste before it is moved (by fog cannons, ultrasonic nebulizers)
- Shrouding of conveyor belts
- Encapsulation and dust exhaust at belt transfer points
- Keeping traffic areas clean
- Cross ventilation of the shop
- No paths through these areas for personnel; regulation of access
- Protective ventilation of drivers' cabs

The most frequent violations of the limit values in waste management compiled here (19.1.1 to 19.1.5) can be found in the areas of delivery, conveying, material input, handling and weighing: 9% of the mean shift-based values for inhalable dust were found to exceed the limit value, at least at the static measuring points, and as many as 18% of the personal and 10% of static mean shift-based values for respirable dust. These are clear indications of widespread deficiencies in protective measures in these areas.

Table 19.1.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	53	32	20 (37.7%)	0.72	92.5	7.5	0.915	7.232	10.71
≥ 2 h	Static	140	72	35 (25%)	0.71	91.4	8.6	0.74	7.78	11.9
< 2 h	Static	44	16	12 (27.3%)	2.86	75	25	3.39	12.02	33.06
Respirable dust										
≥ 2 h	Personal	56	32	22 (39.3%)	0.25	82.1	17.9	+ 0.21	1.934	2.63
≥ 2 h	Static	144	79	49 (34%)	0.48	90.3	9.7	+ 0.14	1.04	1.594
< 2 h	Static	30	20	4 (13.3%)	0.45	46.7	53.3	1.42	3.99	5.13

9.1.2 Vehicles, industrial trucks, transport

At these workplaces, it can be assumed for the most part that filtered breathing air is available in driver's cabs and that no dust from the surrounding work area therefore penetrates the cab. Experience has shown that suitable dust protection systems or protective cabin ventilation enable very low dust concentrations to be attained. Numerous studies have demonstrated the high efficacy of the systems with respect to concentrations of mould fungi in cabs. This is dependent upon the cab being well sealed, which helps to maintain the pressurization of the protective ventilation, and a work cycle that does not require the driver's door to be opened frequently. The windows must of course also remain closed. This is achieved when cabs are air-conditioned; drivers are otherwise often tempted to open windows or vents to cool the cab down, which however allows dust-laden ambient air to enter.

The values measured here demonstrate that the protective function of drivers' cabs is largely in place.

Table 19.1.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	10	7	6 (60%)	0.72	100	0	! LOD	0.92	1.27
≥ 2 h	Static	16	12	3 (18.8%)	0.71	100	0	+ 0.355	0.936	1.26
Respirable dust										
≥ 2 h	Personal	14	10	12 (85.7%)	0.26	100	0	! LOD	+ 0.232	0.408
≥ 2 h	Static	50	26	33 (66%)	0.25	90	10	! LOD	1.12	1.725

19.1.3 Sizing, screening, sorting

This group encompasses both machine processes and manual activities involving waste. Sizing, screening and sorting are typical automated processes in waste management in which the degree of automation and quality of results have risen continually over the years and continue to do so. They play a major role for example in the recycling of recyclable materials. Devices typically used to separate different fractions are rotary screens and starscreens. Some paper sorting plants employ air classifiers. The separation of coarse and fine constituents is followed for example by automatic sorting by means of near-infrared detection, followed in turn by an air blast which ejects the detected material from the material stream. Virtually all plants are equipped with magnetic separators, which separate out ferrous metals.

A feature common to all the processes mentioned is that particulate fractions in the waste are released almost completely into the environment in the form of dust, unless protective measures are implemented. In particular, free-standing rotary screens (for recyclable materials, and also used for compost after decomposition) in sheds may be associated with considerable dust release. Encapsulations, ideally with dust exhaust, are the indispensable method of choice for these and all other separation and comminution processes that cause dust to be released. In practice however, non-encapsulated systems are still encountered.

Besides automated sorting, manual sorting is still significant, either following automated sorting or in place of it. Cabins for sorting waste on the conveyor can be ventilated efficiently, with the result that dust and mould spores occur only in low concentrations. However, faults in design and operation are possible, resulting in the air at workplaces not being acceptable. In extreme cases, the air in the sorting cabin may be even dustier than that in the surrounding machine and delivery shed.

The table shows that potential exists for improvement with respect to respirable dust, the limit values for which are exceeded by 25% (personal) and 9.1% (static), and that these areas must be examined carefully in the risk assessment.

Table 19.1.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	21	12	7 (33.3%)	0.72	95.2	4.8	1.425	8.281	9.0425
≥ 2 h	Static	80	44	15 (18.8%)	0.71	98.7	1.3	+ 0.6	2.55	3.62
< 2 h	Static	29	12	5 (17.2%)	1.43	82.8	17.2	2.165	11.75	14.55
Respirable dust										
≥ 2 h	Personal	24	14	8 (33.3%)	1.25	75	25	+ 0.28	1.894	2.134
≥ 2 h	Static	88	49	24 (27.3%)	0.63	90.9	9.1	+ 0.22	1.086	2.374
< 2 h	Static	13	9	5 (38.5%)	0.56	92.3	7.7	+ 0.285	0.695	1.65

19.1.4 Pressing, shredding, compacting, comminution

During pressing, shredding, compacting and comminution, dust adhering to the material and present in cavities is released into the surrounding environment. Priority must be given here to extensive encapsulation of the processes; dampening of the materials may also reduce the raising of dust. No other workplaces should be located in the vicinity of such installations.

Of 84 shift-weighted measured values (personal and static) for inhalable dust, seven lay above the limit value; for respirable dust, this was the case for three values out of 110. For this body of measured values, it can therefore be stated that the effects of emissions on workplaces appear to be controllable for respirable dust and may present problems for inhalable dust only in certain areas of recycling.

Table 19.1.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	35	23	7 (20%)	0.71	91.4	8.6	1.275	6.225	23.225
≥ 2 h	Static	49	36	16 (32.7%)	0.72	91.8	8.2	+ 0.475	2.534	13.34
< 2 h	Static	24	9	15 (62.5%)	2.86	100	0	! LOD	+ 2.438	3.318
Respirable dust										
≥ 2 h	Personal	42	28	29 (69%)	0.26	97.6	2.4	! LOD	0.602	0.668
≥ 2 h	Static	68	50	29 (42.6%)	0.25	98.5	1.5	+ 0.125	0.422	0.698
< 2 h	Static	11	8	2 (18.2%)	0.33	100	0	+ 0.195	0.677	0.69

9.1.5 Storage, landfill

Table 19.1.5

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Static	49	18	7 (14.3%)	0.71	89.8	10.2	1.285	8.275	13.235
Respirable dust										
≥ 2 h	Static	52	20	11 (21.2%)	0.66	94.2	5.8	+ 0.245	1.12	1.298
< 2 h	Static	12	9	4 (33.3%)	0.45	66.7	33.3	0.81	1.9	5.758

19.2 Glass recycling

Sector
Glass recycling

Up to 90% of waste glass in Germany enters the material recycling stream for the production of new glass packaging. The waste glass, which is usually collected in public glass bins, is first pre-sorted manually in the processing plants. Foreign substances are removed by hand.

The glass is then comminuted in the crusher to a size of approximately 15 mm. Light foreign matter is separated by screening and air classification, metals by means of metal separators. In order to prevent defects and undesirable colour changes in the finished glass products, unwanted coloured glass and opaque materials such as stones and ceramics are separated from the glass fragments by electro-optical sorting. The recycled glass is staged in bays for use as a raw material. Since all processing steps are mechanical, the generation of dust is to be anticipated.

Table 19.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	27	16	2 (7.4%)	0.25	88.9	11.1	2.77	9.267	16.015
≥ 2 h	Static	40	16	0	n/a	82.5	17.5	1.89	11.2	12.1
Respirable dust										
≥ 2 h	Personal	31	17	7 (22.6%)	0.25	90.3	9.7	0.43	1.104	1.541
≥ 2 h	Static	38	15	7 (18.4%)	0.18	92.1	7.9	0.33	0.998	1.388

19.3 Metal recycling

Sector
Metal recycling (scrap)
Recycling of blasting abrasives
Copper recycling
Noble metals recycling

Metals are recycled both in scrap recycling and in plants for recycling copper and other noble metals (for example from vehicle catalytic converters). Dust exposure occurs primarily in the areas of sorting and mechanical comminution, such as by shredders or impact crushers/rotary shears.

Table 19.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	28	19	2 (7.1%)	0.71	85.7	14.3	1.88	13	18.6
≥ 2 h	Static	25	15	8 (32%)	0.71	96	4	0.74	6.325	7.763
Respirable dust										
≥ 2 h	Personal	30	18	8 (26.7%)	0.81	76.7	23.3	+ 0.42	3.6	6.02
≥ 2 h	Static	23	15	10 (43.5%)	1.25	82.6	17.4	+ 0.28	2.067	5.687

19.4 Building materials recycling and sorting plants

Sector
Slag pit
Slag preparation
Sorting plant
Building materials recycling
Recycling of mineral building materials
Contaminated equipment and components

End-of-life mineral building materials (building and civil engineering rubble, road breaking waste, construction site waste) is prepared in stationary, mobile and semi-mobile recycling and sorting installations for re-use. Conceptually, these installations correspond largely to the types of plant used in the natural stone industry for conventional raw material extraction and processing. They include discrete components for the separation of unwanted materials such as construction timber, plastic film, rebar or paper, and for comminution and sizing. The stockpiled material is transported, possibly following pre-sorting, by wheel loader or excavator into the feed hopper, from where it is fed through a pre-screening stage into the crusher. Impact or jaw crushers are primarily used for crushing. Finally, the crushed material is sized in a downstream screening installation, and stockpiled separately by particle size. Workplaces with possible exposure to dust can be found:

- In material charging (pre-sorting on manual picking belts; drivers of wheel loaders or excavators)
- In the entire environment of the installation during its operation and monitoring (inspection rounds)
- Particularly at the crusher intake on mobile installations during monitoring of material input and manual removal of unwanted materials (this is not generally a permanently manned workplace, however)
- During removal and transfer of the recycling material and loading from the stockpile onto trucks by means of wheel loaders

Stationary installations usually possess a cabin from which the installation can be operated and monitored.

The measured values show that the highest dust exposures occur during preparation of the material by crushing. Considerably more dust is generated on impact crushers than on jaw crushers. Substantially lower values were measured in the areas of activity of sizing, sorting, transport and loading for transport. The excavators and wheel loaders employed are equipped with enclosed driver's cabs, which provide protection against dust exposure.

Whereas comprehensive dust removal facilities are the state of the art on stationary recycling and sorting installations, this is not the case for mobile installations, the compact design of which limits the scope for such facilities. The following measures are employed for dust reduction:

- Water sprinkling to prevent dust from drifting from stockpiles
- Water-jetting to promote precipitation of dust on the crusher and at transfer points on conveyor equipment
- Adjustment of drop heights to the angle of repose of the stockpile
- Regular spraying and cleaning of traffic areas

19.4.1 Conveying, storage, transport, loading for transport

Table 19.4.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	40	26	19 (47.5%)	0.71	97.5	2.5	+ 0.355	3.58	5.38
≥ 2 h	Static	22	15	8 (36.4%)	0.61	81.8	18.2	+ 0.35	12.78	19.03
Respirable dust										
≥ 2 h	Personal	44	28	23 (52.3%)	0.5	90.9	9.1	! LOD	1.186	1.934
≥ 2 h	Static	28	18	12 (42.9%)	0.29	92.9	7.1	+ 0.14	0.608	1.572

19.4.2 Crusher, grinding plant

Figure 50: Charging of a crusher in construction material recycling

Table 19.4.2

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³) 50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	40	25	9 (22.5%)	0.71	77.5	22.5	2.57	16.6	23.4
≥ 2 h	Static	23	16	5 (21.7%)	0.71	82.6	17.4	0.985	16.355	31.688
Respirable dust										
≥ 2 h	Personal	46	28	13 (28.3%)	1.15	78.3	21.7	+ 0.57	2.006	4.572
≥ 2 h	Static	31	19	3 (9.7%)	0.25	74.2	25.8	0.51	2.824	6.625

19.4.3 Sizing, mixing, screening, sorting

Figure 51: Manual removal of unwanted materials during recycling of construction materials

Table 19.4.3

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	31	24	4 (12.9%)	0.71	96.8	3.2	2.055	5.129	7.246
≥ 2 h	Static	30	26	1 (3.3%)	0.71	100	0	1.26	6.38	7.595
Respirable dust										
≥ 2 h	Personal	33	24	10 (30.3%)	0.71	90.9	9.1	+ 0.357	1.207	1.454
≥ 2 h	Static	31	25	5 (16.1%)	0.24	93.5	6.5	0.32	0.663	1.19
< 2 h	Static	10	3 **	1 (10%)	0.29	40	60	1.49	3.59	3.795

19.4.4 Control, control cabins, test benches

Table 19.4.4

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m^3)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m^3)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	13	10	3 (23.1%)	0.71	100	0	1.235	4.377	5.69
Respirable dust										
≥ 2 h	Personal	13	9	5 (38.5%)	0.25	84.6	15.4	+ 0.203	1.401	1.633

19.5 Electronic scrap recycling

Sector
Collection point for lamps containing mercury (end-of-life lamps)
Electronic scrap recycling
Recycling of lamps containing mercury
Recycling of LCD devices containing mercury

Electrical appliances are collected, sorted and then broken down into individual assemblies by the use of tools, in order for valuable raw materials to be recovered. The individual assemblies may then be dismantled further or shredded, according to assembly type.

19.5.1 Disposal of cathode ray tubes

Table 19.5.1

Duration of sampling	Form of sampling	Number of measured values	Number of companies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th percentile	90th percentile	95th percentile
Inhalable dust										
≥ 2 h	Personal	79	18	8 (10.1%)	0.71	100	0	2.4	5.838	7.192
≥ 2 h	Static	18	10	2 (11.1%)	0.71	100	0	0.83	2.11	2.237
Respirable dust										
≥ 2 h	Personal	58	12	13 (22.4%)	0.25	100	0	0.36	0.882	0.967
≥ 2 h	Static	24	12	11 (45.8%)	0.86	100	0	+ 0.16	+ 0.426	+ 0.494

19.5.2 Comminution, dismantling, shredding

Table 19.5.2

Duration of sampling	Form of sampling	Number of measured values	Number of com-panies	Values < limit of detection (number and %)	Highest limit of detection* (mg/m³)	≤ LV (%) $	> LV (%) $	Concentrations (mg/m³)		
								50th per-centile	90th per-centile	95th per-centile
Inhalable dust										
≥ 2 h	Personal	79	32	16 (20.3%)	0.71	94.9	5.1	1.515	6.08	9.607
≥ 2 h	Static	49	22	16 (32.7%)	0.71	98	2	+ 0.485	1.786	2.788
Respirable dust										
≥ 2 h	Personal	46	23	25 (54.3%)	1.25	93.5	6.5	! LOD	+ 0.814	1.344
≥ 2 h	Static	48	20	28 (58.3%)	0.25	100	0	! LOD	0.37	0.386

20 Construction industry

Many activities in the construction industry involve the processing of various building materials, particularly mineral materials. Dust is often created or released in these processes.

The dusts typically produced are generally mixed dusts the composition of which depends to a large extent on the type of building material involved. Depending upon the technologies (machinery and equipment) and building materials used, such as natural stone, concrete, lime sandstone moulded elements or plasterboard, the composition of the dust and the ratio of the dust fractions to each other inevitably varies. The dust generated during the drilling of concrete for example differs from that produced when plasterboard is sanded in dry lining work.

Owing to the prevalence of quartz in mineral building materials, it must be assumed that almost all mixed dusts encountered on building sites contain respirable silica dust, in varying levels. This is of particular importance for assessment of employees' exposure at workplaces in the construction industry, since in addition to the GDLV, the recommended value for exposure to silica dust must also be taken into account in the risk assessment.

Owing to the wide range of activities in the construction industry and the mobile and frequently changing working conditions, assessing workplace exposure presents a major challenge. Limiting the assessment and evaluation of health hazards to which workers are exposed to respirable and inhalable dusts is therefore of little benefit in the construction industry; the concentration of silica dust must always be taken into account, and in some cases also other dusts. The composition of the dust produced is particularly unpredictable during construction work in legacy structures. Where work is performed on the fabric of existing buildings, further dusts such as fibre dusts from materials containing asbestos or legacy mineral wool insulation may have to be anticipated, depending upon the age of the building.

During many activities in the construction industry in which dust is released or raised, concentrations may arise in the air breathed which substantially exceed the GDLV stated in the TRGS 900 technical rules governing occupational exposure limits. However, even where the limits for respirable and inhalable dust listed in TRGS 900 are observed, the assessment benchmark for silica dust may be exceeded. Activities in which such situations frequently occur encompass all work involving materials with a high quartz content, such as those in natural stone processing.

For some time now, the construction industry has therefore been stepping up its activities to address this situation, under the auspices of the German Social Accident Insurance Institution for the building trade (BG BAU). With the lowering in 2014 of the GDLV for the respirable fraction and the establishment in 2016 of a new assessment benchmark for silica dust, a further need arose for action to step up these efforts in the sector.

20.1 Dust emissions behaviour of machinery and tools

High concentrations of dust are generated in particular during the mechanized working of mineral substances. Accordingly, Annex I, Clause 2.3 (3) of the German Ordinance on hazardous substances (GefStoffV) requires machinery and tools to be equipped with an effective facility for collecting the dust.

Up until 2008 however, the availability of such equipment and facilities on the market was limited, and in many areas their use had not yet become standard industry practice at that time. Sadly, dust is often perceived in the construction industry as an indispensable part of construction work and is therefore inevitably associated with many activities in it. Consequently, adverse effects on health that are in fact avoidable are not perceived as such. For a long time, parties in the construction sector were not aware of technologies for minimizing dust exposure during construction work.

Equally, awareness was limited of the options available for dust minimization by means of collection devices, and of their efficacy, when used in conjunction with machines. The first systematic efforts to examine the efficacy and potential for improvement were made in the project concerning wall chasers, conducted by the German Social Accident Insurance Institution for the energy, textile, electrical and media products sectors (BG ETEM). The results of this joint project were documented in 2005 in the BG/BIA 2005 Report concerning wall chasers and containing guidance on their use with low dust generation during electrical installation work.

Based on the findings of the test bench studies conducted by the IFA (formerly BIA), the project evaluating the dust emissions behaviour of manually guided machinery and tools for the working of mineral materials was developed further by the BG BAU and other parties. In this project, around 120 machines and tools were tested and evaluated under realistic conditions for the first time with respect to their dust emissions behaviour. In addition to the tests performed in the test chamber, the results were confirmed by exposure measurements taken on construction sites with the use of selected machines.

The results of the studies are documented illustratively in the research report. The involvement of machine and tool manufacturers in the research project enabled continual improvements to be made to many machines and combinations whilst the project was still in progress. The project results have now been incorporated into standards governing power tools.

The tests conducted in the test chamber at the Bavarian Building Academy in Feuchtwangen initially revealed wide differences in emissions behaviour in the various categories of machine studied, such as wall chasers, concrete grinders or diamond cut-off grinders. Depending on the category of machine and the quantities of mineral material released, the dust levels in the breathing air were somewhat low, as in the case of concrete grinders and random orbital grinders, or very high, as in the case of wall chasers and plaster milling machines.

However, although in some cases extremely high quantities of material were removed, it was usually possible for the limit values for respirable and inhalable dust in force at the time to be observed. The use of the machines in combination with an effective Class M dust collector was identified as the main reason for this effective minimization of dust emissions. Not all dust collectors sold at that time were equally suitable for effectively collecting the quantities of dust arising over a longer period of time at the tool. Should the dust collector fail, high quantities of dust are released within a short time. The result is a dust concentration of several times the limit value. The experience gained during the project demonstrated convincingly to the industry that dust exposure can be minimized only by a combination of matched equipment systems.

A matched equipment system is a combination of tool and dust collection equipment which is able to maintain emissions of both dust fractions below the GDLV. Many of the combinations of equipment tested at the time, or their successor models, are also capable of complying with the limit value for respirable dust of 1.25 mg/m³, which has been in force since 2014. Testing of machines and equipment is continuing and the results are being published in lists of approved products on the website of the BG BAU.

A large proportion of the machines and tools tested have also attracted subsidies for several years in the form of OSH bonuses granted by the BG BAU. These subsidies provide financial support to member companies of the BG BAU when they procure technical equipment for the reduction of dust emissions during construction work. The procurement of around 50,000 dust collectors for construction use was supported by OSH bonuses from 2015 to 2019.

20.2 Exposure to dust during work in the construction industry

Experience gained over recent years has shown that exposure to dust during construction work can be considerably reduced by the rigorous use of low-dust technologies and products. Often however, a combination of several components – matched equipment systems, construction site removal equipment, air purifiers and partitioning – is necessary in order for workplace exposure to be reduced to a minimum. A basic form of dust reduction technology comprises the following four components:

- Tools with effective dust collection
- Construction site dust collector
- Air purifier
- Dust-proof partitions/dust doors

Figure 52: Power tool (in this case a demolition hammer) with dust exhaust, construction site dust collect and air purifier. Together with a dust-proof partition (not visible in the image), these comprise the basic equipment for low-dust working methods for each company.

Without this basic equipment, exposure to dust during construction work cannot be reduced effectively. Basic equipment of this kind for low-dust work is available for an investment of approximately € 3,000. The current BG BAU subsidy/OSH bonus significantly reduces these costs.

20.3 BG BAU exposure matrix

As a result of numerous exposure measurements taken under realistic conditions at workplaces in the construction industry in which exposure to silica dust is routinely measured and assessed in addition to the exposure to the dust fractions, the BG BAU exposure matrix has been developed as a tool with which companies can assess their activity and based upon this assessment, easily determine the measures required (www.staub-war-gestern.de).

The columns of the dust exposure matrix for work in the construction industry list numerous activities typical of the construction trades. The first column of the matrix shows the activity. The four subsequent columns are graded according to the hierarchy of protective measures. The order of priority of the measures must follow the STOP principle (substitution, technical measures, organizational measures and personal protective equipment). Respiratory protection may be used only as a last resort, once all other measures have been exhausted.

Working practices for an activity that are associated with lower dust generation (i.e. good practice) are listed on the left-hand side of the matrix. Poor practice (high exposure) is shown further to the right.

- Working practices in which exposure levels lie below the OELs for respirable dust (1.25 mg/m³) and inhalable dust (10 mg/m³) and the assessment benchmark for silica dust (0.05 mg/m³) are shown on a grey background.
- A black background indicates working practices for which exposure to at least one of the dust fractions lies above the OEL or the assessment benchmark. The dust fraction responsible for the violation is indicated by a letter (R, I, S).
- A white background indicates working practices for which no or insufficient exposure data are available. If the exposure associated with a working practice can be estimated, the method is shown in italics (indicating probable violation) or light grey (indicating probable observance).
- The "Comments" column contains guidance on protective measures and the available data. Indication is provided in cases where available data are not yet sufficient, the available exposure data contradict experience, investigation is required, etc.
- The exposure matrix is being developed further and updated continually. Many trades in the construction industry have used the matrix as a basis for developing practical guidance documents for low-dust working practices in the trade concerned in cooperation with the social partners and the BG BAU. In addition to the lowered limit value for respirable dust, the subject of silica dust was a focus of the guidance documents from the outset, for the reasons stated above.

The guidance documents generally share a common structure, which provides companies active in multiple trades with swift access to guidance for their activities. The basis and core of each guidance document is an excerpt from the BG BAU's dust matrix indicating the activities taken into account for the trade in question. These are listed in guidance document No 5, containing the standard industry methods and operating procedures, together with exposure data. Guidance document No 6, containing guidance and describing scope for improvements to technical protective measures, describes technical means of reducing dust emissions in the trade to a minimum, such as mobile dust removal equipment or air purifiers. In accordance with the provisions of the applicable regulations (specifying the order of priority of the protective measures), the technical solutions for the avoidance of dust must always be exploited to the full before recourse is made to organizational solutions. Organizational solutions are listed in guidance document No 7, concerning work organization and personal protective equipment. Sample documentation of the risk assessment and a model operating procedure complete the practical guidance. Annex 3 of each guidance document lists the activities taken by the sector to implement the agreed measures.

Figure 53: Exposure matrix for dust exposure during demolition work
(excerpt from the guidance document concerning dust during demolition and deconstruction work; last updated 2017)

Activity	Ranking according to the hierarchy of protective measures (STOP principle)				Comments
	Good practice			*Poor practice*	
Removal of plaster, flat surfaces	**Plaster milling machines with dust exhaust (list BG BAU, g) A < 1.25 mg/m³**	Chisel with dust exhaust, with air purifier (list BG BAU, i)	**Plaster stripping, air purifier**	**Plaster stripping without dust exhaust Outdoors: R: 4.03 (13; d) S: 0.43 (13;d) Indoors: R: 12.54 (13; d) S: 0.79 (13;d)**	Air purifiers reduce exposure caused by secondary emissions (raising of deposited material) and prevent uncollected dust from accumulating in the indoor area
Removal of plaster Uneven surfaces, unsound plaster	Plaster milling machines (list BG BAU, g) With air purifier (list BG BAU, i)	***Plaster milling machines with dust exhaust (list BG BAU, g)***		**Included in "Removal of plaster, flat surfaces"**	Air purifiers reduce exposure caused by secondary emissions and prevent uncollected dust from accumulating in the indoor area
Cleaning during construction tasks	**Construction site dust collector Sweeping machine (list of construction site dust collectors, h)**		**Collection of coarse dirt (e.g. with a scoop shovel), with air purifier running (measurement necessary)**	**Dry sweeping R: 8.38 (33; d) S: 0.41 (33; d)**	During vacuuming of heavily soiled surfaces and larger quantities of dust, limits may be violated owing for example to secondary emissions (for example where dust is raised by the vacuum hose)
Chiselling, concrete floor surfaces	**Manually operated machines with dust exhaust (list, BG BAU, g) and air purifier (list, BG BAU, i)**			**Chisellling, demolition without exhaus R: 9.28 (56; a) S: 0.82 (56; a)**	
Chiselling Walls	Manually operated machines with dust exhaust (list, BG BAU, g) and air purifier (list, BG BAU, i)	***Manual machines with dust exhaust (list BG BAU, g)***		**Chisellling, demolition without exhaus R: 9.28 (56; a) S: 0.82 (56; a)**	
Cutting of solid bricks	**Manual machines with dust exhaust (list BG BAU) (list BG BAU, g)**	**Wet cutting; water replacement at least daily**	**Wet cutting without daily water replacement R: 3.17 (15; d)**	**Dry cutting without dust exhaust A: 19.77 (29, d)**	
Cutting of perforated bricks	Manual machines without dust exhaust (BG BAU list of approved products)	Wet cutting; water replacement at least daily	**Wet cutting without daily water replacement**	**Dry cutting without dust exhaust**	
Cutting of concrete	**Cut-off grinding tools with dust exhaust (list, BG BAU, g)**		***Wet cutting, sawing of concrete***	**Cutting, sawing of concrete without dust exhaust See cutting of solid bricks**	Dry cutting/milling of concrete without dust exhaust gives rise to extreme exposures; exposures are significantly lower during wet cutting

Figure 54: Examples of guidance documents for reducing dust to a minimum in various trades in the construction industry (www.staub-war-gestern.de)

20.4 Joint declaration on reducing dust to a minimum in construction work

All the efforts made by individual companies are however defeated if the adjacent trade continues to work as before and coats the entire construction site in dust. All parties on the construction site must therefore cooperate. This is the background to the campaign by the German Federal Ministry of Labour and Social Affairs (BMAS) to reduce dust on construction sites to a minimum. Its aim is to reduce all dust and particularly silica dust at the workplace.

Companies should be provided with as much information and guidance as possible to enable them to work safely even during activities associated with high dust levels, become familiar with technologies for dust avoidance and use them competently.

On 25 October 2016, representatives of the social partners in the building trade, the German Federal Ministry of Labour and Social Affairs (BMAS), and associations and institutions in the construction sector signed the declaration concerning the campaign. In this joint declaration they agreed that, in addition to information and advice being provided to affected businesses, checks would also be performed of compliance with the legal requirements.

This is the only effective way of preventing mandatory protective measures from being circumvented to the detriment of committed and reliable businesses. This illustrates all the more the BG BAU's commitment to the campaign and its success, which is to be achieved by thorough action on the part of labour inspectors in their inspection activities on construction sites.

The guideline on reducing dust on construction sites to a minimum has since been drawn up as part of the Joint German OSH Strategy (GDA). Since 2018, the labour inspectors of the German regional authorities and the German Social Accident Insurance Institutions have been taking the same measures against construction businesses that fail to implement effective measures for protecting workers against dust.

Annex 1: Overview of the dust types analysed

Dust type	Inorganic	Organic	Natural	Anthropogenic/ produced industrially	Explosive	Density in g/cm³
Activated carbon	x			x	x	0.2 to 0.6
Alum	x		x	x		1.7 to 1.8
Aluminium	x			x	x	2.7
Aluminium bromide	x			x	x	3.2
Aluminium bronze	x			x		7.4 to 8.2
Aluminium fluoride (including cryolite)	x			x		3
Aluminium hydroxide	x		x	x		2.4
Aluminium nitride	x			x		3.3
Aluminium oxide (non-fibrous), corundum	x		x	x		3.9 to 4.0
Aluminium oxide fibres, possibly containing zirconium oxide	x			x		2.7 to 4.1
Aluminium silicate (non-fibrous), kaolin	x		x			2.6
Aluminium silicate fibres	x			x		2.6
Aluminium titanate	x			x		3.7
Anatase	x		x			3.9
Anhydrite	x		x	x		2.9 to 3.0
Antimony	x		x	x	x	6.7
Antimony disulfide	x		x			4.6
Antimony(III) oxide	x			x		5.2 to 5.7
Aramid fibres		x		x		1.5
Arsenic	x		x	x		5.6 to 5.8
Arsenic trioxide	x		x	x		3.7
Artificial mineral fibres	x			x		2.5
Asbestos	x		x			2.5 to 3.3
Ash	x		x	x		Approx. 0.3
Attapulgite (palygorskite)	x		x			2.4
Barium carbonate (witherite)	x		x			4.3
Barium oxide	x			x		5.7
Barium titanate	x			x		5.9
Bariumsulfat (baryte)	x		x	x		4.5
Bentonite	x		x			Approx. 2.6
Beryllium	x			x		1.8

Dust type	Inorganic	Organic	Natural	Anthropogenic/ produced industrially	Explosive	Density in g/cm³
Beryllium oxide	x		x	x		3
Bird faeces		x	x			Approx. 1.5
Bismuth	x		x	x		9.8
Bismuth oxide (bismuth vanadate, bismite)	x		x	x		8.3
Blasting sand (glass, metal, silicate minerals)		x	x	x		1.5
Borax	x		x	x		1.7 to1.8
Boron carbide	x			x		2.5
Boron nitride	x			x		2.3 to 3.5
Boron oxides	x			x		1.8 to 2.6
Brick and tile	x			x		Approx. 2.5
Cadmium	x			x		8.7
Cadmium chloride	x			x		3.3 to 4.0
Cadmium oxide	x			x		7.0 to 8.2
Calcium carbide	x			x		2.2
Calcium carbonate (lime, calcite)	x		x	x		2.6 to 2.8
Calcium fluoride (fluorspar, fluorite)	x		x	x		3.2
Calcium hydroxide	x		x	x		2.2
Calcium oxide (quicklime, burnt lime)	x			x		3.4
Carbide	x			x		6 to 15
Carbon black	x		x	x	x	Approx. 2
Carbon fibres	x			x		1.8
Cement	x			x		2.9 to 3.1
Ceramics	x			x		Approx. 2.5
Cereal		x	x	x	x	< 1
Chalk	x		x			2.7
Chitin, including insect matter		x	x			1.3
Chromium and chromium compounds	x			x		7 to 8
Clay minerals	x		x			Approx. 3
Coal		x	x	x	x	1.4
Cobalt and cobalt compounds	x			x		7 to 8.9

Dust type	Inorganic	Organic	Natural	Anthropogenic/ produced industrially	Explosive	Density in g/cm³
Coke	x			x	x	<1
Concrete	x			x		2.0 to >2.8
Copper	x			x	x	8.9
Copper oxides	x		x	x		6 to 6.5
Copper sulfate	x		x	x		2.3 to 3.6
Cork		x	x		x	0.5
Cristobalite	x		x			2.3
Crystalline silica (quartz)	x		x	x		2.7
Diamond	x		x	x		3.5
Diatomaceous earth	x		x	x		2.2
Dimethyl ether (DME)	x			x		Approx. 2
Dolomite	x		x			2.6 to 2.9
Emery powder, abrasive agent	x		x	x		3.9 to 4.1
Explosives (e.g. propellants)	x			x	x	Approx. 1
Feldspar	x		x			2.5 to 2.6
Ferromanganese	x			x		7.8
Foods		x	x	x	x	Approx. 1
Foundry materials	x			x		2.2 to 2.8
Fungal spores		x	x			<1
Gemstone polishing particles	x		x			2.7 to 4
Glass	x		x	x		2.3
Glass fibres	x		x	x		2.2 to 2.7
Glazes	x			x		2.2 to 2.8
Graphite	x		x	x		2.3
Gypsum and alabaster	x			x		2.5–8
Hardwood		x	x		x	0.7 to >1
Iron	x			x		7.9
Iron oxides	x		x	x		5.1 to 5.3
Lead	x			x		11.3
Lead oxides, red lead	x			x		Approx. 9.4
Leather		x	x	x	x	0.5 to 0.9
Loess	x		x			Approx. 2.5
Lycopodium spores		x	x		x	Approx. 0.4

Dust type	Inorganic	Organic	Natural	Anthropogenic/ produced industrially	Explosive	Density in g/cm³
Magnesium	x			x	x	1.7
Magnesium carbonate	x		x	x		3
Magnesium hydroxide	x			x		2.4
Magnesium oxide	x			x		3.6
Manganese	x			x		7.4
Manganese oxide (manganese dioxide, pyrolusite)	x		x	x		4.5 to 5.0
Man-made fibres		x		x		0.9 to 1.8
Metals and metal alloys	x			x		4.5 to 9
Mica	x		x			2.8 to 3.1
Mischmetal (cerium mischmetal)	x			x		6.8
Mite feaces		x	x	x		Approx. 1
Molybdenum	x			x		10.3
Molybdenum oxides	x			x		4.7 to 6.5
Mullite	x		x	x		3.1 to 3.3
Natural fibres		x	x		x	1.3 to 1.5
Nickel	x			x		8.9
Nickel oxides	x		x	x		4.8 to 6.7
Noble metals	x		x			10 to 21
Ore	x		x			4 to 10
Paper and cellulose		x		x	x	0.7
Pigments	x	x	x	x	x	2.5 to 19
Plastic		x		x	x	0.9 to 1.2
Pollen		x	x	x		< 1
Porcelain	x			x		2.4
Potassium carbonate (potash)	x			x		2.4
Pumice	x		x			2.3
Quartz	x		x			2.7
Rare earths	x		x	x	x	3.0 to 9.8
Rock	x		x	x		2.3 to 3.2
Rosin (colophony)		x	x	x	x	1.1
Rubber		x		x		Approx. 0.9
Silica glass (quartz glass), silica material (fused silica)	x			x		2.7

Dust type	Inorganic	Organic	Natural	Anthropogenic/ produced industrially	Explosive	Density in g/cm³
Silica/silica gel, produced synthetically	x			x		2.7
Silicon carbide (fibre-free)	x			x		3.2
Silicon carbide fibres	x			x		2.5 to 3.1
Silicon nitride whiskers	x			x		3.4
Skin/callus		x	x	x		< 1
Slag (non-fibrous)	x			x		2.1 to 4.0
Sodium carbonate	x		x	x		2.5
Sodium nitrate	x			x		2.3
Sodium oxide	x			x		2.3
Sodium sulfate	x			x		2.7
Sodium sulfide	x			x		1.4 to 1.9
Starch		x	x	x	x	1.5
Steel	x			x		7.7 to 8.0
Sugar		x	x	x	x	1.5 to 1.6
Sulfur	x		x	x		2.0 to 2.1
Talcum powder	x			x	(x)	2.7 to 8
Tantalum	x		x			2.6 to 2.8
Textile fibres	x			x		16.7
Thallium	x			x		11.9
Tin	x			x		7.3
Tin oxide	x		x	x		6.8 to 7.1
Titanium	x			x		4.5
Titanium dioxide	x		x	x		4.2
Toner	x			x		1.3 to 1.6
Tricalcium phosphate	x		x	x		3.1
Tungsten	x			x		19.3
Tungsten carbide	x			x		15.6
Tungsten oxides	x			x		7.2 to 12.1
Urea		x		x		1.3
Vanadium	x			x	x	6.1
Vanadium oxide	x			x		3.4 to 5.8
Varnish (cured)		x		x	x	1 to 1.3
Vegetable fibres		x	x			Approx. 1

Dust type	Inorganic	Organic	Natural	Anthropogenic/ produced industrially	Explosive	Density in g/cm^3
Welding and soldering fumes	x			x		5.1 to 7.3
Wollastonite	x		x	x		2.8 to 2.9
Wood, possibly with binding agents		x	x	x	x	0.5 to 0.8
Wool, animal and vegetable		x	x			1.3
Yttrium	x			x	x	4.5
Zeolites	x		x	x		2.2 to 2.5
Zinc	x			x	x	7.1
Zinc oxide	x		x	x		5.6
Zinc sulfate	x		x			2
Zirconium dioxide (zirconia)	x		x	x		5.7 to 6.1

Authors

General Information:
Dr. rer. nat. Markus Mattenklott, IFA, Sankt Augustin
Dr. rer. nat. Wolfgang Pflaumbaum, IFA, Sankt Augustin
Dr. rer. nat. Thomas Smola, IFA, Sankt Augustin
Dr. rer. nat. Roger Stamm, IFA, Sankt Augustin
Dr. rer. nat. Marco Steinhausen, IFA, Sankt Augustin
Dr. rer. nat. Gisela Binde, BGHM, Düsseldorf

Exposure data:
Dr. rer. nat. Mario Arnone, IFA, Sankt Augustin
Dr. phil. nat. Stefan Auras, BGHW, Mannheim
Dr. rer. nat. Christoph Emmel, BG BAU, Munich
Dipl. Ing. Dirk Fendler, BGETEM, Cologne
Dr. rer. nat. Hans-Peter Fröhlich, BGHW, Mannheim
Stefan Gabriel, IFA, Sankt Augustin
Dipl.-Ing. Arno Goebel, IFA, Sankt Augustin
Dr. rer. nat. Karlheinz Guldner, VBG, Hamburg
Dipl. Ing. Walter Gunreben, BG Bau, Berlin
AdB Michael Koob, BGRCI, Bochum
Dr. rer. nat. Heike Niemann, UK Nord, Hamburg
Dipl. Ing. Marnix Poppe, BGHM, Cologne
Dr. rer nat. Rainer Radtke, UK RLP, Andernach
Dr. rer. nat. Alexandra Riethmüller, SVLFG, Kassel
Dr- Ing. Peter Rietschel, BGN, Mannheim
Dipl. Chem. Rainer Van Gelder, IFA, Sankt Augustin
Dipl. Ing. Wolfgang Wegscheider, BGW, Cologne
Dipl.-Ing. (FH) Eckart Willer, BG Verkehr, Hamburg

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Deutsche Gesetzliche
Unfallversicherung e.V. (DGUV)

Glinkastraße 40
10117 Berlin, Germany
Phone: +49 30 288763800
Fax: +49 30 288763808
E-mail: info@dguv.de
Internet: www.dguv.de