The MGU – a monitoring system for the collection and documentation of valid workplace exposure data

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Abstract Health and safety at workplaces in Germany, especially with respect to chemical and biological risks, is monitored by the German Social Accident Insurance Institutions in line with their legal obligations. For this purpose, the MGU measurement system for exposure assessment has been in place for almost 30 years now, formerly abbreviated as BGMG in German. The article gives an overview of the system and describes the methods of data collection and quality assurance measures applied. In this specialized system data on workplace conditions, job titles and activities along with information on measurement conditions and exposure values are recorded and documented in the database MEGA. Emphasize is given to the coding of the work areas. It is proposed to use them e. g. in the description of exposure scenarios under REACH.

Das MGU – ein Monitoringsystem zur Ermittlung und Dokumentation valider Daten zur Exposition am Arbeitsplatz

Zusammenfassung Die Sicherheit und Gesundheit an Arbeitsplätzen, insbesondere im Hinblick auf chemische und biologische Gefährdungen, wird in Deutschland im Rahmen ihrer gesetzlichen Verpflichtung von den Unfallversicherungsträgern überwacht. Für diese Aufgabe steht ihnen seit fast 30 Jahren das MGU – Messsystem Gefährdungsermittlung der Unfallversicherungsträger (früher als BGMG abgekürzt) zur Verfügung. Dieser Beitrag gibt einen Überblick über das System und beschreibt die Methoden der Datenermittlung sowie der dabei eingesetzten Qualitätssicherungsmaßnahmen. In dem System werden Daten zur Situation am Arbeitsplatz, zu Berufen und Tätigkeiten sowie Informationen über die Messbedingungen und Expositionswerte erfasst und in der Datenbank MEGA dokumentiert. Betont wird die Vorgehensweise bei der Verschlüsselung der Arbeitsbereiche. Es wird vorgeschlagen, diese Verschlüsselungen z. B. bei der Beschreibung von Expositionsszenarien unter REACH zu verwenden.

1 Introduction

Employees at their workplaces may be exposed to a variety of different risks. As one component of safety and health protection, identifying and evaluating these risks is of special importance. "At a glance" and without specialized knowledge, it is not usually possible to gauge the role played by hazardous substances in this connection and the effect they may have on the safety and health of employees; nor is it possible to define the protective measures that may be useful and appropriate in the case in question. To make a sound assessment of the risks to employees arising from the handling of hazardous substances and biological agents at the workplace, exposure measurements are therefore often indispensable. Along with determining the scale of exposure, it is also important to document the determinant factors for exposure so that the data are applicable beyond the case in question [1; 2].

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Different workplace monitoring systems investigating measurement values have been established in Europe [3; 4], e.g. the French system at INRS which is called COLCHIC [5]. A European proposal for core information for the investigation, storage and exchange of workplace exposure measurements on hazardous substances has been developed in the 1990s [6].

Exposure data and contextual information mentioned in this publication allow for multifunctional use – for prevention, occupational disease identification and research (epidemiology, modelling of exposure, and validation of exposure models). Accordingly the following basic requirements of such a system have been defined:

- Comprehensive qualitative and quantitative description of the ambient work area conditions capable of affecting measured hazardous substance values – particularly relating to
  – products,
  – technical details of ventilation and extraction, including quantitative description,
- systematic data collection, supported by coding lists,
- checks of completeness and plausibility,
- no further manual transfer or revision of data,
- satisfaction of the REACH criteria in order to create exposure scenarios on the basis of the acquired data.

In connection with the chemical safety assessment required by the REACH regulation of the European Union (EU), exposures have to be estimated. The guidance document R.14 [7] names "*actual measurement data of high quality … raw data supported by information of key exposure determinants*" as the best source for this. The following are named as key exposure determinants:

- Physical state of the substance,
- physical state of the product handled,
- vapour pressure for liquids, "dustiness" for solids,
- the level of containment,
- presence or absence of local exhaust ventilation (LEV),
- duration of activity,
- what is done with the substance.

The present article gives an overview of the German MGU system thus answering the question whether the MGU satisfies the above-listed requirements for acquired data.

2 Description of the MGU

The MGU measurement system for risk assessment – previously abbreviated as BGMG from a former acronym – of the German Social Accident Insurance Institutions is a monitoring system for the measurement, analysis and assessment of exposure to hazardous substances and to biological agents at the workplace. Its purpose is to gather and document valid operating and exposure data from workplaces. Data input may result from supervisory obligations of the accident

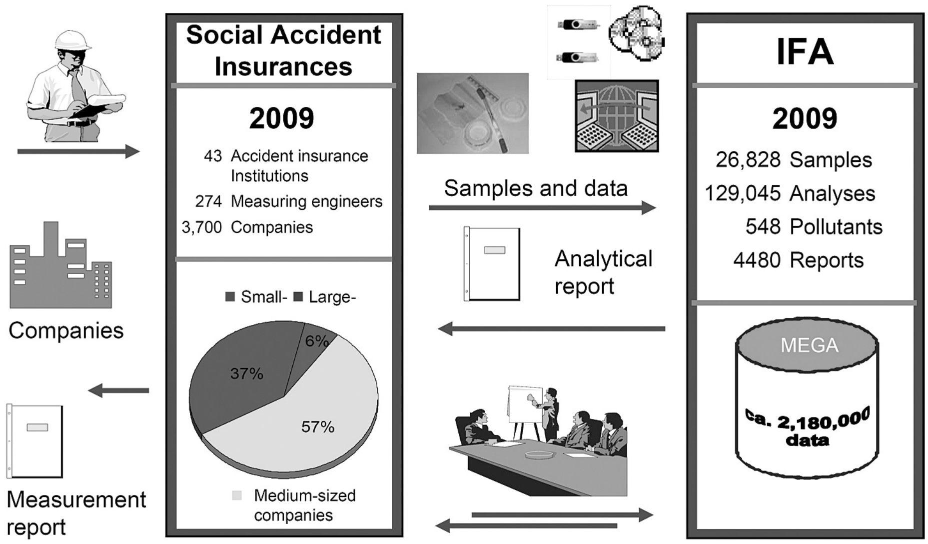

Figure 1. MGU performance in 2009.

insurers or from measurement programmes. Such programmes have e.g. been performed on indoor air, on metalworking fluids and on welders' workplaces. They resulted in additional input beside standard data as collected usually.

The MGU is organized by the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA, formerly abbreviated as BGIA) and the measuring services of the statutory accident insurers. According to the underlying German legal provision (Art. 9, SGB VII) the accident insurers have the task, among others, of monitoring exposure, accident prevention and advising their members. To this end, they maintain measuring services that, in particular, take samples of the air and materials at workplace and gather the necessary information [8; 9]. Along with measurements in connection with their supervisory duties, they also conduct measurement programmes with the goal of publishing their results and making them available to companies for their prevention activities.

Workplace samples are analysed at the IFA's laboratories and other MGU laboratories, the results serving as one basis of an analysis report together with the data documented on the working environment and with instructions for the interpretation of the exposure level. From this, the measuring services issue the measurement report which is made available to the company where the measurement was carried out. On the basis of the measurement report, the accident insurer may initiate suitable occupational safety and health measures.

In 2009, about 27,000 samples were taken in about 3,700 companies and about 130,000 chemical analyses were carried out (**Figure 1**). These data are permanently stored in the exposure database MEGA maintained at the IFA. This database with well over 2 million data records contains all the data surveyed and acquired since 1972 in connection with workplace measurements of the Social Accident Insurers [10 to 12].

Statistical analyses of this data pool lay the foundations to identify and quantify existing or past inhalation-related exposure and measures to prevent occupational diseases and work-related health hazards.

3 Scope and system of MGU data collection

3.1 Overview

MGU data are recorded by means of the specialized OMEGA hazardous substances software [13]. OMEGA is the German acronym for the IT-supported "Organization system for the collection and use of measured data on exposure to hazards at the workplace". The system is based on coding lists, specialized files and record files. It links them together and ensures data workflow from the measuring services via analysis reporting at the IFA through to documentation of the data in the exposure database MEGA.

The software has been developed at the IFA and is available to all employees in the MGU free of charge. The present content and systematic structure of the data collected are developed by the accident insurers' Operating and Exposure Data Acquisition work group and are based primarily on the results of European projects that compared exposure databases in the mid-Nineties. These identified and defined "core information" necessary for a description and assessment of exposure [3; 4; 6].

Efforts are made to determine and describe all factors that may have a significant effect on the measurement result (**Figure 2**). The data also include information on the effect of other emission sources at the site of measurement. Data on the working situation are likewise recorded (normal working situation, preparatory and equipping work, possible worst cases, unforeseeable breakdowns or replicated working situations for investigations into occupational diseases).

3.2 Quality assurance during data acquisition

The MGU data are systematically gathered with the aid of the OMEGA hazardous substances software [13], the software constitute an essential element of quality assurance in the MGU [14]. By not having to transfer the operating, exposure and sampling data a second time manually from paper into the software or vice versa a major source of error is eliminated. The exposure data can be put to multifunctional use without having to be reviewed.

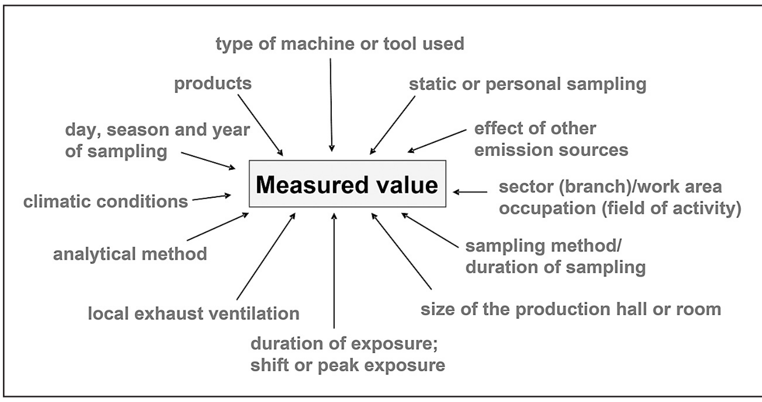

Figure 2. Exposure variables within MGU data acquisition.

Table 1. Completion rates for fields for exposure-related air samples from 1990 to 2007.

Designation of data field	Fields completed	
	Absolute	(%) *
Process number	1,263,084	100
Accident insurer	1,263,084	100
Reason for measurement	1,245,376	99
Individual company work area	1,068,564	85
Sector (branch) of company	1,263,084	100
Work area	1,263,084	100
Occupation (Field of activity)	1,182,938	94
Respiratory protection (Yes/No)	1,051,341	83
Type of respiratory protection	171,527	14
Skin contact	351,321	28
Skin protection employed	343,423	27
Type of skin protection	56,152	4
Machine, tools	812,377	65
Throughput	246,621	20
Processing temperature	116,452	9
Manufacturer of the machine, tools	384,743	30
Type of machine, tools	247,348	20
Year of construction	195,903	16
Mode of operation: continuous/discontinuous	964,198	76
Mode of operation: automatic/manual	940,200	74
Number of shifts per day	812,421	64
Type of working material (products)	686,149	54
Trade name	414,773	33
Manufacturer	335,258	27
Skin protection necessary	271,960	22
Quantity processed	192,691	15
Relevant components	296,899	24
Room (outdoors, enclosed room, below ground, …)	1,262,626	100
Length, width, height	1,188,166	94
Diameter	18,787	1
Natural ventilation	1,155,076	91
Technical (forced) ventilation	1,098,127	87
Air guidance	926,299	73
Air velocity	88,829	7
Influence of other emission sources	605,149	48
Exposure peaks	425,104	34
Emission control measures	931,056	74
Collection of emissions, LEV	1,063,461	84
Heat recovery/return of clean air	609,867	48
Weather (dry, precipitation, …)	1,201,294	95
Wind (light, moderate, strong)	1,151,986	91
Indoor temperature	1,111,298	88
Outdoor temperature	1,007,936	80
Air pressure	563,662	45
Relative humidity	1,020,187	81
Measurement plan (workplace, in-door, climate measurement)	1,258,229	100
Work area situation	481,155	38
Representativeness	1,263,084	100
Duration of exposure	1,254,230	99
Reason for shortened exposure	178,384	14
Sampling date	1,263,084	100
Sampling method (static, personal)	1,263,084	100
Type of sample carrier	1,263,084	100
Sampling system	1,263,084	100
Duration of sampling	1,260,799	100
Volume flow	1,253,258	99

* The figures are rounded to integers.

The data are checked for plausibility and completeness both during data input on site in the company and in the central OMEGA software at the IFA and other MGU laboratories.

3.3 Obligatory and optional data fields

The data collection process has developed steadily over the decades. Starting with a dataset of about 30 items of information per measured value as collected during the period from 1972 to 1989 and expanding to about 150 items in the timeframe from 1990 to 2000, the number of possible data fields that can be filled in has now risen to over 200. **Table 1** presents some of the data fields along with their completion rates as contained in the database for exposure-related air samples from 1990 to 2007. The obligatory fields show a 100% completion rate. The other fields are completed to varying degrees depending on the workplace situation that is being described and assessed.

Extensions to the set of data may arise due to new technologies or legal requirements. Since 2005, for instance, image documents and drawings can be optionally stored into the measurement report and support the assessment of the work area. In an internal questionnaire survey of the accident insurers on measurement reports in 2008, the occupational safety and health supervisors and those processing notifications of suspected cases of occupational diseases came to the conclusion that the current scale of gathered data meets the requirements of the German Hazardous Substances Ordinance and the Technical Rule for Hazardous Substances (TRGS) 400 “Risk assessment for activities involving hazardous substances”. The recorded data may have to accommodate further requests in the near future in connection with REACH.

When conducting evaluations based on the exposure database MEGA it is essential to be aware of the historical developments in data acquisition and bear these in mind in the interpretation of the data. Also required is detailed knowledge of the current state of the data system, e.g. in terms of obligatory and optional fields. Only with this background know-

Table 2. Workplace coding applying MGU and NACE coding.

MGU Group	MGU code/designation	NACE group	NACE code/designation
24xxxx Steel construction, mechanical and vehicle engineering	**242300** Manufacture of agricultural machinery	**DK** Mechanical engineering	**29.3** Manufacture of agricultural and forestry machinery
24xxxx Steel construction, mechanical and vehicle engineering	**249100** Repair shops, motor vehicles	**G** Trade, maintenance and repair of motor vehicles and consumer durables	**50.2** Maintenance and repair of motor vehicles
26xxxx Wood, paper and printing industry	**260550** Plants producing wood chipboard and fibreboard	**DD** Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	**20.20** Manufacture of veneer sheets and wood-based panels
26xxxx Wood, paper and printing industry	**261350** Upholstered furniture, manufacture	**DN** Manufacture of furniture, jewellery, musical instruments, sports goods, games and toys and manufacturing not elsewhere classified; recovery	**36.11** Production of seat furniture

ledge is it possible to undertake technically founded and goal-oriented data searches and selections and avoid misinterpretations of statistical findings. This is why MEGA database evaluations are only performed by skilled specialists and raw MGU data are not passed on to third parties.

3.4 Technical data contained in the MGU

The technical data gathered along with the other MGU data describe (mostly qualitatively) the workplace conditions, e.g. the presence of natural or technical (forced) ventilation and include information on air conditioning and extraction equipment, room size, emission sources in the work area, and weather conditions. Technical information has so far been voluntary.

The degree of completion for these voluntary fields, at an average of 66%, is thoroughly satisfactory, while for measurement programmes such as those on metalworking fluids [15] and in-door air monitoring [16] the figure is significantly higher and in some cases approaching 90%.

4 Coding lists

4.1 Introduction

The MGU data are in most cases indexed by using coding lists uniformly for all operations. Coding refers not only to the sectors (branches) of industry, work areas and occupations, but also, for instance, to technical workplace information, product groups (e.g. GISCODE [17]), sampling methods, analytical methods and to hazardous substances with classifications and limit values. A total of over 30 coding lists are managed and further developed centrally at the IFA. Great importance is attached here to compatibility with existing codes. Training is available for the measurement services to ensure uniform coding.

The coding of sectors (branches) of industry as well as work areas and occupations permits a selection of measured values so that homogenous data collectives can be evaluated [18]. This ensures that data from comparable work areas can be brought together in anonymized form and statistically processed. The three most important coding lists on sectors (branches) of industry, work areas and occupations are explained in greater detail in the following sections.

4.2 The coding of sectors (branches) of industry

For the coding of sectors of industry, there is a MGU coding list [19] based on the index on the system of branches of industry issued in 1979 by the German Federal Office of Statistics [20]. This coding list has been developed further and extended over the decades to meet the MGU's needs and permits the detailed coding of sectors of industry. By July 2008, measured values were available for roughly 650 branches of industry.

The basic classification criterion for the coding developed by the Federal Office of Statistics starting in 1950 was whether a company was mainly engaged in manufacture, trade or the provision of services. Secondly, distinctions were made between the stages in manufacture and trade e.g. processing, construction industry, and wholesale and retail trade, with account also being taken of the type of manufactured and sold goods and provided services [21].

Another coding system for economic activities is the NACE code [22] which was developed by the EU and is frequently used internationally in exposure databases. A comparison of four examples in which coding has been undertaken on the basis of the MGU code and NACE (**Table 2**) shows the differentces between the two coding tables. For classification in a group of sectors, the MGU code tends to stress the initial product processed in a branch of industry. The first two sectors are classified in "metalworking and processing", the second two in "wood processing". In the NACE code, the emphasis is on the difference between manufacture and services or whether the product concerned is either still being further processed (NACE section DD) or intended for the ultimate consumer (NACE section DN).

Further differences arise due to the fact that the system of branches of industry (issued in 1979) was geared to German industry and did not contain any sectors that did not exist or no longer existed in Germany. These, however, are in some cases included in the NACE code applicable throughout the EU. On the other hand, certain sectors of importance in Germany are covered in greater detail than in the internationally coordinated NACE (EU) and ISIC (UN) codings.

At the data collection stage exclusively the MGU code is used. With the aid of a code conversion table, it can be translated into the NACE code in German, English or French. Thus, the basic preconditions are met for using MGU data for a comparison of exposure data at international level. A joint publication (in preparation) on a selection of carcinogenic hazardous substances of the INRS COLCHIC exposure database (France) [23; 24] and the German MEGA database addresses the subject of coding and interfaces between different code types.

4.3 The coding of occupations

The coding list of occupations used within the MGU has been based for over three decades on the code applied by the German Federal Labour Office [25]. The internationally familiar ISCO code (International Standard Classification of Occupations) [26] is not used here, as it is often too unspecific for MGU's requirements. ISCO is geared more to the degree and type of completed training and less to the actually performed tasks which have a stronger bearing on the employee's exposure profile.

4.4 The coding of work areas

Workers engaged in the same occupation may be involved in entirely different work processes. Therefore the MGU codes describe the work situation i.e. the work area by applying a hierarchic level beneath the occupation. By assigning a measured value to a work area, it is possible to define "homogenous exposure groups" as proposed by *Rappaport* et al. [18]. For this level of coding there has so far been no international coding index which is why the classification of the work area follows the MGU's own coding list [19]. Overall, there are about 6,800 different codes for work areas. As of July 2008, measured values were available in the MEGA database for about 4,350 work areas and for about 27,000 combinations of industrial sectors and work areas.

Work area codes are grouped in different work area plans. Work areas which can be found in different branches of industry are included in a general work area plan (**Table 3**). In addition, work areas are listed in about 70 special work area plans assigned to individual branches of industry, e.g. ceramic industry, construction, electroplating, shipping and waste incineration and permit a detailed, sector-based specification of work areas (**Table 4**).

Experience has shown that the number of work areas has to be appropriately defined for each special work area plan. The work areas must not be defined too general as this would hamper analysis of the exposure-relevant work steps with their parameters. On the other hand, the work areas must not be defined too specific, resulting in too few measured values being gathered per work area. As statistical evaluations should only be conducted if enough measurement values exist per collective, there would then be a need to merge work areas into groups again.

If work areas are coded properly then it is possible to identify specific risks to these groups. In a second step risk management measures can be derived and the situation at the work place can be improved.

In the development of exposure scenarios under REACH [27 to 30] the use of hazardous substances and products (preparations) is considered in individual work steps or "identified uses". Here the special MGU work area plans can serve as a valuable guide, particularly when the identified uses are subsequently linked with the demanded ambient conditions of use [31]. This would benefit the handling of REACH processes within the supply chain.

It is therefore proposed that efforts should be made on the international level to establish a strategy for the coding of work areas.

Table 3. General work area plan (extract).

Work area code	Work area designation
1104	Warehouse, general
1131	Conveying, manual
1202	Breaker, charging
1203	Breaker, discharging
1309	Mixing, by hand
1311	Dry mixer, closed, general
1312	Dry mixer, closed, manual charging
1313	Dry mixer, closed, mechanical charging
1506	Caulking, mechanical
1507	Chiselling, manual
1508	Chiselling, mechanical
1511	Sawing
1512	Milling
1513	Abrasive cutting
1620	Weighing room
1621	Weighing by hand
1622	Decanting, general
1643	Tyre fitting
1726	Façade cleaning
1738	Control room
1788	Copying room
1851	Gluing, hotmelt adhesives
1852	Gluing, heat-seal adhesives
3102	Metal inert gas welding (MIG)
3103	Metal active gas welding (MAG)
3105	Tungsten inert gas welding (TIG)
3212	Hard soldering, flame soldering

Table 4. Work areas of special work area plan 5 "Ceramics" (extract).

Work area code	Work area designation
115	Preparation, material charging by hand, in mills and blungers
116	Preparation, mill, wet
117	Preparation, mill, dry
202	Forming, extruder
203	Forming, turning
204	Forming, manual shaping
306	Drying, belt dryer
307	Drying, tunnel dryer
523	Firing, roller kiln, inlet
524	Firing, roller kiln, outlet
601	Post-treatment, grinding
610	Post-treatment, drilling
702	Cleaning with industrial vacuum cleaners
716	Repair of kiln cars

5 The use of exposure data

The exposure data gathered and documented within the MGU are referred to for the assessment of the specific workplace situation in a company. All of the contextual data obtained on site in the company and the measured values, are included in the analysis report issued by the IFA. This is structured in such a way that the accident insurers can convert it into the final measurement report which is delivered to and discussed with the company. This report contains assessments relating to the work area, if necessary also identifying specific measures for improving the hazardous substance situation in the work area.

All the data are documented in the exposure database MEGA for statistical evaluation. This involves, among other things, retrospective approaches in the identification of suspected cases of substance-related occupational diseases and evaluations of the substance-specific exposure levels on the basis of the current state of the art in certain work areas and sectors of industry.

Statistical evaluations of exposures in connection with preventive measures are included, among other things, in EGU recommendations (EGU, Empfehlungen Gefährdungsermittlung der Unfallversicherungsträger) and are available to companies as an aid to risk assessment. Also produced are substance- and process-specific analyses of time trends of exposure levels. Work area registers with retrospective overviews of exposure are published in reports, such as BGIA Report 8/2006e "Exposure to quartz at the workplace" [32]. Analysing about 100,000 measured values, 90-percentiles are given for selected work areas and the data periods evaluated.

Since technical conditions, e.g. the air change rate, are described qualitatively rather than quantitatively, the use of MGU data for deterministic models of exposure is only possible to a limited extent. Quantitative data in the MEGA database, e.g. room volumes, can be used for deriving default values [33] to describe the situation in work areas. Measured hazardous substance values with their ambient conditions are used as an "empirical gold standard" on conditions at work for the validation of exposure models. A number of exposure models are currently available [34 to 38]. Some of them, such as EASE and COSHH Essentials, have already been validated [39 to 41].

MEGA data have been referred to in the validation of the TNO Stoffenmanager [42]. This software is available in Dutch and English for estimating the risk associated with hazardous substances in the form of risk banding [34]. During validation it was checked, firstly, whether the data from MEGA are fundamentally suitable for validation and, secondly, to which extent deviations between the model calculation and measurement values occur. It was possible to include directly a large portion of MEGA variables for the evaluation. Further variables had to be recoded or adopted from free text variables. As a consequence the structure of the database will be further developed in order to fulfil better the requirements for modelling.

The assignment of measured values to work areas is a help to the use of exposure data for risk assessments in connection with REACH. Of the important determinants of the exposure level named in the guidance document R.14 [7], most are already documented in the MGU. Variables containing information on the dustiness of solids will be added in the future.

6 Conclusions

MGU data collection of workplace monitoring data in Germany has been developed over a period of more than three decades. The process has been prompted by changes in legal codes combined with growing needs to gather and document exposure data. The assessments of complex hazardous substance situations in work areas have resulted in the adaptation of the measurement reports to more stringent requirements. In individual cases, this has been ensured by extending the scope of data collection.

Coming back to the question posed in Section 1 of this article, it can be stated that today the data base structure of the MGU system satisfies most requirements listed above. For some variables – still lacking at the moment – plans exist for including them in the future. On the other hand the coding of the work areas within the MGU as described here in detail could be the starting point for an internationally established coding list of tasks or activities. While the coding of branches and job titles is established internationally the use of the coding of tasks or activities is not spread widely. In our opinion efforts have to be made to harmonize a concept of data collection for this important determinant of exposure.

REACH will be a challenging motive force in gathering exposure data. REACH calls for exposure descriptions in the framework of hazardous substances. These can only be generated on the basis of good quality exposure data including detailed contextual information. Additionally a good database structure for workplace descriptions can also be transferred to the risk assessment of other factors such as noise, vibration or physical load.

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