DIFFERENT METHODS OF SAMPLING AND ANALYSIS OF OCCUPATIONAL DUST: EQUIPMENT AND TECHNIQUES

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Abstract: *One of the national legislation mandatory requirements in the SHO domain is the assessment of workers professional exposure to chemical agents in their workplace. One of the methods to make this assessment is to measure this concentration and compare the results with the Threshold Limit Values (TLVs). Industrial processes and chemical agents are both very diversified. This diversity constitutes a problem for the technicians who do the sampling and subsequent analysis. The obstacle becomes even bigger when the technician is not a worker from the company where he is doing the sampling and does not have enough data to plane his work. In order to make proper planning NP EN 689:2008 which was recently published can be consulted for guidance. Occupational dusts are a type of chemical agent that is usually found in ambient air of many working sectors. Dusts can be found in various particle sizes. Occupational dusts have different morphologic/chemical features which result in a different selection of both sampling methodology and analysis. With this paper we intend to point out some guidelines to better identify the type of dust to be sampled, providing different methods of sampling and their associated analytical techniques.*

Keywords: *Chemical agents, Occupational Dust, Sampling Equipment, Methods and Analytical Techniques.*

AS DIFERENTES METODOLOGIAS DE RECOLHA E ANÁLISE DE POEIRAS OCUPACIONAIS: EQUIPAMENTOS E TÉCNICAS

Resumo: *Um dos requisitos obrigatórios referidos na legislação nacional, na área da SHO, é a avaliação da exposição profissional dos trabalhadores aos agentes químicos no ambiente de trabalho. Medir essa concentração e comparar com os valores limite de exposição (VLE) estabelecidos é uma das formas para se proceder a essa avaliação. Os processos industriais assim como, os agentes químicos são muito diversificados. O problema para os técnicos que irão fazer as amostragens e conduzir a análise posterior reside nesta diversidade. Este obstáculo assume maior dimensão quando o técnico que vai realizar a amostragem é externo à empresa e não dispõe de dados suficientes para a preparação do trabalho. Como guia para uma adequada preparação poderá ser seguida a recente NP EN 689:2008. As poeiras ocupacionais são um tipo de agente químico que se encontra presente regularmente no ar ambiente de muitos sectores de actividade. Estas podem-se apresentar em diferentes fases granulométricas. As poeiras ocupacionais apresentam características morfológicas/químicas diferentes que fazem com que a selecção das metodologias de amostragem e análise sejam diferenciadas. Com este artigo pretendemos apontar algumas orientações para um melhor reconhecimento do tipo de poeiras a amostrar, apresentando diferentes metodologias de amostragem e técnicas analíticas associadas.*

Palavras-chave: *Agente químico, Poeiras Ocupacionais, Equipamentos de Amostragem, Metodologias/Técnicas Analíticas*

1. Introduction

Currently, evaluation of occupational exposure of workers to chemicals in the workplace is a concern for health and safety technician, whether by legal obligation or the risk that chemical agents may have for workers health. This assessment consists in the determination of the concentration of these agents in the air of workplaces through methodologies and equipment indicated in standards and their subsequent comparison with reference values, that represent acceptable levels of exposure. It is recommended to use reference values (ELVs) defined in Portuguese Standard 1796 (2007) [1].

In this standard the requirements of the sizes of fractions for measuring particles suspended in air are based on definitions from standard NP EN 481 (2004) [2], using the terminology of the standard NP EN 1540 (2004) [3]. The ELVs contained in the NP1796 (2007) [1] were set based on TLVs - Threshold Limit Values, ACGIH (2006) (American Conference of Governmental Industrial Hygienists). When an agent is not referenced in this standard, may be regarded as the REL (Recommended Exposure Limit) of NIOSH (National Institute for Occupational Safety and Health)

or PEL (Permissible Exposure Limits) from OSHA Occupational Safety & Health Administration).

2. Methodology

The health and safety technician making this assessment, given the diversity of production processes and chemical agents in suspension in air environment, may rely on NP EN 689 (2008) [4] to define its strategy of measurement. However, the statement focuses on solid chemical agents, commonly known, there are occupational dust in ambient air in a wide range of dimensions, resulting from production processes. The particles may result from stationary sources or mobile sources while its size is directly related to its potential to cause harm to health.

The strategy of the evaluation of occupational exposure could be developed in 2 phases, assessment and measurement.

2.1 Strategy of Appreciation

This strategy includes 3 phases:

a) List of chemical agents;

b) Identification of the factors inherent in the workplace;

c) Consideration of the exhibitions.

2.1.1 List of chemical agents

Technician may request a listing of all existing chemical agents at workplace. To make the list you must apply for a number of elements: raw materials, intermediate products, final products, reaction products, by-products and safety data sheets. Based on previous data and being that the gotten values will be compared with the ELVs set in NP 1796 (2007) [1] refers to the classification of occupational dust, according to this standard. The sizes of the particles are classified in the following ways:

- Inhalable particles (IP): particles that are deposited in any region of the respiratory tract with an aerodynamic diameter d50 = 100 μm;

- Thoracic particles (PT): particles that are deposited in the region of the pulmonary channels and gas exchange area, with sizes that range from 0 to 25 μm, with an average aerodynamic diameter d50 = 10 μm;

- Respirable particles (RP): particles being deposited in the gas exchange area with sizes that range from 0 to 10 μm, for a median aerodynamic diameter d50 = 4 μm.

2.1.2 Identification of factors inherent to the workplace

At this stage, processes and procedures are evaluated to determine the potential for exposure to chemicals through a detailed review of some factors, such as:

- Activities;

- Work patterns and techniques (continuous, pauses);

- Production processes;

- Configuration of the workplace;

- Safety measures and procedures;

- Ventilation systems and other forms of engineering control;

- Emission sources;

- Exposure times;

- Type of work (mild, moderate or heavy).

2.1.3 Consideration of exposure

This phase of the exposure assessment includes the identification of potential exposures, the factors of the workplace and their interconnections. This requires a structured approach that can be conducted in three stages:

- Initial review:

    * Listing of all chemical agents;

    * Factors inherent in the workplace;

    * Variables that influence the concentration of chemical agents;

    * Variables related to the actions and individual behaviors of the workers.

- Preliminary study;

- Detailed study.

In these developing appreciation stages of the occupational exposure of workers to chemicals, we will develop the knowledge of agents present in the workplace and it is not necessary in most situations to use all stages of assessment.

After the initial analysis, the next stage, called preliminary study, seeks to obtain quantitative information that can be gained through previous measurements or by comparison with previous work developed in similar cases, fruit of labor of the technician. The detailed study aims to provide reliable and valid information on exposure, when it is close to the threshold value.

2.2. Measurement Strategy

This phase of the measurement strategy will become relevant when exposure of workers to chemicals in the workplace is suspected to be close to the threshold value. In this case, it is necessary to develop a more precise and targeted approach, by means of instrumental and analytical techniques.

In order to develop and achieve the most complete and cost-effective strategy for measuring, whether in terms of human resources for the company providing the service or to the company that will benefit from the service, there are factors that have a high contribution and may add to the representativity of the sampling / measurement.

Among several factors, we consider the following to be the most relevant:

- The selection of workers among all workers exposed, through the careful study of patterns of work and results assessment of preliminary sampling, incurring in the risk of random or systematic variations, within those standards;

- The definition of the type of sampling, between measurements in a fixed station (stationary), in the immediate vicinity of workers or directly over the workers, always remembering to do so at a breathing height;

- Distribution of the sampling time, which must be established to cover most developed activities, being the ideal situation the collection of samples during the whole working period.

3. Methods of Measuring and Monitoring

3.1 Test methods

The test methods applied to sampling may follow the methods of the NIOSH (National Institute for Occupational Safety and Health), OSHA (Occupational Safety & Health Administration), the MDHS (Methods for the Determination of Hazardous Substances - Health and Safety Laboratory) or other equivalent. Table 1 presents some examples of acceptable methods for determining some parameters / chemical agents present in the air of workplaces.

Chemical agents	Method
Particulates not otherwise regulated: Total Respirable	NIOSH 0500 [5] NIOSH 0600 [6]
General methods for sampling and gravimetric analysis of respirable and inhalable dust	MDHS 14/3 [7]
Silica, Crystalline, by XRD	NIOSH 7500 [8]
Silica, Crystalline, by IR	NIOSH 7602 [9]
Crystalline silica in respirable airborne dusts	MDHS 101 [10]

Table 1 - Testing standards for some chemicals (illustrative)

In these methods are defined flows of air to be sampled, maximum and minimum volumes, filters characteristics to use during the collected of the sample, among others, such as equipment collection and analytical methodologies to be employed specifically for each agent to evaluate.

3.2 Equipment collection

The dust sampling equipment should simulate, as nearly as possible what happens in the respiratory tract, where the installation of particles, i.e., the material who should be collected was the particles that have the opportunity to penetrate in the respiratory tract. Only then, the sample is representative of occupational exposure.

Assuming and as stated at the outset, we are focusing specifically on solid chemical agents, commonly called, occupational dust where the air working environment, we talk about collection equipment for such samples.

Sampling should be conducted, according to indications from the norm, with equipment to enable sampling of the inhalable fraction in PVC cassettes and the respirable fraction in cyclones (Higgins-Dewell (HD), aluminum or nylon). It is presented in Figure 1 an example of how to assemble the equipment. The sampling pumps must be calibrated before and after tests, using a calibrator, to ensure the quality of the results as an indication of the NP EN 482 (2008) [11].

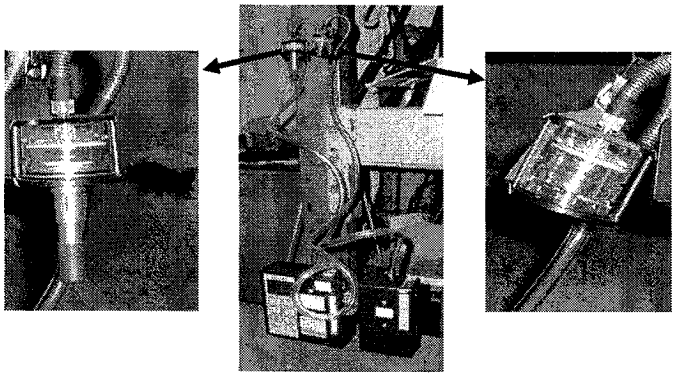

Figure 1 - Example of assembly with two sampling pumps for collection of respirable fraction in the cyclone of aluminum (detail at left) and inhalable fraction in a cassette for air sampling (detail at right).

3.3 Analytical determinations

The analytical determinations of each chemical agent are described in the methodology used. For example, the determination of respirable or inhalable particles is performed by gravimetry, the metal content by spectrophotometry, etc.. In all these cases should be followed the recommendations of methods, including the type of scales, quality of reagents, etc..

4. Conclusions

To enable a representative work, properly executed and conclusive, it is important to apply a strategy well reasoned and supported by accurate data.

The choice of standard or test methods is crucial to the success of the study, with direct implications both at the technical level (equipment, consumables, time of measurement, analytical technique, limit of quantification, etc.) or, in economic terms.

In this type of evaluations the story of the measurements and the accumulated experience are important, particularly in deciding the number of points sampled (representatively / costs) and the best technique for collecting (stationary or personal)

Standard test	Sampling					Analytical Method	VLE-MP (NP1796:2007)
	Filter type	Filter Holder	Flow Rate (l/min)	Volume (liters)	Nº of blanks		
NIOSH 0600	PVC 5µm	Cyclone HD, nylon Aluminum	2,2 1,7 2,5	Min. 20 Max. 400	2 to 10	Gravimetry	3 mg/m^3 (R) (annexe B)
NIOSH 0500	PVC 5µm	Cassette	1 to 2	Min. 7 Max. 133	2 to 10	Gravimetry	10 mg/m^3 (I) (annexe B)
NIOSH 7300	PVC 5µm or MCE 0,8µm	Cassette	1 to 4	Tabulated according to the agent	2 to 10	ICP – AES or AAS	1,5 mg/m$^{3(I)}$ (Ni)
NIOSH 7500	PVC 5µm	Cyclone HD, nylon Aluminum	2,2 1,7 2,5	Min. 400 Max. 1000	2 to 10	DRX	0,025 mg/m^3 (R)

Table 2 - Examples of Application Testing standards for some chemical agents.

5. References

NP 1796 (2007) – Occupational Health and Safety. Occupational exposure limits to chemical agents.

NP EN 481 (2004) – Workplaces atmospheres. Size fraction definitions for measurement of airborne particles.

NP EN 1540 (2004) – Workplaces atmospheres. Terminology.

NP EN 689 (2008) – Workplaces atmospheres. Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy.

NIOSH 0500 (2ª Edition 15/08/94) – Particulates not otherwise regulated, Total

NIOSH 0600 (3ª Edition 15/05/98) – Particulates not otherwise regulated, Respirable

MDHS 14/3 (February 2000) – General methods for sampling and gravimetric analysis of respirable and inhalable dust

NIOSH 7500 (3ª Edition 15/01/98) – Silica, Crystalline, by XRD

NIOSH 7602 (2ª Edition 15/08/94) – Silica, Crystalline, by IR

MDHS 101 (February 2005) – Crystalline silica in respirable airborne dusts

NP EN 482 (2008) - Workplaces atmospheres. General requirements for the performance of procedures for the measurement of chemical agents.