Visualisation of Contaminant Transport and Exposure in the Workplace

Rosén G
National Institute for Working Life, Stockholm, Sweden.

Introduction

Clean air and many air contaminants are under normal conditions invisible. In order to ensure a good air quality it is however desired to actually see the movement of air or the emission and transport of contaminants in it. Methods aimed at the visualisation of air flow, contaminants emission to the air and its transportation out in the work place and to the breathing zone of the worker are therefore important tools for the control of hazardous exposure in the work place.

The reasons for using different visualisation techniques may be divided into purely technical and pedagogical ones. The technical reasons for using the visualisation techniques are obvious. The designers of ventilation have a great interest in studying the air flow in a factory hall, around a certain process or machine, if the design of a local ventilation unit is successful etc.

The background for using visualisation methods of pedagogical reason is the fact that proper use and maintenance of industrial ventilation in most situations are dependent on persons without the deep knowledge about air and contaminant transport phenomena that can be expected from the designer of the systems. There are numerous examples of well designed industrial ventilation systems, not fulfilling it's original function, depending on a lack of knowledge in how to take advantage of and maintain the system in the most effective way. The knowledge in some basic qualities of the system and important air transport phenomena among the staff, supposed to use and take advantage of the ventilation system, is therefore fundamental to reach desired goals. This is of special importance when local ventilation systems are used since the efficiency of the system very often is dependent on the behaviour of the worker.

There are of course a number of methods that can be classified as methods for the visualisation of air flow and contaminant dispersion. This paper describes some of them that have been used in a special project aimed at the identification of ways to reduce exposure to air contaminants in work places (1).

The Dust Lamp

If a spotlight with a parabolic reflector is used, resulting in mainly parallel beams of light, the visibility of dust and smoke in the air is markedly improved. This effect is called the Tyndall effect and is utilised in special dust or Tyndall Lamps (2). The dust lamp is based on the effect that when parallel beams of light are directed to a cloud of fine particles, the most intensively scattered light is in the forward direction.

Smoke Generation

A common principle for the production of smoke for this purpose is to evaporate a mineral oil by heating it with electricity and to mix the vapour into air. The oil will then condense and form a mist. Such apparatus can be found on the market. Some of them are aimed for the visualisation of air flow but others for special effects in theatres, discotheques etc. Hand held smoke emitters are the simplest, cheapest and practically most accessible for air flow visualisation. They are sold in different forms, e.g. small glass tubes or plastic bottles through which air is pumped manually. Time for use of one unit is typically one hour or up to several days.

Also smoke emitters, mainly aimed for fire drills, pressure testing of chimneys etc. are sometime used for air flow studies. They are normally in the form of big tablets that are put in fire and emitting large amounts of smoke.

Graphical Presentation of Area Measurements

By measuring the concentration of an air contaminant at the same time in several points with the help of a real time monitoring instrument it is possible to visualise the spatial distribution of it by making a graphical presentation of data. If the measurements for example are made at a constant distance from the floor and regularly placed measuring points in a grid, it is easy to produce a 3D-graph illustrating how the contaminant concentrations are distributed (3). By manual collection of data it is therefore possible to visualise the spatial distribution if the situation is mainly stable within the time limits for collection of data.

Different standard software packages for computers may be used for the processing of data to a 3D-graph. By also superimposing the graph over a perspective drawing of the measured area the result will very effectively visualise how, for example, contaminants are leaking out from a machine and in what direction the contaminants are transported. By making a series of such measurements and graphical presentations is it possible to visualise the effect of changes like a alteration in the ventilation system.

Graphical Presentation of Measured Parameters in Video

The use of smoke, dust lamp and graphical presentations of area measurements are very important tools for the studies of air contaminant flow in the work place and how the contaminant is dispersed in the work room. Those methods will however only give good indications on how much of the contaminant is reaching the breathing zone.

One method for the visualisation of workers exposure to air contaminants is the PIMEX-method (4). The method is based on the simultaneous use of real time monitoring instruments for the contaminant in question and video recording. The instrument is placed so that it samples in the breathing zone of the worker. The work is video taped with the help of a video camera. The results from the measurements are presented as a graph, which is superimposed in the video picture. Different technical solutions for this have been presented. Equipment that is available on the market uses telemetry to transfer the signal from the instrument to a laptop computer equipped with needed hardware and software for the task. The software makes it possible to present

data as a bar graph or as a time-concentration graph, in both cases continuously updated. The software also facilitates a detailed analysis regarding the variation of concentrations in the breathing zone and it's dependence on the situation in the work place (5, 6).

This method has been used for a variety of applications to visualise the concentration of different air contaminants in the breathing zone and how it relates to factors as design of local ventilation, work practice etc. Typical situations where it has been used are when the contaminant source is close to or handled by the worker e.g. welding, painting and woodworking.

Concluding Remark

A successful control of worker exposure to air contaminants in work places is depending on the experts knowledge about the risk involved with the exposure to the contaminant, how it is emitted from a source and transported to the breathing zone of the worker. This expertise must however be combined with the expertise of the staff in the work place. Tools that make it possible for the experts and the worker to study together and understand important facts are therefore important for a success. The visualisation methods shortly described in this paper are thereby very important tools. With those tools used as a part of a well-planned company project, aimed at the reduction of air contaminant exposure, the chances are good that the goal will be reached without investments in expensive control technology.

References

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