



## **VOLATILE ORGANIC COMPOUNDS: GUIDELINES FROM THE AUSTRIAN WORKING GROUP ON INDOOR AIR**

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### **ABSTRACT**

An indoor air working group at the Austrian Ministry of the Environment has developed guidelines for the evaluation of exposure to Volatile Organic Compounds (VOC). Due to the variability in the composition of the VOC spectrum and diverse effects of different components, a procedure has been recommended based on specified ranges of VOC concentrations, derived from characteristic indoor levels and evaluation of effects observed in epidemiological and experimental studies.

Broad ranges take the limited evidence about the impact of VOC into account as well as the uncertainty resulting from sampling and analytical procedure. Furthermore, in contrast to single air pollutants for which exposure standards can be derived, rather an integrated situation dependent evaluation is advocated: Assessment of VOC mixtures requires a case by case analysis that should include considerations of specific compounds, observed reactions and health problems in exposed individuals.

### **INDEX TERMS**

Guidelines, Health risk, VOC

### **INTRODUCTION**

Public health services are increasingly confronted with inquiries from the public concerning indoor air pollution. Health problems associated with volatile organic compounds (VOC) have in fact become a major concern. After occurrence of health problems, often presenting as unspecific symptoms, complaints about odors or for precautionary reasons analytical laboratories are frequently ordered to perform measurements of VOC.

Evaluation of the results is difficult, the spectrum of VOC in indoor areas having shifted qualitatively and quantitatively over the past few years and often displaying no prominent single compound. As a result, existing criteria for evaluation are only of limited value, especially because they were established more than a decade ago (Scheiblinger et al., 2002).

Therefore the derivation of guidelines for VOC was one of the major objectives of the Working Group on Indoor Air, established by the Austrian Federal Ministry of Environment. The task of this multidisciplinary working group, composed of health professionals, toxicologists, chemists, technicians and lawyers, is to define harmonized procedures for assessment and evaluation of indoor air. Based on toxicological considerations indoor air guideline values for selected air pollutants have been derived (Hutter et al., 2002).

The recommendations are published by the Federal Ministry of Agriculture, Forestry, Environment and Water Management as a loose-leaf edition (Arbeitskreis Innenraumluft 2004, [www.lebensministerium.at/publikationen](http://www.lebensministerium.at/publikationen)). The following guidelines were published: "Indoor Air Evaluation - General Part", "Volatile Organic Compounds (VOC) - General Part", "Tetrachlorethene (TCE)", "Toluene", "Styrene".

### **VOLATILE ORGANIC COMPOUNDS AND HEALTH**

The effects of VOC on health and well being range from minor changes to the sensorium seen with low concentrations to toxic acute and long-term effects at higher concentrations.

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Only a few epidemiological studies about effects of total VOC have been published so far. Previous studies including measurements of VOC concentrations investigated Sick Building Syndrome (SBS) related symptoms. It was hypothesized that indoor air pollutants and particularly VOC were responsible for the prevalence of SBS symptoms. Although available studies of SBS indicate an association between specific symptoms and VOC, no general conclusion regarding the effects of total VOC as characterized by a “sum score” can be drawn (Seifert, 1999).

While some studies reported positive correlation between symptoms and total VOC concentration (e.g. Norbäck et al., 1990; Hodgson et al., 1991; Pitten et al., 2000), others did not (e.g. Skov et al., 1990; Nagda et al., 1991). Several studies even showed a reduced prevalence of symptoms with increasing VOC-concentrations (e.g. Stridh et al. 1993; Sundell et al. 1993).

As mentioned before, it is not clear whether the discrepancy in these results are due to different methods used for VOC measurements or to the different compositions of the VOC mixture. However, in the majority of cases the incidence of symptoms is higher at increased total VOC concentrations.

Even though total VOC concentration may be similar in different environmental settings, one has to consider the individual compounds of total VOC; despite large studies comparing different countries demonstrated gross similarity in average VOC pattern (WHO, 1998).

### GUIDELINES

Due to the variable composition of the VOC spectrum and the individual variation in responses no precise or generalized exposure-response relationship can be assumed. The rules applied typically for the deduction of exposure standards for indoor pollutants cannot be applied given the nature of the exposure-response relationship of total VOC.

Previous attempts to derive a procedure for assessing VOC exposure may be categorized into two groups: one defining specific mixtures of VOCs often encountered in office or home environments and assessing the relationship of exposure concentration and symptoms experimentally (e.g. Mølhave et al., 1991; 1997), subsequently generalizing to a broad range of exposure conditions; the second using representative measurements in indoor environments as a basis and deriving guideline levels statistically arguing that in highly developed societies unhealthy conditions would have already been discovered if they are prevailing in the indoor environment.

*Table 1. Total VOC (“sum score”) and proposed classification.*

VOC concentration (mg/m <sup>3</sup> )	proposed classification
< 0,25	low
0,25 - 0,5	average
0,5 - 1	slightly increased
1 - 3	considerably increased
> 3	strongly increased

Both procedures have limitations and were not adopted by the working group. Instead a guideline was derived starting from a consideration of the measured total VOC concentration that is classified into five ranges and proceeds to steps to be taken depending on the total VOC falling in one of these categories (table 1).

These broad ranges take into account the limited evidence about the impact of VOC and the uncertainty in sampling and analysis. Even if total VOC is classified as “low” further steps are necessary because there is no level no concern. At least the so called SIE, the Situation dependent Integrated Evaluation, has to be performed consisting of an assessment of complaints, of potential sources of exposure, and of the spectrum of VOCs (figure 1).

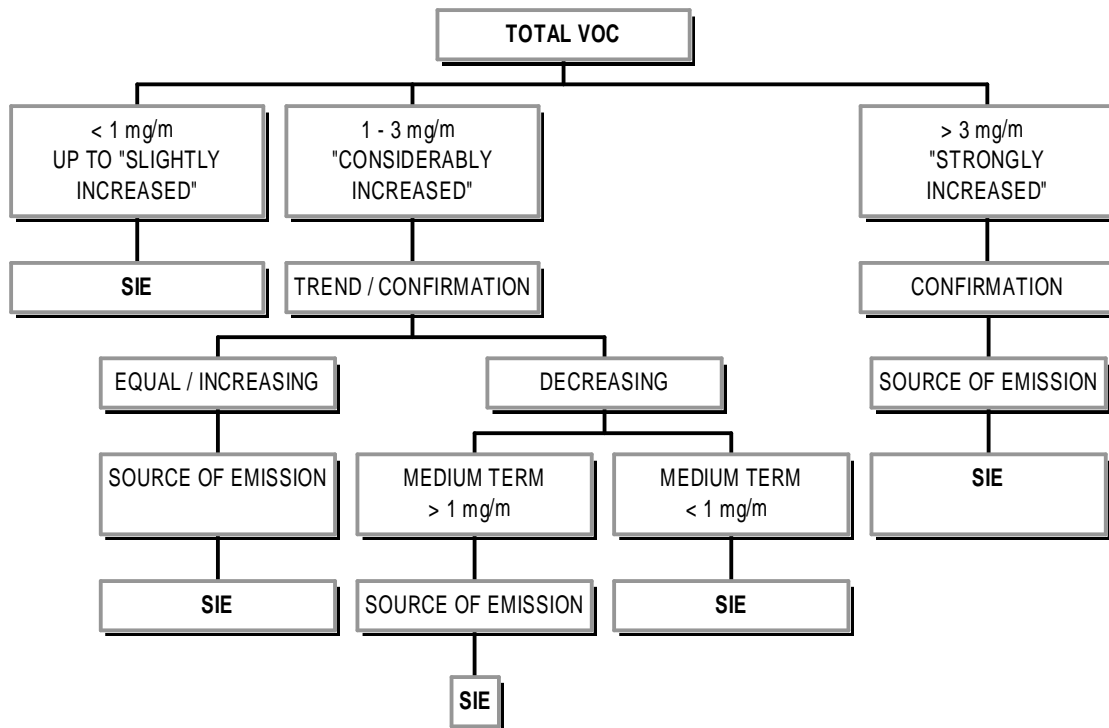


Figure 1. Procedure regarding evaluation of total VOC concentrations (SIE: Situation dependent Integrated Evaluation).

#### EVALUATION OF TOTAL VOC SCORE

It has to be emphasized that total VOC alone are not sufficient to assess a health risk, but can be viewed as a starting point. Without information about the concentrations of substances contributing to total VOC, assessment of total VOC is of little value. Apart from monitoring the trend in VOC concentration during a significant time span, it is essential to determine the concentration of the individual compounds contributing to total VOC in order to assess a possible health risk. Additionally, information about these individual compounds may aid in the identification and removal of the sources of these exposures.

In health risk assessment, carcinogens, compounds with low olfactory threshold and substances with defined guideline levels have to be considered separately.

#### EXAMPLE FOR APPLICATION OF THE “SIE”-SCHEME

Until now in cases of occurrence of bad smells, health complaints and/or complaints of discomfort as well as in cases of personal interest or fears of the inhabitants the following procedure was usually performed: In the first step the total-VOC concentration was measured. If the VOC-concentrations were below  $1 \text{ mg/m}^3$  the investigation was finished. The health complaints were interpreted as not indoor air related.

Applying the recommended scheme of the Austrian Working Group on Indoor Air (Figure 1) the so called Situation dependent Integrated Evaluation “SIE” has to be performed even if total VOCs are below  $1 \text{ mg/m}^3$ . As mentioned above besides total VOC the determination of concentrations of the individual compounds contributing to total VOC is necessary too. In the case of e.g. increased concentrations of individual compounds in the dwelling investigations of the vicinity is essential. So accurate investigations with the focus on specific substances and their intrusion into the dwelling have to be applied if - for example - a company using chemicals can be found nearby.

After moving into a new building inhabitants complained about headaches and occasionally about symptoms of irritation and about bad smells. Measurements after one night with closed windows resulted in a total of  $790 \text{ } \mu\text{g/m}^3$  of VOC. Inspection of the spectrogram did not show dominant compounds. Evaluation of the local conditions within “SIE” revealed that a mechanic in the basement used regularly TCE for cleaning. Specific measurements of TCE in the apartments above the facility showed TCE-concentrations between  $270 \text{ } \mu\text{g/m}^3$  and  $420 \text{ } \mu\text{g/m}^3$  and were above levels recommended by the Austrian Working Group on Indoor Air. By replacing TCE in the works the



problem could be solved and subsequent measurements showed a consistently declining trend of TCE as well as total VOC.

## CONCLUSIONS

The main objective of the Austrian working group on indoor air was to develop a generally applicable and harmonized procedure. This is supposed to aid experts who are familiar with the evaluation of a specific situation and furthermore to guarantee the reliability for often far-reaching decisions.

In conclusion, an assessment of VOC mixtures requires a case by case analysis to allow for an integrated assessment. Applying this approach often involves consolidated measurements of the trend in VOC concentration and identification of the emission sources of the individual compounds.

In the next two years an evaluation of the guideline and the SIE-scheme is planned.

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