Arh. hig. rada toksikol., **30** *(1979) suppl. pp. 1083–1086.*

A NEW METHOD OF PERSONAL MONITORING BY DIRECT-READING, LONG-TERM GAS DETECTOR TUBES

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ABSTRACT

The detector tube method is internationally approved for short-term analysis of the ambient air. An extension of this gas measuring system has been developed, capable of determining the average concentration of atmospheric contaminants in workplaces over a fairly long period of time (up to 8 hours). The new system consists of specially developed long-term detector tubes, calibrated in microlitres, and a peristaltic pump with a rate of flow of 15 cm^3/min.

Many millions of detector tubes are used each year throughout the world for measuring the concentration of hazardous gases and vapours in the atmosphere at workplaces. These tubes permit evaluation of the concentration within a few minutes, but the result of measurement, which is read-off directly on the tube, is valid only for this comparatively short sampling period. Bearing in mind that limit values for toxic substances in workplace atmospheres are very often specified as mean concentrations over a working shift, the measurement of the long-term mean value is of practical importance. A known method utilises sorption on activated charcoal or similar surface-active substances, contained in glass tubes, through which the air sample is passed at a known rate of flow. At the end of the sampling period, which normally takes several hours, the tube contents have to be processed analytically. This requires a well-equipped laboratory and the result of measurement will probably not be available until the next day, at the earliest. This method is costly and time-consuming. We have looked into ways of overcoming this disadvantage and have developed direct--reading, long-term detector tubes, in which the result is available immediately after completion of sampling, without having to resort to laboratory facilities. Here, we profited by the experience which we gained over several decades in the development of short-term detector tubes, of which there are now well over a hundred different types. As earlier investigations have shown, it is not possible to suck air through commercial short-term detector tubes for several hours at the rate of flow on which calibration is based. This would give a volume of over a hundred litres and the water vapour present would have considerable detrimental effects on the indicating preparation. On the other hand, measurements with low rates of flow and, consequently, smaller total volume, have shown that the resultant, longer times of contact of the gas with the indicating preparation lead to undesirable side reactions and adsorption effects, which can have an unforeseeable influence on the result of measurement.

We have, therefore, developed new reagent systems for long-term tubes (Table 1), in which, with a rate of flow of approximately 1 litre/hour, the indicating properties are not affected by water vapour, even with considerable fluctuation in concentration, and the indication (length of discoloration) is proportional to the absolute amount (mass) of gas present.

The latter condition means, for example, that with a gas concentration of 10 ppm and an air sample volume of 8 litres, the length of discoloration would be the same as with a concentration of 80 ppm and a sample volume of 1 litre. In other words, the product of concentration and volume must be constant.

FIG. 1 – Dräger – Polymeter for monitoring work-place atmospheres.

TABLE 1
Dräger long-term tubes.

Long-term detector tube	Catalogue N°	Maximum period of use (hours)	Measuring range absolute unit (20 °C, 1013 mbar)	Measuring range in ppm for maximum period of use	Measuring range in ppm for shorter period of use
Ammonia 10/a-L	67 28 231	4	10 to 100 μl	2.5 to 25 ppm (volume 4 litres in about 4 hours)	20 to 200 ppm (volume 0.5 litre in about 1/2 hour)
Benzene 20/a-L	67 28 221	4	20 to 200 μl	5 to 50 ppm (volume 4 litres in about 4 hours)	20 to 200 ppm (volume 1 litre in about 1 hour)
Carbon dioxide 1000/a-L	67 28 611	4	1 000 to 6 000 μl	250 to 1500 ppm (volume 4 litres in about 4 hours)	1000 to 6000 ppm (volume 1 litre in about 1 hour)
Carbon monoxide 50/a-L	67 28 121	8	50 to 500 μl	6.3 to 63 ppm (volume 8 litres in about 8 hours)	100 to 1000 ppm (volume 0.5 litre in about 1/2 hour)
Chlorine 1/a-L	67 28 421	8	1 to 20 μl	0.13 to 2.5 ppm (volume 8 litres in about 8 hours)	0.5 to 10 ppm (volume 2 litres in about 2 hours)
Chloroprene 5/a-L	67 28 431	4	5 to 100 μl	1.3 to 25 ppm (volume 4 litres in about 4 hours)	5 to 100 ppm (volume 1 litre in about 1 hour)
Hydrocarbons 100/a-L (calibrated for n-octane)	67 28 571	4	100 to 3 000 μl	25 to 750 ppm (volume 4 litres in about 4 hours)	100 to 3000 ppm (volume 1 litre in about 1 hour)
Hydrochloric acid 10/a-L	67 28 581	8	10 to 50 μl	1.3 to 6.3 ppm (volume 8 litres in about 8 hours)	10 to 50 ppm (volume 1 litre in about 1 hour)
Hydrocyanic acid 10/a-L	67 28 441	8	10 to 120 μl	1.3 to 15 ppm (volume 8 litres in about 8 hours)	10 to 120 ppm (volume 1 litre in about 1 hour)
Hydrogen sulphide 5/a-L	67 28 141	8	5 to 60 μl	0.63 to 7.5 ppm (volume 8 litres in about 8 hours)	10 to 120 ppm (volume 0.5 litre in about 1/2 hour)
Nitrogen dioxide 10/a-L	67 28 281	8	10 to 100 μl	1.3 to 13 ppm (volume 8 litres in about 8 hours)	10 to 100 ppm (volume 1 litre in about 1 hour)
Nitrogen oxides 50/a-L ($NO + NO_2$)	67 28 191	4	50 to 350 μl	13 to 88 ppm (volume 4 litres in about 4 hours)	50 to 350 ppm (volume 1 litre in about 1 hour)
Sulphur dioxide 5/a-L	67 28 151	4	5 to 50 μl	1.3 to 13 ppm (volume 4 litres in about 4 hours)	5 to 50 ppm (volume 1 litre in about 1 hour)
Toluene 200/a-L	67 28 271	8	200 to 4 000 μl	25 to 500 ppm (volume 8 litres in about 8 hours)	100 to 2000 ppm (volume 2 litres in about 2 hours)
Trichloroethylene 10/a-L	67 28 291	4	10 to 200 μl	2.5 to 50 ppm (volume 4 litres in about 4 hours)	10 to 200 ppm (volume 1 litre in about 1 hour)
Vinyl chloride 10/a-L	67 28 131	8	10 to 50 μl	1.3 to 6.3 ppm (volume 8 litres in about 8 hours)	10 to 50 ppm (volume 1 litre in about 1 hour)

These remarks show that it is logical to choose for the printed scale in long--term tubes, not concentration units, but absolute units, in our case microlitres. In contrast to short-term tubes, in which a given sample volume is specified, it is possible here to make an intermediate evaluation after expiry of a given, shorter time interval during the measuring period.

Apart from the tube, the other important component of the measuring system is the air supply device. To achieve optimum, overall accuracy, it was required that the pump maintain a constant rate of flow throughout the entire measuring period and regardless of the flow resistance of the tube used.

These requirements are particularly well fulfilled by a peristaltic pump, for the development of which it also had to be borne in mind that it must be able to be carried on the person and used independently of a mains power supply and be able to be used in areas subject to the maximum explosion-protection requirements.

Consideration of all these factors led to the development of an instrument with a rechargeable battery, overall dimensions of 85 mm × 170 mm × 50 mm and a weight of approximately 1 000 g. This peristaltic pump is equipped with a special hose, which is changed before the start of each measurement, to guarantee a constant intake volume with high reliability in operation. The counter built into the pump indicates the number of turns of the rotor. The total volume sucked through is obtained by multiplying this number by the hose constant, determined individually by the manufacturer and printed on each hose pack. The mean concentration during the measuring period in microlitres per litre or cubic centimetres per cubic metre, corresponding to ppm by volume, is obtained by dividing the length of discoloration in microlitres, read-off on the tube, by the total volume in litres.

Long-term tubes for the measurement of ammonia, benzene, carbon dioxide, carbon monoxide, chlorine, chloroprene, hydrocarbons, hydrogen chloride, hydrogen cyanide, hydrogen sulphide, nitrogen dioxide, nitrous fumes, sulphur dioxide, toluene, trichloroethylene and vinyl chloride are now available for the pump described, the Dräger Polymeter. The development of further tube types is under way and is regarded as a high-priority operation.