

# SETTING THE TARGET (MAXIMUM ADMISSIBLE) MEASUREMENT UNCERTAINTY FOR DIFFERENT ANALYTICAL GOALS

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**Problem:** Measurement is fit for the intended use if adequately small uncertainty is reported but, in many cases, no target value for this parameter is set.

**Methodology:** Identification of information available to set the target measurement uncertainty (MU) and definition of adequate algorithms to convert this data into a target MU.

**Scope:** Measurements in chemistry for which no target measurement uncertainty is set

## Target values of conventional parameters

In some analytical fields, target values of relevant conventional performance parameters are set, such as the maximum standard deviation of measurement intermediate precision,  $s_{IP}^{tg}$ , and the maximum,  $\bar{E}_{Max}$ , and minimum,  $\bar{E}_{Min}$ , mean error. Since intermediate precision and mean error can quantify major random and systematic effects, it can be used to estimate the target standard uncertainty,  $u^{tg}$ :

$$u^{tg} = \sqrt{(s_{IP}^{tg})^2 + \left(\frac{\bar{E}_{Max} - \bar{E}_{Min}}{2\sqrt{6}}\right)^2}$$

### Example:

Assessment of the compliance of cadmium in drinking water with Council Directive 98/83/EC [1].

$$u^{tg} = \sqrt{(s_{IP}^{tg})^2 + \left(\frac{\bar{E}_{Max} - \bar{E}_{Min}}{2\sqrt{6}}\right)^2} = \sqrt{\left(\frac{5 \cdot 0.1}{2}\right)^2 + \left(\frac{5 \cdot 0.1}{\sqrt{6}}\right)^2} = 0.32 \mu\text{g L}^{-1}$$



1. Council Directive 98/83/EC on the quality of water intended for human consumption.

## Measurement reproducibility

For operationally defined measurement procedures, whenever the standard deviation,  $s_R$ , of measurement reproducibility is known and considered adequately low for the typical purpose of measurements, the target standard uncertainty,  $u^{tg}$ , is:

$$u^{tg} = s_R$$

The  $u^{tg}$  should not be larger than the larger observed dispersion of results produced by the used procedure.

### Example:

The measurement of pentachlorophenol (PCP) in leather, according to ISO 17070 standard [2], has a reproducibility standard deviation,  $s_R$ , of  $0.6 \text{ mg kg}^{-1}$  between 1-25  $\text{mg kg}^{-1}$ . Therefore, the target standard uncertainty,  $u^{tg}$ , in this range is:

$$u^{tg} = s_R = 0.6 \text{ mg kg}^{-1}$$

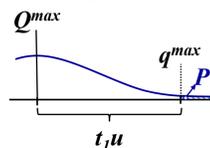


2. ISO 17070:2006, Leather – Chemical tests – Determination of pentachlorophenol content.

## Decision Risk

If compliance of an item with a maximum permissible quantity,  $Q^{max}$ , is decided by taking measurement uncertainty into account for a confidence level of  $1-P$ , measurement results have an approximate normal distribution and a measured quantity value,  $q^{max}$ , is defined beyond which probability of item being non-compliant should be larger than  $1-P$ :

$$u^{tg} = \frac{q^{max} - Q^{max}}{t_1}$$



where  $t_1$  is the one-tailed Student's t for  $(1-P)$  confidence level and the degrees of freedom of the measurement uncertainty,  $u$ .

### Example:

Good manufacturing practice of gold/silver/copper alloys, to be used in gold artefacts, are known to produce gold contents with deviations from the target composition not larger than 5%. Therefore, deviations of gold content larger than 5 % are not satisfactory. For this reason, the target standard uncertainty,  $u^{tg}$ , of these measurements should be:

$$u^{tg} = \frac{5\%}{t_1^{99\%}} = \frac{5\%}{2.93} = 1.7\%$$



## Minimum difference between items

If a variation of  $\alpha$  % of the analysed system or a difference of  $\alpha$  % of characterised items must be distinguished, with a confidence level of 99%, the measured quantity values must be reported with a relative standard uncertainty not larger than  $\alpha/4.2$  [3].

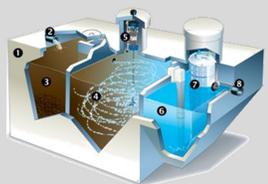
$$u^{tg} = \frac{\alpha}{3\sqrt{2}}$$

3. R. J. N. Bettencourt da Silva, Water 5 (2013) 1279-1302.

### Example:

The optimisation of a wastewater treatment scheme by changing conditions in a pilot plant is controlled by the percentage reduction of the chemical oxygen demand (COD) with the treatment. If COD reduction of 5% are considered relevant, the determination of COD reduction should be carried out with a relative standard uncertainty not larger than 1.2%:

$$u^{tg} = \frac{5\%}{4.2} = 1.2\%$$



## Conclusion:

Target values of conventional performance parameters, measurement reproducibility and quantitative values of the purpose of measurement results can be used to objectively define how good measurements should be; i.e. to set the target measurement uncertainty.