

Measurement Uncertainty

1. Uncertainty in measurements

Statistical error and accidental error are constituents of error caused during a measurement. Uncertainty is the combination of all constituent errors. Uncertainty can be calculated using the following equation:

$$\text{Uncertainty} = \text{square root of } (\text{statistical error}^2 + \text{accidental error}^2)$$

Statistical error is error that does not depend on the statistical method in a series of measured values. Accidental error is error that depends on the statistical method in a series of measured values.

2. Statistical error and accidental error in SFT

Included in statistical error are measurement differences in sampling, the measurement environment, and the individual sampler. The main point to consider here is the certified error of the SFT standard sample in your possession. Certified standard sample error is $\pm 5\%$ (or $\pm 10\%$) as written on the standard certificate.

Included in accidental error is statistical variable error in the X-ray measurement, the size of which depends on the fluorescent X-ray intensity obtained by that measurement. The fluorescent X-ray intensity is greatly affected not only by the primary X-ray intensity (tube current, collimator size, etc.), but also by measurement time and sample thickness. Fluorescent X-ray intensity is estimated by the following equation, taking into consideration accidental error from measurement time.

$$I \pm \text{square root } (I / t) \quad (I: \text{X-ray intensity, } t: \text{measurement time})$$

3. Actual measurement uncertainty in SFT

Actual measurement uncertainty of the SFT as per statistical error contains certified standard sample error. The certified error of an SFT standard sample is usually $\pm 5\%$, but may be $\pm 10\%$ for alloys or for standards less than 1 micron in thickness. Standard deviation for accidental error is calculated from repeated measurements of the same sample at the same spot. In one example, if statistical error is $\pm 5\%$ and accidental error is $\pm 5\%$, then uncertainty is calculated as:

$$\text{Uncertainty} = \text{square root of } 5^2 + 5^2 = \sqrt{50} \approx 7\%$$

4. Conclusion

There are two major factors in measurement uncertainty that make unqualified debate over the accuracy of measurement values meaningless. Statistical error will be at least $\pm 5\%$ (or $\pm 10\%$) as long as a SFT standard sample is used. However, using the proper collimator and setting an adequate measurement time can help in reducing accidental error.