측정 불확도 산정 및 표현
(Expression of Uncertainty in Measurement)

최 성 운*
Choi Sung Woon

Abstract

The ISO "Guide to the Expression of Uncertainty in Measurement (GUM) establishes a unified method for evaluating uncertainty in measurement worldwide. This paper discusses the concepts and procedures of uncertainty evaluation.

Keywords: Uncertainty, Measurement, Unified Method

1. Introduction [3]

1.1 Five Levels of Standards

Working Level : This level includes Gages used at the work center.

Calibration : Standards	These are standards to which working level standards are calibrated.
Functional : Standards	This level of standards is used only in the metrology laboratory of the company for measuring precision work and calibrating other standards.
Reference : Standards	These standards are certified directly to the NIST and are used in lieu of national standards.
National and International Standards :	This is the final authority of measurement to which all standards are traceable.

1.2 Download Direction of Traceability

(1) National Institute of Standards and Technology
(2) Standards Laboratory
(3) Metrology Laboratory
(4) Quality Control System (Inspection Department)
(5) Work Center

* 경원대학교 산업공학과 교수

2.Uncertainty in Measurement [1, 2]

2.1 Uncertainty

2.1.1 Old : Systematic Error, Random Error

New : Type A, Type B (확률에 근거를 둠)

2.1.2 Type A: 반복측정값의 빈도 분포에 근거한 확률밀도 함수에서 구함.

Type B: 기존의 정보 또는 문헌을 통해 측정값이 가질 수 있는 확률밀도 함수를 가정하여 구함.

2.1.3 Type A

$$U_A = U(x) = s(\bar{x}) = [\frac{1}{n(n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2]^{\frac{1}{2}}$$

2.1.4 Type B

$$U_{B_1} = U(x) = \frac{a}{Z_{\frac{\alpha}{2}}} \quad (Z_{\frac{\alpha}{2}} = 1.64, 1.96, 2.58$$

(1) Normal Distribution : :신뢰수준90%,95%,99%)

(2) Rectangular Distribution : $U_{B_2} = U(x) = \frac{a}{\sqrt{3}}$

(3) Triangular Distribution :

(4) U Distribution :

2.1.5 Combined Standard Uncertainty

: Root Sum Square, Additivity of Variance, Propagation

$$U_c = \sqrt{U_A^2 + U_{B_1}^2 + \cdots + U_{B_i}^2}$$

2.1.6 Expanded Uncertainty

U=k U_o k= Coverage Factor (2~3)

2.1.7 교정성적서의 불확도

보고된 측정의 확장 불확도는 정규분포에서 약 95%의 포함확률에 상응하는 Coverage

Factor k=2를 합성 표준 불확도에 곱한 값

2.1.8 유효 자유도 : Welch - Satterthwaite

$$\nu_{eff} = \frac{U_c^4}{\sum_{i=1}^{N} \frac{U_i^4}{\nu_i}} \text{(Truncate)}$$

3. 측정 불확도 예 [4]

3.1 Type A

Given : 표준자석 NMR 교정 : Hall Gaussmeter 를 Transfer Device로 사용
0.1T 표준자석을 n회 반복측정 (x_1, x_2, x_3), ···, x_n

Find : Type A

$$U_A = U(\overline{x}) = \left[\frac{1}{n(n-1)} \sum_{i=1}^{n} (x_i - \overline{x}) \right]^{\frac{1}{2}}$$

3.2 Type B

Given : (1) 표준자석 교정 불확도 b_1 ; 2 σNormal Distribution
(2) NMR Gausmeter 정확도 b_2 Rectangular Distribution
(3) 자장균일도 b_3 Triangular Distribution
(4) Hall Gausmeter 분해능 b_4 U Distribution

Find : Type B

(1) $U_{B_1} = \frac{b_1}{2}$

(2) $U_{B_2} = \frac{b_2}{\sqrt{3}}$

(3) $U_{B_3} = \frac{b_3}{\sqrt{2}}$

(4) $U_{B_4} = \frac{b_4}{\sqrt{2}}$

3.3 Combined Standard Uncertainty

$$U_c = \sqrt{U_A^2 + U_{B_1}^2 + U_{B_2}^2 + U_{B_3}^2 + U_{B_4}^2}$$

3.4 Expanded Uncertainty

$$U = k\ U_c$$
$$= 2\ U_c \quad (95\%)$$

4. Summary

- Uncertainty : Type A, Type B
- Type A : Standard Deviation, Central Limit Theorem
- Type B : Normal, Rectangular, Triangular, U Distribution
- Combined Standard Uncertainty: Propagation
- Expanded Uncertainty: Coverage Factor, Welch - Satterthwaite

References

1.KSA3000:2004, 한국표준협회, 서울, 2004.

2. R.D. Carlsen, J.A. Gerber, J.F. McHugh, Manual of Quality Assurance Procedures and Forms, Prentice Hall, Englewood Ciffs, NJ, 1992.

3. B.Wortman, CQE Primer, Quality Conucil of Indiana, 2005.

4. http://kolas.go.kr