The Discussion for Measurement Uncertainty

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Abstract. The source and development for measurement uncertain were summaried in this paper. Measurement uncertainty and measurement error were analyzed. The important significance for evaluating uncertainty of measurement result was clarified.

1.Introduction

For a long time, people were continuing to seek the best way to estimate the measured value, and scientifically to evaluate the quality of the measurement result. Due to the presence of measurement error, coupled with the measured self-definition and error correction which were not perfect and other reasons, the real value was difficult to accurately reproduce and measurement result was with uncertainty. The term "Uncertainty " originated in the uncertainty principle which was first proposed in the field of quantum mechanics by German physicist Heisenbreg in 1927. In 1963 Eisenhart in US NBS (American National Standards Institute) was first proposed to quantify the recommendation of uncertainty in the measurement calibration. Since 1970, the United States NBS promoted MAP (Measurement Assurance Program), which explicitly adopted the representation of uncertainty. Metrology department of some countries started to use uncertainty sequentially. Measurement uncertainty of the basic concepts and assessment methods had begun to be accepted, which was basis for the exchange of many areas of science and technology, economy, trade and so on. Currently we were also pending in-depth study in these areas: establish measurement model, the main method of determining the source of uncertainty, multiple variables case, general (engineering) evaluation of measurement uncertainty, and applicable to the case of non-normal distribution, small sample Bayesian estimation, robust automation estimate, dynamic measurement problems. Currently measurement uncertainty was applied with the following main areas: building, saving and comparing measurement standards and reference materials in the international and national; measurement certification, metrological confirmation, quality certification and laboratory accreditation activities; calibration and verification of measuring instruments; production process quality assurance and control, and inspection and testing of products; scientific and engineering measurements, and trade settlement, health, safety, environmental monitoring and resource measurements, etc. Evaluation of the measurement results of the above cases, could be broadly understood as conceptual and theoretical test, measurement method, complex components and systems analysis.

2.The Connotation of Measurement Uncertainty

Measurement uncertainty was associated with the measurement result, and characterized reasonable dispersion parameters of measurand. That definition included the following three meanings:

(1) That parameter was a dispersion parameter. The parameter quantified the quality of the measurement result, which could be a standard deviation or the given multiple, or could be description of the half-width of the confidence interval level.

(2) That parameters were generally made up of several components, which were collectively referred to as the uncertainty components. The key was reasonably to estimate the proportion of these components of uncertainty. Preferably we should know the reliability of these components. For convenience of handling problems, we wouldl assess these problems fall into two components,

which were A type evaluation of component and B type evaluation of component. A type evaluation of component was experimental standard deviation based on the statistical distribution of a series of measurement data. B type evaluation of component was standard deviation based on experience or probability distribution assumed form other information.

(3) That parameter was used to completely characterized the measurement result. Complete characterization of the measurement result should include two parts: the best estimate of the measured parameters and dispersion. Contribute to the measurement uncertainty of the section should include all uncertainty components, in which, in addition to the inevitable impact on the measurement result of random contribute, including of course the impact caused by the system. Such as components about the correction value and reference characterization, all contributed to the dispersion.

In principle, ,all the sources of measurement uncertainty which were the factors influencing the measurement result should be taken into account. Firstly, we must focus on building a mathematical model of the relationship between measurement, and strat from finding the quantitative relationship between input, influence quantity and output. Secondly in order to simplify the analysis and processing methods, under the premise of figuring out major source of uncertainty, we could discard uncertainty minor components while retain the main components of uncertainty. So that a reasonable and effective measure of uncertainty to be assessed.

A measurement uncertainty with the standard deviation called Standard Uncertainty. Uncertainty evaluation method whih the statistical analysis of sample observations called Type A Evaluation of Uncertainty, or called Type B Evaluation of Uncertainty. Also including Combined standard Uncertainty and Expanded Uncertainty.

3.The Sources of Measurement Uncertainty

Measurement Result was one of measuring elements. And other measuring elements, such as the measurement objects, measurement of resources, environment measurement and so on, would produce different effects on the measurement result in the measurement process. All elements that would have an impact on the measurement result, were the sources of measurement uncertainty. They could be due to the following reasons:

(1) Definition of the measurement was incomplete or imperfect.

(2) Define methods to reproduce the measured was unsatisfactory.

(3) Measurement samples were not representative enough. That’s to say, the measurement sample could not be fully representative of the defined measured.

(4) The understanding of measurement process affected by the environmental impact is not comprehensive.

(5) Analog instrument readings inaccurate.

(6) Limitations on the instrumental performance.

(7) The standard value of measurement standards and reference materials was uncertain.

(8) Constant referenced or other parameter referenced was not accurate.

(9) Approximation or assumption about measurement methods and procedures.

(10) On the face of it the same measurement conditions, repeated observations of measured were changing.

(11) In case there was a system effect (error), we should try to find out the degree of influence, and correct the measurement result. Residual effect after correction should be treated as a random effect, be considered in the evaluation of measurement uncertainty.

(12) In some cases, we needed to change certain measurement conditions, or within a longer period of time specified evaluation the change of measurement result. At the same time, the dispersion of the measured values caused by corresponding conditions change was measurement uncertainty of the results under the measurement conditions.

4. Measurement Uncertain and Measurement error

Measurement error was the difference between the measurement result and the true value. Since the true value was the ideal concept, in some measurement occasions could only get conventional true value. Strictly speaking, the conventional true value containing the corresponding uncertainty and the imperfect definition of measured caused errors which was unknown. Accordingly, although people desired to know measurement result how far away from the true value，yet that could not be known strictly. People turned to concern the credibility of measurement result. So introducing a reasonable characterization of dispersion parameters that was the concept of measurement uncertainty was necessary. Only with the definition "Measurement Uncertainty" to assess the value of the uncertainty of measurement result, was more reasonable comprehensive. The smaller uncertainty was, the better quality of the measurement result with great value was. And it was accompanied by high quality measurement. On the contrary, the result was the opposite. There were both connections and completely different places between definition of measurement uncertainty and measurement error. The so-called contact was that both were concerned with the measurement result. And they both were reflected in the quality of the measurement result from a different perspective. The former was uncertain of the extent of the measurement result and the latter was the difference between the Measurement result and the true value. For the former, it was completely subjective to estimate based on the master data of the measurement result. The latter in the strict sense was subjective unknowable, but in the case of the known conventional true value the measurement result was knowable. Measurement uncertainty to some extent, also reflected the lack of understanding for the "true value" of measured. Reasonably be attributed to the measured value by measuring was not unique, but there were many possible values. We did not know where was the "true value", but could only get a best estimate. However, the "true value" was within the range of uncertainty of the best estimate. That was consistent with the degree of awareness of the real world. The use value of measurement result depended on the value of uncertainty, which became an important indicator with operation and reasonable characterization measurement quality. Measurement error was mainly used to analyze the source of errors in the measurement process. Through the error analysis, we tried to take measures to achieve the purpose of reducing, amending and eliminating errors, and tried to improve the quality of measurement. Of course, it could also be used for errors the analysis and processing of the final measurement result. Finally, before the evaluation of the measurement result, the data of the measurement result was required proper statistical analysis and processing to get the best estimate. At the same time, according to the relevant measurement information, with the evaluation and representation of measurement uncertainty, we obtained the best and reasonable estimate of measurement uncertainty. In short, the measurement uncertainty and measurement error were two different concepts and should not be confused and misused.

With social progress and development of technology, it had been recognized that we only unify the unit of measurement in measuring activities. Since the assessment and presentation of the results of measurements inconsistent, it caused a lot of inconvenience in domestic and international technology exchange including metering, trade talks. In particular, in many fields of today's rapid development of science and engineering precision measurements, it was urgently need a unified assessment and presentation reflecting the quality of the measurement result worldwide. That wouldl undoubtedly have a more profound impact in promoting scientific and technological progress and economic exchanges in the world.

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