**Certification bodies play an important role**

**in the NMAC of bulk nuclear facilities**

**in China**

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**Abstract**

In recent years, the threat of international nuclear terrorism has become increasingly severe, and the risk of nuclear material diffusion and loss is also increasing. In order to ensure the safety of human beings and the international community and prevent the theft and illegal transfer of nuclear materials, effective technical means must be adopted to accounting and control nuclear materials. The accuracy of nuclear material measurement needs to be evaluated with uncertainty. 6 ITVs have been issued for the protection and calculation of nuclear materials by IAEA, in 1983, 1987, 1988, 1993, 2000 and 2010, respectively. Both the facilities and the inspection agencies need to measure the reference value of the method performance indicators to determine the volume, quality or isotopic composition of the measured objects. The target value can be used as a reference standard to determine the effectiveness of the measurement. The realization of international target value depends on a variety of factors. According to the actual situation in China, this paper will discuss the aspects of the uncertainty, the measurement of the holdup, the requirement of the standard material, the comparison activities, the establishment of the certification organization, the development of the measurement software and so on.

**Key words:**

**ITVs; NMAC; safeguards; sub item uncertainty; DA; NDA; comparison.**

With the worldwide rejuvenation of nuclear power and the rapid development of nuclear technology industry, the application of nuclear materials and nuclear technology is more extensive, and the risk of nuclear material diffusion and loss is also increasing. In recent years, the threat of international nuclear terrorism is becoming more and more serious, especially after the "9.11" event in the United States. The international community has caused unprecedented attention to nuclear security and increased the awareness of nuclear security. With the rapid development of nuclear power in China, the activities of production, storage, transportation and use of nuclear materials will be greatly increased. In order to ensure the safe development of the nuclear industry and prevent the theft and illegal transfer of nuclear materials, it is necessary to use effective technical means and evaluation methods to accounting and control nuclear materials.

The accuracy of nuclear material measurement needs to be evaluated with uncertainty. 6 ITVs have been issued for the protection and accounting of nuclear materials by IAEA, in 1983, 1987, 1988, 1993, 2000 and 2010, respectively. Both the facilities and the inspection agencies need to measure the reference value of the method performance indicators to determine the volume, quality or isotopic composition of the measured objects. The target value can be used as a reference standard to determine the effectiveness of the measurement. The realization of international target value depends on a variety of factors. This article will discuss the requirements of the regulations, the uncertainty of the sub item, the measurement of the holdup, the need of the standard material, the development of the comparison activities, the establishment of the certification organization, the development of the measurement software and so on.

**1. Regulation requirements**

The domestic law stipulates that the precision and accuracy of the method for measuring bulk materials shall meet the requirements of the state for the uncertainty of MUF measurement in nuclear material evaluation. As shown in the following table, the uncertainty of each parameter, material, method, and so on is not specified, and the future reference to the ITVs value of IAEA will be challenged.

Table 1 the relative standard deviation limits of closed material accounting MUF for various facilities

|  |  |
| --- | --- |
| **Type of nuclear facility** | **σ(MUF)（%）** |
| U enrichment | 0.2 |
| U processing | 0.3 |
| Pu processing | 0.5 |
| U reprocessing | 0.8 |
| Pu reprocessing | 1.0 |

**2. The subitem error determines the total error**

In production practice, all kinds of errors are superimposed and transmitted each other. In the bulk nuclear facilities, the total error variance is influenced by random error, long term system error and short term system error. A certain domestic PWR assembly factory makes statistics on the three errors. For example, it can be seen that the contribution of the random error variance to the total error is very small. Long term systematic error variance accounts for about 99% of the total error variance.In order to make MUF closer to the real value, in accounting, we need to seize the key main error factors, improve the measurement system, and improve the measurement accuracy.

|  |  |  |  |
| --- | --- | --- | --- |
|  | The proportion of random error variance to total error variance**%** | The proportion of l**ong term systematic error variance** to total error variance**%** | The proportion of short **term systematic error variance** to total error variance**%** |
| Total weighing | 0.08 | 50.64 | -- |
| Analysis methods | 0.874 | 15.91 | 0.7 |
| Sampling method | 0.05 | 32.41 | -- |
| Total | 0.977 | 98.96 | 0.7 |

**3. Application in the transfer of nuclear materials**

The international target value can be used as the error parameter of the shipper and the actual error parameter of the receiving party for error propagation. The relative standard deviation of one party's weighing system error and random error is close to no more than 0.05% and the maximum error of the other side is not more than 0.1%. The relative standard deviation of the nuclear material is not more than 0.1%, and it is appropriate to use 0.1% as the criterion for determining the accept-shipping difference.

**4. Unable to achieve in the measurement of holdup**

There is no very effective scientific method to estimate the amount of holdup in the equipment and pipeline of the bulk plant. The domestic regulations require that all the data in the fuel cycle should be the actual measurement value, but the holdup in the equipment pipe can not be measured and can not meet the requirements of the accounting evaluation. At present, the nuclear facility mainly adopts the empirical estimation method to estimate the amount of holdup in process equipment and pipelines, and the uncertainty is relatively large. In measuring the amount of holdup, the international target value can not be achieved.

**5 The standard substance is the criterion**

Nuclear materials and other radioactive materials need to be monitored during the operation of nuclear facilities, which may contain 235U, 239Pu and other special nuclear materials with unknown quantities, and its physical and chemical forms are very complex, and the distribution of matrix and uranium and plutonium may be extremely uneven, which makes it difficult to analyze. In order to ensure the accuracy of the measurement, the measuring instruments and methods must be calibrated and calibrated by the standard substance (RM) that can be traced to the international SI standard in each measurement.

The preparation of standard material is made by the unit in accordance with the needs of the project, selecting a batch of physical and chemical properties, characteristics, and stable sources of raw materials, prepared, mixed and separated according to a specific method. After completion of the preparation, uniformity and stability tests shall be carried out. After the adoption of the test, the unit needs to select at least 6-8 peers, setting the standard substance, and the value setting process needs to be traced to international standards. Finally, the unit needs to apply to the relevant administrative department to obtain the certificate.

At present, there are 33 batch and 113 uranium standard substances in China, including 109 standard materials for one grade and 4 standard material for grade two, including 47 uranium ore, 62 nuclear materials and 4 others. The standard material of nuclear material is basically pure uranium products, and there is little difference between different matrix (uranium dioxide, uranium eight oxidation, uranium hexafluoride, etc.). These standard substances can be used in the nuclear fuel cycle facilities. However, with the rapid development of nuclear power in recent years, the production of nuclear fuel has been increasing, and the whole nuclear fuel cycle system has a huge demand for uranium standard substances, and the development of standard materials will take at least three years, and there is a risk of exhaustion. The fast reactor fuel is a low enriched uranium with a U-235 enrichment of close to 20%. The highest existing uranium standard substance is only 8%; the future use of the MOX fuel component is the uranium plutonium mixture, which is not consistent with the existing matrix of the existing uranium standard substances, and these differences will affect the measurement results. The thorium molten salt reactor requires thorium reference material, and there is no such standard material in China.

The measurement of NDA equipment needs calibration. It is urgent to develop standard of U3O8 product tank, uranium hexafluoride 30B tank and waste tank. It can not only improve the accuracy of verification measurement, but also promote the development of NDA technology in China.

**6 Necessary to carry out comparative activities in various fields**

The target value includes the random error and the system error. It is necessary to carry out the experiment and data comparison for each material and each method of analysis and measurement to get the effective uncertainty target value. Uranium forms are mainly uranium hexafluoride (depleted, natural, low concentration), natural uranium, low enriched uranium, uranium oxide, uranium metal. Taking the measurement of 235U enrichment as an example, it can be divided into DA and NDA methods. As shown in the following table, if HpGe spectrometer is used to measure the enrichment of U, the method of infinite thickness can be used, and the method of peak area ratio also can be used, namely use fram analysis.

With regard to the comparison of the NDA, as early as 2001-2004, the CTBT interim Technical Secretariat of the comprehensive nuclear test ban treaty organized the international comparison and analysis of the 1 aerosol samples every year; In 1995, China carried out UF6 comparison activities.

With regard to DA analysis, CIAE participated in the "nuclear safeguards measurement evaluation" program organized by the NBL of the US Department of energy, for the comparison of uranium content and isotopic analysis capability of uranium samples.

Comparison activities involve many factors such as sample preparation, distribution, transportation of radioactive materials, activity organization and other factors. It will be faced with many challenges in the future.

**7. Establishment of a certification body**

The target values of each sub item uncertainty need to be approved by the competent authorities before they can be issued and used. The communication between different units and experience feedback need to be led by organization.

**8. Development software**

The MUF evaluation involves more data and more complex calculation. It is troublesome and easy to make mistakes by hand. The 404 companies in China use Delphi programming language to design MUF evaluation software, and calculate the random error variance, long-term system error variance and short-term systematic error variance.

**9. Conclusion**

To establish and improve the target value of uncertainty will be of great significance to improving the accounting and control of nuclear materials in China, making relevant regulations and standards, developing relevant technical research, establishing certification bodies, carrying out comparison activities in various fields, and strengthening the exchange of experience in various nuclear facilities. It is a challenge to be faced with in the future.

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