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REGULATORY GUIDE 5.18

LIMIT OF ERROR CONCEPTS AND PRINCIPLES OF CALCULATION IN NUCLEAR MATERIALS CONTROL

A. INTRODUCTION

Section 70.51 of Part 70 of Title 10 of the Code of Federal Regulations requires certain AEC licensees authorized to possess special nuclear material to calculate statistical limits of error as part of their material control and accounting procedures for use in assuring that special nuclear material in their possession is accounted for. This guide identifies concepts, principles, and referenced methods that are acceptable to the Regulatory staff for calculating such limits of error.

B. DISCUSSION

Statistical controls are required as an integral part of special nuclear materials control and accounting systems to assure that licensees of fuel processing and fuel fabrication facilities effectively account for the special nuclear material they possess and localize losses when they occur. A primary statistical indicator of control is the quantity of material unaccounted for, which is the observed difference between the amount of material that should be on hand (book inventory) and the amount of material determined as physically on hand (ending inventory). Another indicator is an observed shipper-receiver difference, which results from comparing two independent determinations of transferred material. Essential to a comprehensive evaluation of the significance of these indicators are statistical techniques using associated limits of error for testing whether detected imbalances may be attributable to measurement error, biases other than those due to measurement, possible diversions, or other factors.

In the treatment of measurement data, the concept of a systematic error is important. A systematic error is said to have occurred when all members of a subset of the measured values are shifted in the same direction and by the same amount. This shift changes the expected values of the measurements, and the effect of the shift can therefore be thought of as a bias. When the shift is itself a random variable characterized by a mean and variance, various statistical procedures can be employed to distinguish the random components due to systematic effects from those due to "purely random" effects. When scrutinizing a particular measurement procedure, it is imperative to differentiate between systematic effects which behave like biases and those which are created by random phenomena. In particular, biases do not "propagate" in the same way as do random variables.

Subcommittee N15-3 of the American National Standards Institute (ANSI) Standards Committee N15, Methods of Nuclear Materials Control, has developed a standard for calculating limits of error. This standard is designated ANSI N15.16, "Limit of Error Concepts and Principles of Calculation in Nuclear Materials Control." The limit of error is defined in 10 CFR Part 70 as the uncertainty component used in constructing a 95% confidence interval associated with a quantity after any recognized bias has been eliminated or its effect accounted for. Regulatory Guide 5.3, "Statistical Terminology and Notation for Nuclear Materials Management," dated February 2, 1973, states that limit of error is construed as the uncertainty component used to construct a 95% confidence interval and states, in addition, that the uncertainty component should include systematic as well as random errors. The new ANSI standard N15.16, however, defines limit of error as twice the standard deviation of the estimator. This is not consistent with 10 CFR Part 70 and Regulatory Guide 5.3 since it does not always result in 95% confidence intervals.

C. REGULATORY POSITION

The concepts, principles, and referenced methods for calculating limits of error contained in the final draft of ANSI N15.16, "Limit of Error Concepts and Principles of Calculation in Nuclear Materials Control,"[1] are generally acceptable to the Regulatory staff for use in nuclear material control and accounting procedures, subject to the following:

1. The calculated limits of error defined in Section 3.2 of the standard should be based on 95% confidence intervals for the estimator, which must consider the effective degrees of freedom associated with the estimated variance.

2. Section 4.6 of the standard should be interpreted to mean that mistakes and blunders arising from the recording, processing, or reporting of measurement data, whenever they are appropriately identified, should be excluded from the input to a limit of error calculation.

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[1] Copies may be obtained from the Institute of Nuclear Materials Management, 505 King Ave., Columbus, Ohio 43201, Attn: Mr. H. L. Toy.