Statistical Quality Value for Performance of BDMS Flow Measurements

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In February 1993, The United States and the Russian Federation signed an agreement allowing the purchase of 500 metric tons of highly enriched uranium to be extracted from dismantled Russian nuclear warheads and blended down to be used in American nuclear power plants. Embedded in this agreement was the stipulation of Transparency. Transparency is defined as "Agreed upon measures which build confidence that the arms control and nonproliferation objectives of the HEU agreement are met", as defined by the U.S. Department of Energy (DOE). One of the aspects of this transparency, and perhaps the most important, is the Blend Down Monitoring System[1] (BDMS), which monitors the blending of high enriched uranium (HEU) with low enriched uranium. The Flow Monitor[1] (FM) is one of two BDMS components. It measures the mass flow rate of fissile material on a pipe by observing the time of flight of fission products created in the fissile flow by neutrons from a Cf-252 source.

Though the flow measurement process is straightforward, the actual detector signals are rather hard to interpret and thus statistical parameters must be identified pertaining to the quality of the flow measurements[2]. The process by which we determine the adequacy, or the "quality", of the measurement is the topic of this research.

Once sufficient data is collected from the detectors, an iterative process is used to essentially match the measured detector profile to a pre-calculated profile with no noise. Once an approximate match is concluded, the pre-calculated profile is subtracted from the signal, and statistical parameters of the residual noise are determined. The adequacy of this measurement, presently referred to as "quality" is determined by taking a variation of the Snedecor-Fisher F test[3] of the variances of each of the signals. This F test is a measure of the existence of flow in the pipe by comparing the variance of the residual noise to that of the actual signal. The residual noise in this case is taken as the signal without flow. If the variance of the noise is less than that of the signal, and if there is significant difference between the two variances, then the subtraction was successful to a degree measured by the F test, it represents a probability that there is flow in the pipe.

The goal of this research is to analyze and quantify the existence of a noticeable distribution of quality values even if no flow is assumed. Through Monte Carlo analysis of simulations, this paper studies the statistical behavior of the quality value, and it presents the probability of obtaining a particular quality value when there is no flow in the pipe (i.e., the false-detection probability).

REFERENCES

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