Estimating Root-Zone Moisture and Evapotranspiration With AVHRR Data*

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WEB INTERFACE FOR CONTROL OF SPENT FUEL MEASUREMENTS AT FCF

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ABSTRACT

The material control and accountancy system for the Fuel Conditioning Facility (FCF) initially uses calculated values for the mass flows of irradiated EBR-II driver fuel to be processed in the electrorefiner. These calculated values are continually verified by measurements performed by the Analytical Laboratory (AL) on samples from the fuel element chopper retained for each chopper batch. Measured values include U and Pu masses, U and Pu isotopic fractions, and burnup (via La and Tc). When the measured data become available, it is necessary to determine if the measured and calculated data are consistent. This verification involves accessing two databases and performing standard statistical analyses to produce control charts for these measurements. These procedures can now be invoked via a Web interface providing: a timely and efficient control of these measurements, a user-friendly interface, off-site remote access to the data, and a convenient means of studying correlations among the data. This paper will present the architecture of the interface and a description of the control procedures, as well as examples of the control charts and correlations.

I. INTRODUCTION

As part of the EBR-II Spent Fuel Demonstration Project in the Fuel Conditioning Facility (FCF), irradiated subassemblies are dismantled; elements containing Zr-alloy fuel are chopped in the element chopper; and segments of the chopped elements are loaded into fuel dissolution or anode baskets for processing in the electrorefiner. Operation of the FCF requires accurate estimates of the masses, compositions, decay heat and activity of these chopped fuel segments. The Mass Tracking (MTG) system initially uses computed estimates of these quantities derived from ISOZ files maintained in the Physics Analysis Database (PADB). These calculated or theoretical ISOZ files are based on the REBUS-3, RCT, and ORIGEN-RA codes, and the experimental validation of this methodology for the binary and ternary Zr-alloy fuel has been documented in References 8 and 9.

These calculated values are continually verified by measurements performed by the Analytical Laboratory on samples retained from the element chopper. Routine measurements on these samples include:

- Sample Mass
- U Mass / Sample Mass
- Pu Mass / Sample Mass
- Zr Mass / Sample Mass
- Na Mass / Sample Mass
- La Mass / Sample Mass
- Tc Mass / Sample Mass
- U Isotopic Fractions (\(^{234}\text{U}/\text{U}, ^{235}\text{U}/\text{U}, ^{236}\text{U}/\text{U}, \text{and } ^{238}\text{U}/\text{U})
- Pu Isotopic Fractions (\(^{238}\text{Pu}/\text{Pu}, ^{239}\text{Pu}/\text{Pu}, \text{and } ^{239}\text{Pu}/\text{Pu}).

When the measured data become available, it is necessary to determine if the measured and calculated data are consistent. If so, the MTG System retains the calculated data. If measured and calculated data are not consistent, measurements must be repeated on a backup sample. Knowledge of the uncertainties in both the measured and calculated data is fundamental both to determining whether the data are consistent and to determining which of the data are to be used. Furthermore, variance propagation of the errors associated with these data provides uncertainties in the inventory difference of the special nuclear materials. Both variance propagation and measurement control are required by DOE order concerning control and accountability of nuclear materials.

Initial determination of the bias and uncertainties in the measured and calculated data was necessarily based on very limited available validation data. However, continued operation of the FCF has already processed 100 EBR-II driver subassemblies as part of the Spent Fuel Demonstration Project, yielding to date measurements on over 150 chopped driver fuel segment samples. This extensive database of measured and theoretical values of masses and compositions of samples of irradiated fuel taken from the element chopper allows careful statistical analysis of both the biases and uncertainties in these measurements.
values. The procedures for comparing (and accepting or rejecting) the measured and calculated values and evaluating the associated errors have been implemented through a World Wide Web interface. The interface is a useful tool that allows analysts to efficiently review both databases of measured and calculated data, to display measurement control charts graphically, and to perform the necessary statistical tests. The following sections describe the measurement control procedures and the web interface.

II. INTERFACE FUNCTIONS

The use of an Internet browser to develop the interface yields a number of advantages. The Internet browser technology is easy to adapt and the ability to use HTML, Java Script and Java languages can provide the programmer with a number of tools, which can be easily used to build a user friendly interface. An Internet browser-based interface is independent of the computer architecture, whether it is a PC or a workstation, and is also independent of the operating system as long as the operating system can run the browser.

At the heart of the interface and the measurement control procedures are two tables—the measurement and the calculation table. These tables have a data record for each driver segment sample that contains AL Log Number; Sample Identification; Element Chopper Batch Number; Sample Location; as well as values for each of the measured parameters. These tables are automatically updated each evening (or can be updated on demand) to include all available new measured data. Programs (written in C++) compute for each parameter the calculated-to-measured (C/M) values, as well as their mean and variance. Each C/M value is checked to fall within a 95% and 99% predictive interval surrounding the mean C/M value. All C/M values are tracked on a control chart for each measured parameter.

The interface architecture is shown in Figure 1. The basic idea of the interface is to use an Internet browser to access the software modules, which perform the measurement control activities, through the World Wide Web. Communications between the software modules and the browser are performed using PERL programming language scripts which is convenient for use with Internet applications.

III. CONTROL CHARTS

One part of the interface allows the analyst to display C/M control charts for each selected parameter. The interface accesses the measurement and calculation database tables and controls the plotting of data through a PERL script which receives its input parameters through the interface. For example, the analyst may consider only fuel samples located in a particular region of the EBR-II core or samples from a particular axial location of the fuel element. The next step involves the analysis and plotting of the data, which is actually performed within the Internet
browser using an "applet". An "applet" is a Java language computer program that is downloaded over the Internet and executed by the browser on the user's machine. An example of one of these C/M control charts is shown in Figure 2. This chart displays the C/M values for the Pu content of all samples taken near the axial center of the fuel elements. Notice that the values shown in these charts are the normalized deviation (Z) of C/M values of each parameter from the center or mean value. $Z = (x - c) / \sigma$, where $x$ is the C/M value, $c$ is the actual mean of all of the C/M values, and $\sigma$ is the standard deviation of those values. The chart displays the mean C/M value and its standard deviation and includes upper and lower control limits (represented as dotted lines for 2 sigma limits and as solid lines for 3 sigma limits). Samples for which backup samples have been analyzed have a unique marker on the charts (as do the backup samples). Use of the Java language to create these charts allows several interactive features for the analyst. For example, "double-clicking" on any single point retrieves (in a separate window) all of the pertinent data for that point. The analyst can also redraw the plot within a selected region of interest, change the scale of the plot, redraw the plot in its original form, or "click" on buttons to branch to other types of plots, to provide help, or to display lists of the data.

The principal uses of these control charts are, of course, to monitor the quality and consistency of the measured and calculated isotopic masses for the chopped driver fuel segment samples and to identify "discrepant" values. However, the statistical analysis and graphical display of these data can be useful in many other ways. For example, consider again the control chart data displayed in Figure 2 for the Pu content of "center" samples. The mean of those C/M values is 1.063 and the standard deviation (1σ) in this mean is 0.043. Control charts for this measurement parameter (total Pu content in sample) can also be obtained for samples obtained near the top and near the bottom of the fuel elements. The mean and standard deviation of these C/M values are $1.061 \pm 0.041$ and $1.071 \pm 0.048$ for the top and bottom samples, respectively. These values are very consistent with the values obtained for the center samples, indicating there is no systematic bias due to axial location of the sample in either the calculational or measurement methods. This is, of course, an important consideration when sampling is performed for purposes of MC&A.

IV. SUMMARY

A Web interface is now available for use at the FCF to produce C/M control charts and isotope correlation charts for measured and calculated data obtained for the irradiated EBR-II driver segment samples. This software allows the analyst to efficiently review the consistency of any of the measured and calculated data; and allows a straightforward process of accepting or rejecting any of these data. The use of Web technology provides many advantages of ease and accessibility. More importantly, this software improves the rigor and reliability of these review procedures. The statistical treatment of the ensemble of measured and calculated data provide defensible estimates of the biases and uncertainties in these values, which in turn are input to the variance propagation to determine uncertainties in the inventory difference of the special nuclear materials for the FCF operations.

Figure 2. Control Chart of Pu Content for Chopped Fuel Segment Samples.
REFERENCES


