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Continuous Integration and Deployment Software to Automate Nuclear Data Verification and Validation

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We developed and implemented a highly-automated nuclear data quality assurance system ADVANCE (Automated Data Verification and Assurance for Nuclear Calculations Enhancement) which is based on the continuous integration and deployment concept that originated from the software industry. ADVANCE uses readily available open-source software components to deliver its powerful functionalities. This paper presents in detail the system's data verification functionalities which are being used to ensure the quality of every new evaluation submitted to the NNDC. Also discussed are the current development efforts to incorporate data validation capabilities into the system.

I. INTRODUCTION

Data verification and validation are critical to ensuring the quality of a nuclear data library prior to its release. However, based on our experience in processing ENDF/B-VII.0 [1] and ENDF/B-VII.1 [2], these activities were tedious, resource-intensive and could place a strain on limited manpower. In the last few years, automated nuclear data quality assurance (NDQA) systems [3, 4] were developed and are still being used to address these issues. However, these systems do not offer extensive data verification capabilities needed to meet the rigorous requirements of U.S. nuclear data evaluators as recommended in Refs. [5, 6]. Moreover, Web-based remote access to these systems has been made available only to a selected group of users most likely due to legal and/or cyber security reasons.

Cognizant of the strong need for a good and widely accessible NDQA system, we developed and deployed in November 2012 ADVANCE (Automated Data Verification and Assurance for Nuclear Calculations Enhancement), a highly-automated, modular system accessible via the Web to the U.S. nuclear data evaluators.

II. THE ADVANCE NUCLEAR DATA QUALITY ASSURANCE SYSTEM

The ADVANCE system ensures that all nuclear data evaluations submitted to NNDC for inclusion in the ENDF/B library pass the basic tests. It is based on the continuous integration and deployment (CID) concept which originated from the software industry. The system's CID capability is powered by ControlTier [7], an open-source software from DTO Solutions, Inc. ControlTier was selected from among today's popular CID software because it is: 1) proven to be robust and reliable, 2) operating system-independent being written in pure Java, 3) most complete platform, 4) highly scalable, and 5) cost-free.

A. System Reports Generation

To the evaluator, the ADVANCE system reports are perhaps the most useful so we will discuss them first. These reports assist in quickly finding the errors and deficiencies in an evaluation. To do this, we developed Python scripts to parse the log files generated by the processing codes, extract, filter and then reformat essential information for posting on the NNDC Web site.

To view the reports, the evaluator visits the link at *http://www.nndc.bnl.gov/endf/b7.dev/qa/index.html*, selects the sublibrary to which the new evaluation belongs and then clicks on the preferred type of view ('Periodic Table' or 'Material List'). Fig. 1 shows the neutron sublibrary in *Periodic Table* view. Color coding enables the evaluator to spot quickly elements with material evaluations having processing issues. The evaluator needs only to pay immediate attention to elements in boxes colored red or blue. Red indicates that some or all material evaluations belonging to an element had serious processing issues, e.g. crashes and memory core dumps, with at least one of the codes. Blue means that some or all material evaluations belonging to an element did not pass *all* the verification criteria.

For more details on processing results, the evaluator simply clicks on the element to which the evaluation be-

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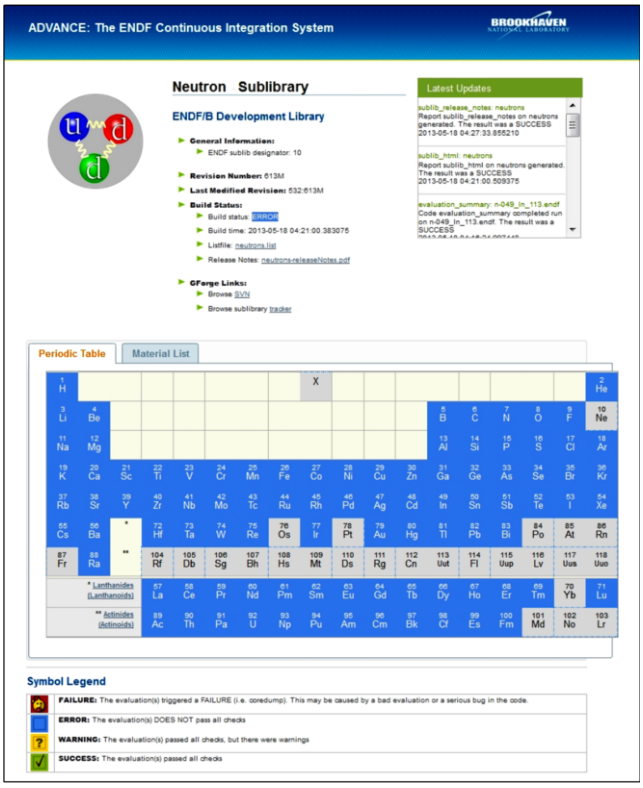

FIG. 1. The *Periodic Table* view of the neutron sublibrary Web page. Energy balance issues in almost every isotope's evaluation resulted in all elements marked in blue.

longs and selects a material from the list in the pop-up window. This will display a summary Web page of the verification results. Fig. 2 shows a summary Web page for a ^{235}U evaluation. The processing results are grouped under 5 different tabs. For the sake of brevity, we will discuss only the tab labeled 'Code Results'. A color coded scheme similar to the one used by the 'Periodic Table' view in Fig. 1 is used here to easily identify in which codes the evaluation has processing issues. The evaluator should pay immediate attention to the red and blue buttons, if there are any. By clicking on the button with the code's name, details of the error messages generated by the code are displayed below the button.

B. Plotting Capabilities

As further aid in the evaluation process, ADVANCE also generates basic plots. This feature is available from the tab labeled 'Cross Section Plots' in the summary Web page shown in Fig. 2. It provides plots of cross section versus incident energy for each reaction channel in the evaluation. In these plots, cross section data from an evaluation at 0^{o}K are compared to PREPRO [8] at two different temperatures, FUDGE [9] at 0^{o}K with uncertainty band, and experimental data retrieved from EXFOR. Fig. 3 is a plot using the ^{233}U capture cross section.

C. System Architecture

As shown in Fig. 4 , ADVANCE is powered by three servers: 1) GForge, the USNDP/CSEWG collaboration server also known as NNDC Ensemble, 2) ControlTier, the continuous integration and deployment server, and 3) Web Services, NNDC's nuclear data dissemination server. The GForge server [10] uses the Subversion open-source software as the versioning system to store and keep track of all the versions of an evaluation.

An evaluator commits (uploads) a new evaluation to the ENDF repository on the GForge server. Every hour, the ControlTier server checks for new evaluations and, for each found, triggers a series of data verification processes. A set of reports is generated for every process and published on the Web Services server for the evaluator to review. Finally, the evaluator corrects any errors or deficiencies shown in the reports and performs another com-

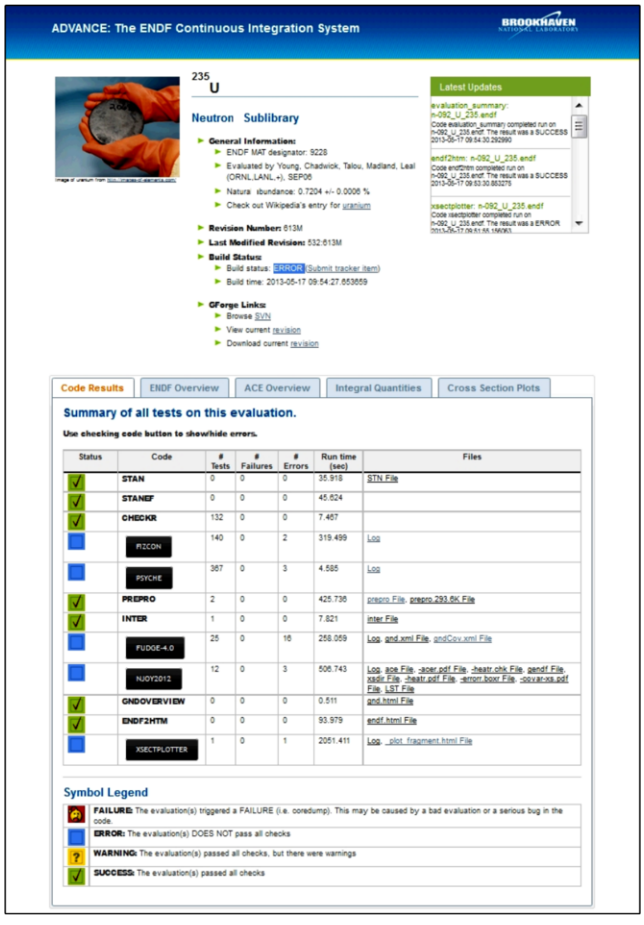

FIG. 2. The summary Web page for a ^{235}U evaluation. The results show that the evaluation has still some processing issues with the codes marked in blue namely FIZCON, PSYCHE, FUDGE, NJOY and XSECTPLOTTER.