SAFETY EVALUATION BY THE OFFICE OF NEW REACTORS
LICENSING TOPICAL REPORT WCAP-17079-P FOR ABWR
"SUPPLEMENT 3 TO BISON TOPICAL REPORT RPA 90-90-P-A SAFIR CONTROL SYSTEM SIMULATOR,"
WESTINGHOUSE ELECTRIC COMPANY
PROJECT NO. 772

1.0 Introduction

1.1 Background

Westinghouse Electric Company (Westinghouse) submitted WCAP-17079-P, "Supplement 3 to BISON Topical Report RPA 90-90-P-A SAFIR Control System Simulator" (hereafter Supplement 3) (Ref. 1) for U.S. Nuclear Regulatory Commission (NRC) review and approval by letter dated October 13, 2009 (Ref. 2). This licensing topical report (LTR) applies to both boiling-water reactors (BWRs) and advanced boiling-water reactors (ABWRs). Supplement 3 is an additional supplement to the BISON LTR RPA 90-90-P-A. BISON is a one-dimensional, two-phase thermal-hydraulic code with a two-group, one-dimensional neutron kinetics model. BISON was first approved by the staff in 1989 (Ref. 3). BISON is used to analyze anticipated operational occurrence (AOOs) and anticipated transients without scram (ATWS).

ASEA Brown Boveri/Combustion Engineering (ABB/CE) supplemented the original BISON LTR in 1994 with CENPD-292-P-A, "BISON—One Dimensional Dynamic Analysis Code for Boiling Water Reactors: Supplement 1 to Code Description and Qualification," for staff review and approval (Ref. 4). The purpose of this topical report (CENPD-292-P) was to update the code package to enable analysis of cores containing SVEA-96 fuels.

Westinghouse submitted WCAP-16606-P, "Supplement 2 to BISON Topical Report RPA 90-90-P," for NRC review in 2006 (Ref. 5). The purpose of Supplement 2 was to extend the applicability of the BISON analysis methodology to analyze ATWS beyond the time of peak pressure so as to calculate the mass and energy release to containment during the boron injection phase of an ATWS. The staff approved Supplement 2 in 2007 (Ref. 5).

In its review of the original BISON LTR, the staff imposed a series of conditions. In particular, Condition 6 from the staff's safety evaluation (SE) for the BISON LTR states that "we require a staff-approved model when modeling is necessary to simulate control systems." When a control system simulation is required, such simulations must be performed using a staff-approved model (Ref. 3). Westinghouse intends to use the SAFIR control system simulator methodology to satisfy Condition 6 in the staff's SE for the BISON LTR.

While Supplement 3 has been provided as a supplement to the BISON LTR, SAFIR(Logics and control component toolbox) is a control system simulator methodology that is used in conjunction with BISON to model plant control systems. The use of SAFIR together with BISON in the applicant's transient evaluation methodology will be referred to subsequently in this report as "BISON-SAFIR." Supplement 3 states that SAFIR is capable of modeling control systems consistent with the provisions of CENPD-300-P-A "Reference Safety Report for Boiling Water Reactor Reload Fuel," issued July 1996 (Ref. 6).

The intent of the current application is to use the SAFIR control system simulator methodology in conjunction with BISON to analyze transients. Furthermore, it has been made clear that the applicant intends to analyze ABWR transients with the new evaluation model, in addition to the conventional BWR 2–6 transients for which the currently licensed BISON evaluation model will be used. Supplement 3 specifically details the coupling of the SAFIR method with BISON.

This part of the safety evaluation report (Enclosure 3) is applicable to ABWRs only. Enclosure 1 gives the NRC staff's evaluation of the applicability to BWRs 2–6 of the new transient evaluation model incorporating SAFIR.

1.2 Regulatory Evaluation

Title 10 of the *Code of Federal Regulations* (10 CFR) 50.34, "Contents of Applications; Technical Information," requires that the licensee (or vendors) provide safety analysis reports to the NRC detailing the performance of systems, structures, and components provided for the prevention or mitigation of potential accidents.

General Design Criterion (GDC) 10, "Reactor Design," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

Analysis methods used to perform safety analyses, such as those employing BISON and SAFIR, must be maintained under a quality assurance program that meets the requirements of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50. As a minimum, this program must address design control, document control, software configuration control and testing, and corrective actions.

The NRC staff used the review guidance provided in NUREG-800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (SRP), Section 15.0.2, "Review of Transient and Accident Analysis Methods" (SRP Section 15.0.2), (Ref. 7), in conducting its review of Supplement 3. The review covered the areas of (1) documentation, (2) evaluation model, (3) accident scenario identification process, (4) code assessment, (5) uncertainty analysis, and (6) quality assurance plan.

2.0 Technical Evaluation

The staff performed its review of the BISON-SAFIR evaluation model, as documented in WCAP 17079-P (Ref. 1), under a technical assistance contract with Energy Research, Inc. (ERI).
SRP Section 15.0.2 provides an evaluation methodology that may be used to evaluate whether an application should be subjected to a graded or full review. To determine the appropriateness of a graded evaluation approach, the SRP recommends judging the submittals against the following criteria: (1) novelty, (2) complexity, (3) degree of conservatism in the evaluation model, and (4) extent of plant design or operational changes requiring reanalysis. The staff concluded that the results of evaluating Supplement 3 against these criteria justify a graded reassessment of the BISON-SAFIR evaluation model that meets the following requirements:

The applicant needs to demonstrate that the introduction of SAFIR into BISON has not disabled or changed the performance of previously approved BISON methodology with regards to its applicability to ABWR.

The applicant needs to demonstrate that BISON-SAFIR is capable of acceptably replicating previously accepted analysis results for some representative transient scenarios using control systems defined by SAFIR components, and the results of these analyses should demonstrate acceptable safety system performance and provides confidence in the evaluation model ability to predict the course of transients for ABWR.

To accomplish the required review objectives, the NRC staff issued several requests for additional information (RAIs) from the applicant. Staff evaluation of the RAIs is included in Appendix B to this SER. In addition, the staff conducted audits at the Westinghouse office in Rockville, MD, on July 29, 2010 (Audit-1), and at the Westinghouse corporate offices in Pittsburg, PA on September 2, 2010 (Audit-2), during which several RAIs were specifically discussed. Westinghouse presented information that answered several RAIs and illustrated the use of BISON-SAFIR by presenting and comparing the results of BISON-SAFIR analysis for several relevant ABWR scenarios (Audit-2 summary report for the September 2, 2010, audit in Pittsburg, Agencywide Documents Access and Management System (ADAMS) Accession No. ML102730292).

2.1 Documentation

The staff reviewed Supplement 3 to determine the adequacy of the documentation relative to the review guidance provided in SRP Section 15.0.2.

Section 3 of Supplement 3 provides a basic description of the SAFIR methodology, detailing the available components for constructing a control system model, model initialization, the interface between BISON and SAFIR, and time step selection. Because its subject matter is largely restricted to SAFIR itself and to SAFIR's interface with BISON, initially the staff found this material to be inadequate to describe the BISON-SAFIR evaluation model. However, RAI responses and sample calculations presented at the September 2, 2010, site audit yielded additional information that filled the gaps present in Supplement 3 documentation.

Because SAFIR is a control system simulator, it is intended for use in a variety of transient analyses. In the subject review, SAFIR is applied to transient analyses in conjunction with BISON. Initially, Supplement 3 did not include documentation of a scenario identification process or of a list of specific scenarios to which the BISON-SAFIR evaluation model may be applied. This is of particular importance because the list of scenarios to be analyzed for the ABWR may not correspond exactly to those analyzed previously for BWRs 2–6. The RAI process later elicited a specific scenario list from the applicant; this is discussed in Section 2.3 of this report.

Sections 4 and 5 of Supplement 3 describe the verification and validation (V&V) processes for components and models in SAFIR, respectively. Section 6 of Supplement 3 provides the results of V&V of SAFIR models against plant data collected at a Swedish BWR [[ ]] during a load rejection test in 2001 and against startup tests performed at an ABWR (Hamaoka Unit 5, hereafter "Hamaoka 5") in Japan in 2005. The BWR [[ ]] model includes a complex control system model comprising three SAFIR submodels: (1) a turbine control model, (2) a valve process model, and (3) a turbine model. The Hamaoka 5 model includes (1) a recirculation flow control system model, (2) a turbine control system model, and (3) a feedwater control system model.

The [[ ]] and Hamaoka 5 model validations provide a comprehensive validation of the SAFIR components used to simulate complex control systems and compare the predictive capability of the code against plant data, and the Hamaoka 5 (an ABWR) validation in particular provides confidence in the ability of BISON-SAFIR to model transients for ABWRs. Section 6 of Supplement 3 provided model diagrams for the various control system models. The staff finds that these V&V examples provide sufficient documentation of the code assessment for the intended purpose.

Supplement 3 includes no mention of uncertainty analysis in the context of either SAFIR or the integrated BISON-SAFIR evaluation model. RAIs elicited information from the applicant about the uncertainty analysis process.

Section 3.10 of Supplement 3 provides a list of the available components currently coded in SAFIR. These component descriptions provide the transfer function and the time-dependent solutions for various component types. These equations provide the basis for the larger macros and models that are composed of several components.

The staff reviewed the user manual and found that it adequately provides (1) detailed instructions about how the code is used, (2) a description of how to choose model input parameters and appropriate code options, (3) guidance about the code limitations and options that must be avoided on an analysis-specific basis, and (4) documentation of procedures for ensuring complete and accurate transfer of information between different elements of the evaluation model (Audit-1 Summary Report for audit in Rockville Offices July 29, 2010, ADAMS Accession No. ML102240585).

Section 3.8 of Supplement 3 refers to the standard code update procedures. Sections 4 and 5 describe the development, verification, and validation processes for SAFIR components and models. The staff finds that this information is mostly adequate to address the procedures and controls under which the code is developed and assessed and the corrective action procedures. However, the staff obtained additional information on quality assurance procedures during the RAI process.

2.2 Evaluation Model

The SAFIR methodology is used to construct models of BWR control systems. These models are built from predefined component models. The individual component models calculate control system response to input signals based on simple operators such as transfer functions, filters, or Boolean operators.

Components are building blocks for complex control systems, in which, typically, several components are strung together via their input and output signals to generate a cascade of components that simulate control system signals based on plant instrumentation signals.

Section 3.10 provides a description of the components available in SAFIR. These components provide a means for flexible control system modeling and encompass a variety of standard control system components. Each component is characterized by inputs to the component and parameters that may be specified for a unique component. Several components are characterized by transfer functions common in control system analysis, such as the integrator component. Other components may perform simple mathematical operations, perform Boolean operations, or filter signals. Table 3-2 provides a comprehensive summary of the available components, the input specifications, and the expressions used to determine the component signal output.

Supplement 3 describes a process for adding new component models to SAFIR after the approval of Supplement 3. The staff's review of the process for developing and implementing new component models is discussed in Section 2.4.5 of this SE.

The time-dependent output functions provided in Section 3.10 are consistent with numerical analysis and the definitions for the sampling time. Section 3.9 of Supplement 3 provides details of the time sampling for digital and analog control systems. This section states that, for a digital control system, the component sampling time shall be the same as that for the real plant component. For analog control system components, the sampling time shall not be longer than the transient code time step. Additional information elicited at site Audit-2 provided assurance that the selection of sampling time in SAFIR would not be inconsistent with the BISON time advancement, nor would it be likely to pose numerical difficulties for actual ABWR system modeling.

Given that the sampling times reflect the condition of the plant control system components or are set to values consistent with the transient analysis code, the staff finds that the methodology to account for the sampling time is acceptable.

SAFIR is used in conjunction with transient code BISON. To couple these codes, SAFIR must be compiled and loaded as part of the transient code itself. The interface between the transient code and SAFIR is dictated by a matrix of input/output interfaces. For BISON, these output/input interfaces are provided in Table 3-1. These parameters describe the parameters required for normalization, time control, initialization, and flows or flow areas that are controlled by SAFIR-modeled control systems.

Section 3.11 specifies the limitations to SAFIR. Three general limitations are listed: (1) a signal can only be connected to one single output, (2) a model must have at least one input signal, and (3) an instance of a component must have a unique name within a model. The NRC staff requested additional information about the first limitation. The staff asked Westinghouse to describe how configurations that use a single input signal for several control systems are modeled in SAFIR.

Supplement 3 contained limited information about the evaluation model that is understood to comprise BISON and SAFIR, focusing instead on SAFIR and its interface. RAIs 16, 17, 18, 21(b), 23, 26, 27, 28, 29, 31, 32, 33, 34, and 39 (see Appendix B) asked for various details of the evaluation model, including transfer functions of individual SAFIR components, the BISON-SAFIR interface, numerical stability and feedback loops, integral windup of integrating components, and feedwater and condensate system momentum balance. Also, several sample calculations, including calculations involving ABWR systems, were presented to the staff in detail at site Audit-2 to illuminate the BISON-SAFIR methodology. Together with information presented in Supplement 3, the information provided at the audit and in response to RAIs is judged by the staff to constitute an acceptable description of the evaluation model.

2.3 Accident Scenario Identification Process

SAFIR is intended for use with NRC-approved BISON for transient and accident analysis. The accident scenario identification process is relegated to the approval of the associated transient methods for specific accident and transient analyses. In the subject review, Westinghouse presented detailed information about the coupling of SAFIR with BISON. BISON is approved to analyze AOOs, overpressure transients, and ATWS events. In the case of BISON, the accident scenario identification process has been previously established.

In a response to RAI-15 (see Appendix B), the applicant confirmed that the set of scenarios to be analyzed using BISON-SAFIR for ABWR applications is unchanged from that which was originally approved for BISON in CENPD-300-P-A.

The staff finds that the scenario identification process is acceptable on the basis of the previous approval of the transient methods and the assurance that SAFIR is applied within the provisions of the previously approved in CENPD-300-P-A (Ref. 6).

Code Assessment

2.4.1 Verification and Validation for Components

Supplement 3 and several RAI responses emphasize that the BISON portion of BISON-SAFIR is unchanged following introduction of the SAFIR control system module. Consequently, the applicant presented only limited code assessment information. That information came in the form of a discussion of how control system models are developed, verified, and validated, as well as a comparison of BISON-SAFIR predictions against two integral tests. Presentations made at site Audit-2 included two additional code-to-code comparisons of BISON-SAFIR against BISON with SAFIR disabled (i.e., the older, approved evaluation model).

SAFIR relies on developing macros and models from combinations of simpler components. Section 4 of Supplement 3 describes the V&V process for components within SAFIR. The V&V process for components is performed within the Westinghouse standard quality assurance process. The staff review of the quality assurance process is documented in Section 2.6.

Generally, components are verified using a set of verifications commensurate with the complexity of the component itself. For very simple components such as AND gates or the SUM component, only a limited set of verifications are required to confirm the functionality of the component consistent with the requirements. The staff finds that this approach is reasonable and therefore acceptable.

For more complex components, the verification set is expanded. Potential verifications include comparison of the component model to theoretical solutions, code-to-code comparisons, or other methods of solution. For the vast majority of control system components, the components are described by relatively simple transfer functions for which analytical solutions are available. The testing of the SAFIR component models against these analytical solutions provides a viable basis for verification. Therefore, the staff finds that the verification process is acceptable.

The validation process generally requires comparison of the SAFIR component model against measurement data. Since many components are composed of simple transfer functions, the staff agrees that, for many cases, verification against analytical solutions is sufficient to confirm the adequacy of the model. However, certain SAFIR components may be empirical and are designed to fit measurement data. In these cases, Supplement 3 specifies that validation must be performed using comparisons to measurement data. The rigor of the validation process is commensurate with the complexity of the component models; therefore, the staff finds the validation approach to be reasonable.

For cases in which the models are empirical in nature, the validation process requires validation against measurement data. The staff finds that this requirement is appropriate and necessary for this subset of component models.

The staff reviewed the introduction of new components into the SAFIR method; it is discussed separately in Section 2.4.5 of this SE.

Section 4.4 of Supplement 3 provides an example V&V for the Proportional Integrating (PI) component. The verification ensures that all relevant aspects of the component were tested and assured to be accurate. The verification cases were sufficient to test all of the requirements for the PI component functions.

The results of the SAFIR calculations demonstrate excellent agreement with the analytical solution. Figure 4-8 of Supplement 3 provides a direct comparison of the SAFIR and analytical solutions. The staff agrees that the verification process addresses the functions of the components and has, in the case of the PI component, ensured adequate performance of the SAFIR solution methodology.

The staff finds that the requirements and elements of the V&V process for components are acceptable in terms of scope, quality assurance, and rigor. The example provided for the PI component demonstrates acceptable performance of SAFIR and confirms that the V&V process for components is sufficiently robust to test all functions of the components. Therefore, the staff finds the component V&V process to be acceptable.

2.4.2 Development, Verification, and Validation for Models

The development process for SAFIR models is divided into three steps: (1) requirements, (2) design, and (3) implementation. The requirements step requires each model to specify (1) desired functionality, (2) limitations and assumptions, (3) communications with adjacent systems, and (4) communication with the transient code.

The staff reviewed these requirements and found that these specifications are sufficient to allow for the design step to follow. Further, the model requirements explicitly ensure that the models are applied appropriately within the greater code hierarchy in terms of communication and are implemented within specific constraints specified by the limitations of the model. Therefore, the staff finds that the requirements step in the model development process is acceptable.
The design and implementation are straightforward steps in the development process.

Development of a SAFIR model requires subsequent V&V. The V&V process for SAFIR models is largely akin to the V&V process for SAFIR components. One difference discussed in Supplement 3 is that SAFIR models are constructed from the available SAFIR components, and that new model development does not require software upgrades to implement any new features within SAFIR.

The verification process requires testing of the SAFIR model to ensure that functionality of the model. Section 6.1.4 of Supplement 3 provides example verification for the SAFIR control system model for a turbine controller model for [[ ]]. To verify the model, several perturbations were applied to the control system model, and the SAFIR output was simulated. The verification confirmed that the model behavior was consistent with expectations based on the specific perturbations applied. The staff found the scope of the perturbations to be consistent with the model functionality and found the results to be acceptable.

Validation of the model requires that the model behavior be compared with reference data. Two approaches may be taken here. In the first approach, the model is validated against recorded plant data collected during startup tests or during operational occurrences. When these data are available, they are used in the validation process. For instances in which recorded plant data are unavailable, Westinghouse relies on code-to-code comparisons.

The staff finds that it is acceptable to use plant data whenever available to validate the SAFIR model. Supplement 3 provides two example cases of validation of SAFIR models against recorded plant data. The staff review of these validation cases is documented in Sections 2.4.3 and 2.4.4 of this SE.

RAIs 19, 20, 21(a), 22(b), 22(c), 24, 25, and 36 (see Appendix B) asked for further information about which ABWR systems, structures, and components would be subject to modeling in SAFIR and how those models would be developed, verified, and validated. Information provided in response to these RAIs, as well as example models and calculations presented at site Audit-2, is considered by the staff to be adequate to demonstrate the applicability of SAFIR model development procedures to the ABWR.

Development and implementation of new components is addressed in Section 2.4.5 of this SE.

2.4.3 Swedish BWR [[ ]] Load Rejection Test

Section 6.1.5 of Supplement 3 provides the results of validation of the [[ ]] pressure control system model. The pressure control system model is a complex SAFIR control system model with several subsystems. The pressure control model is composed of a turbine controller; valve process models for high-pressure valves, bypass valves, reheater valves, and a capacity trimming valve; and one simple turbine model. Section 6.1.3.1 of Supplement 3 provides a detailed description of the pressure control system model, including flow diagrams that depict the various subsystems in the SAFIR model. The staff finds that the pressure control system model is complex and involves many of the SAFIR component models. Therefore, the staff accepts validation against the [[ ]] test data as a reasonable demonstration of the sufficiency and capability of the SAFIR control system simulator.

Additionally, the validation case serves as a prototypic example of the V&V process and illustrates the exercise of the model development and V&V process for a typical plant control system.

The pressure control system model was validated against data collected during the generator load-rejection test performed in 2001. The load rejection was initiated by switching off the plant breaker. The validation case considers the plant response after the first 59 seconds (which were excluded). The calculated and measured control system responses provided in

Figures 6-78 through 6-87 indicate excellent agreement between measurements and prediction. Some subtle differences were observed, [[

]]. Therefore, small differences of this order are expected. However, plant response and code performance indicate a high degree of agreement overall.

The pressure control system validation provides reasonable assurance in the capability of SAFIR to simulate large, complex, realistic BWR plant control systems. The specific validation results indicate that the V&V process ensures that the SAFIR models produce highly accurate results when compared against full-scale measurement plant data for transient conditions. Therefore, the staff finds the results to be acceptable.

2.4.4 Hamaoka Unit 5 (ABWR) Startup Testing

Validation was also performed for various plant control systems against data collected at Hamaoka 5 (an ABWR) in Japan. The staff considered these validation data in the context of (1) demonstration of the capabilities and accuracy of the SAFIR method to model ABWR systems and (2) demonstration of the robustness of the general validation process described in Section 5 of the Supplement 3 LTR.

The startup testing exercised several plant systems. The specific tests considered as part of the SAFIR validation included (1) a pressure control system step change, (2) a feedwater control system step change, and (3) a recirculation flow control system ramp change. These test data allow validation of the pressure control system, the feedwater control system, and the recirculation flow control system against full-scale recorded plant data.

These control systems are complex and composed of several subsystems. Section 6.2.2.1 of Supplement 3 provides the details of the control system models and the subsystems. The staff finds that these systems are likewise complex and provide a robust basis for the validation of the capability of SAFIR to accurately predict the behavior of plant control systems, particularly in the context of the ABWR.

Figures 6-92 through 6-97 illustrate comparisons between the BISON-SAFIR-predicted plant behavior and the measurement data. In all cases, the measurements and calculations indicate excellent agreement. Within the context of the staff review, these validation comparisons indicate that the BISON-SAFIR code performance is very accurate in the prediction of plant system behavior. The differences between measurements and calculations are only minor. The staff also finds that validation activities provide an acceptable means for demonstrating the adequacy and robustness of a plant-specific SAFIR control system model. Additional details about the Hamaoka 5 startup test example were elicited in RAI 35 (see Appendix B). The staff finds these validation studies and the RAI response to be acceptable.

2.4.5 Development and Implementation of New Components

Section 4 of Supplement 3 states that additional component models may be integrated within SAFIR using the Westinghouse code update process and associated procedures. The staff finds that, although SAFIR includes a large number of components and SAFIR's performance using these pre-existing components indicates a reasonable degree of agreement with validation data, it is advantageous to maintain a capability to include additional component models in SAFIR to ensure continued applicability to control systems for a wide variety of plant configurations. Therefore, the staff reviewed the process detailed in Supplement 3 for the potential addition of new SAFIR components within the SAFIR methodology.

Supplement 3 states that new components added to SAFIR must comply with the V&V processes and the standard Westinghouse quality assurance processes. The staff issued RAIs 11 to 14 related to the development and implementation of new components; resolution of these RAIs is included in Appendix B to this report. The staff reviewed the V&V process for components and finds this process to be flexible, robust, and acceptable.

The example provided for the PI component verification indicates that the process is thorough and that high accuracy may be maintained in the SAFIR simulation when compared against analytical solutions.

2.5 Uncertainty Analysis

To assist the staff in understanding the use of SAFIR within the context of the reference safety report (Ref.6), the staff requested that Westinghouse provide a sample calculation to demonstrate the uncertainty analysis process.

This approach is consistent with Section II.1.D of SRP Section 15.0.2. RAI 22(a) (see Appendix B) also elicited more information about the uncertainty bounds of various physical models in BISON-SAFIR.

The purpose of referring to CENPD-300-P-A (Ref. 6) is to clarify that the control system model will be developed in the same way as the model of any other plant system important to the transient analysis, and that SAFIR will be used to apply control system inputs to plant models in accordance with the provisions of the NRC-approved methodology; for example, in the reference safety report (CENPD-300-P-A). Therefore, the uncertainties and justification of the models will be treated in the same way as those of any other plant model that is input to the licensing analysis according to current licensing methodology.

In the safety analysis method for AOOs, the model uncertainty is typically accounted for [[

]]

Uncertainties in SAFIR modeling parameters can be estimated from the comparison between SET data and SAFIR simulation of such SETs. The comparison between measurements and code predictions for the relevant modeling parameters yields either the distribution function of differences or the mean bias and the standard deviation of the bias.

For example, validation results against the plant data (SET) for the pressure controller of a specific plant are shown in Figures 6-78 through 6-81 in the topical report. [[

]] Comparison of the model output parameters (BAFR, BATT and APRM-Filter) yields the following probabilistic data:

- [[ ]]
- [[ ]]
- [[ ]]

It should be noted that the examples in the V&V presented in Supplement 3 were aimed to show the capability of SAFIR to model plant systems, and that comparisons were made against expected behavior and measurement data. In licensing applications, conservative plant responses are modeled by altering the system response in a conservative manner; i.e., by changing setpoints or the performance of critical functions in the model.

The control systems required and the complexity of these systems will be determined at the time of the application in connection with a license amendment request.

Currently, the NRC-approved Uncertainty Method A from Section 7.3.3 in CENPD-300-P-A is used in licensing applications. [[ ]] SAFIR modeling uncertainties will be addressed consistent with the approved methodology for AOO uncertainty evaluation.

2.6 Quality Assurance Plan

Section 3.10 of Supplement 3 alludes to the "Westinghouse standard quality assurance process for code changes." As part of the RAI process, the applicant submitted additional information about this quality assurance process.

In the RAI -37 response (see Appendix-B), the applicant stated that the code would be maintained in accordance with the Westinghouse quality management system (QMS) program, which meets all of the requirements of Appendix B to 10 CFR Part 50 and International Organization for Standardization (ISO) 9001, "Quality Management Systems—Requirements," and which has previously been reviewed and approved by the NRC. The definitions for V&V provided in the LTR are consistent with the requirements for computer software development described in Section 4.2 of the Westinghouse QMS. Functional requirements, design documents, test requirements, and test results are verified in accordance with written procedures. Verification is performed at the completion of each phase to ensure that the output of a given phase fulfills the requirements established by previous phases. Validation is performed upon completion of software development to ensure that the code satisfies all identified requirements and produces correct results. The staff finds these explanations to be acceptable.

The principal discussion in Supplement 3 pertaining to quality assurance relates to the V&V process for components and control system models within BISON-SAFIR. Evaluations of the V&V process for component and model development in SAFIR are covered in Sections 2.4.1 and 2.4.2 of this safety evaluation report, respectively. RAIs 30, 37, and 38 (see Appendix-B) asked for details of the Westinghouse quality assurance procedures, code error handling, and procurement and control of purchased materials. The NRC staff considers the responses to all of these RAIs to be adequate. Therefore, the staff finds that quality assurance for the component and model V&V process is acceptable.

3.0 Limitations Specified in Supplement 3 LTR

Limitations for the SAFIR control system simulator method have been identified throughout Supplement 3. On the basis of the staff review, the staff finds that the limitations specified within the Supplement 3 LTR are sufficient and complete.

4.0 Conditions and Limitations

Licensees referencing WCAP-17079-P must ensure compliance with the following conditions and limitations when using it in analysis of ABWR transients:

1. Approval of SAFIR is limited to use in combination with NRC-approved BISON. BISON is the transient code interacting with SAFIR, but other dynamic BWR codes may be used as described in other licensing topical reports and subject to NRC approval on a code-by-code basis.

2. SAFIR shall model control systems consistent with the provisions of CENPD-300-P-A. Conditions and limitations imposed upon the use of BISON in submittals prior to Supplement 3, (Refs. 3, 4, and 5) continue to remain in effect. However, it should be noted that the staff finds that Condition 6 of Reference 3, requiring staff approval for the use of control system models, has been fulfilled in the case of SAFIR.

5.0 Conclusion

The staff concludes that the SAFIR model is capable of modeling the control systems of the ABWR with an acceptable degree of accuracy when integrated into the existing BISON transient evaluation model. The staff concludes that Restriction 6 from the BISON safety evaluation report should be removed as regards the new evaluation model's application to ABWRs.

On the basis of the staff's review of Supplement 3, the staff finds that SAFIR is an acceptable method for the simulation of control systems. The staff finds that SAFIR may be used in conjunction with BISON to simulate control system response in the modeling of the ABWR systems for the purpose of conducting reactor safety analysis.

The staff's findings in this matter are contingent on the use of SAFIR complying with the conditions and limitations in Sections 3 and 4 of this SE and on the methodology as reported by the applicant throughout the SAFIR LTR (Supplement 3).

The staff concludes that that this topical report is acceptable for use in licensing applications for Toshiba ABWRs.

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Date: February 2012

6.0 References

1. WCAP-17079-P, "Supplement 3 to BISON Topical Report RPA 90-90-P-A SAFIR Control System Simulator," Westinghouse Electric Company, October 2009 (ADAMS Accession No. ML093080100).

2. Westinghouse letter (LTR-NRC-09-49) from Maurer, B.F., to U.S. Nuclear Regulatory Commission, "Submittal of WCAP-17079-P/WCAP-17079-NP, 'Supplement 3 to BISON Topical Report RPA 90-90-P-A SAFIR Control System Simulator' (Proprietary/Non-Proprietary)," October 13, 2009 (ADAMS Accession No. ML093080098).

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