Nuclear Operating Company
South Texas Project Electric Generating Station P.O. Box 289 Wadsworth, Texas 77483

December 6, 2010
U7-C-STP-NRC-100251

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

South Texas Project
Units 3 and 4
Docket No. PROJ0772
Response to Request for Additional Information

Reference: Request for Additional Information Re: South Texas Project Nuclear Operating Company Topical Report (TR) WCAP-17079P Revision 0, "Supplement 3 to BISON Topical Report RPA 90-90-P-A SAFIR Control System Simulator"

Attached are responses to NRC staff questions included in the referenced letter. Attachments 1 through 3 address the RAIs shown below:

RAI-16S001
RAI-19S001
RAI-24S001

The RAI-16S001 response also addresses action items from an NRC audit of Westinghouse in Monroeville, PA on September 2, 2010.

There are no commitments in this letter.

If you have any questions, please contact me at (361) 972-7136, or Bill Mookhoek at (361) 972-7274.

T007

STI 32784754

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 12/6/10

Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

jet

Attachments:

1. RAI-16S001
2. RAI-19S001
3. RAI-24S001

cc: w/o attachment except*
(paper copy)

Director, Office of New Reactors
U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, Texas 76011-8064

Kathy C. Perkins, RN, MBA
Assistant Commissioner
Division for Regulatory Services
Texas Department of State Health Services
P. O. Box 149347
Austin, Texas 78714-9347

Alice Hamilton Rogers, P.E.
Inspection Unit Manager
Texas Department of State Health Services
P. O. Box 149347
Austin, Texas 78714-9347

*Steven P. Frantz, Esquire
A. H. Gutterman, Esquire
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Ave. NW
Washington D.C. 20004

*Tekia Govan
*Ekaterina Lenning
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852

(electronic copy)

*George F. Wunder
*Tekia Govan
*Ekaterina Lenning
Loren R. Plisco
U. S. Nuclear Regulatory Commission

Steve Winn
Joseph Kiwak
Eli Smith
Nuclear Innovation North America

Peter G. Nemeth
Crain, Caton & James, P.C.

Richard Peña
Kevin Pollo
L. D. Blaylock
CPS Energy

RAI-16S001

QUESTION:

Since the topical report WCAP-17079-P is being reviewed using the guidance described in NUREG-0800 Section 15.0.2, "Review of Transient and Accident Analysis Methods", the subject of which is a transient evaluation model rather than an individual computer code, approval cannot be granted to SAFIR generically but only to an appropriately documented evaluation model employing SAFIR (e.g., BISON, SAFIR, and any other codes or procedures necessary to perform the complete analysis).

NUREG-0800 Section 15.0.2 Subsection II.1 requires that the documentation include "[a]n overview of the evaluation model", "[a] complete description of the accident scenario", "[a] complete description of the code assessment", and "[a] determination of the code uncertainty".

WCAP-17079-P does not clearly present the evaluation model. It does not relate the SAFIR control system models to a description of the accident scenarios (see RAI-15 and RAI-15S001). It does not present a code assessment in terms of the evaluation model that includes BISON and SAFIR. It does not address any changes to the uncertainty from having introduced SAFIR into the evaluation model previously including BISON. The addition of SAFIR constitutes a change to an existing evaluation model; therefore, the provisions of NUREG-0800 require that the documentation address these topics. Additionally, STP's response to RAI-16 failed to provide a requested list of ABWR top-level systems that would be modeled using BISONSAFIR, which makes it impossible for the reviewers to determine the extent of code assessment and uncertainty analysis that would be required for approval. There was also no adequate response to RAI-37(b), which requested information on the specific means of quality assurance performed for each of these systems, as required by the review guidelines of NUREG-0800 Section 15.0.2 Subsection II.6. Therefore:

a) Provide an assessment of changes in performance of the evaluation model resulting from coupling of BISON and SAFIR by providing a detailed comparison of at least two ABWR transients. This would involve comparing the results of BISON-SAFIR evaluation model with and without using SAFIR to model control systems. These assessment calculations should consist of ABWR transient scenarios that fall within the defined applicability of the previous and revised evaluation models. Furthermore, the transients chosen should demonstrate the acceptable modeling of safety and non-safety systems important to the progression of the transients.

b) Identify the individual ABWR systems that will be modeled using the evaluation model that includes BISON and SAFIR. (Note: this question refers to ABWR systems as defined in Chapter 7 of the DCD [e.g., Reactor Protection System, Steam Bypass and Pressure Control System, Rod Control and Information System, etc.]) and requests that you indicate which protection, ESF, safe shutdown, information and non-safety systems you intend to include in the BISON-SAFIR evaluation model.

c) For each of the systems identified in (b), state which means of quality assurance (i.e., either verification or validation, as described in WCAP-17079-P Sections 4.2 and 4.3) is used in order to assure adequate performance of its corresponding BISON-SAFIR model.

RESPONSE:

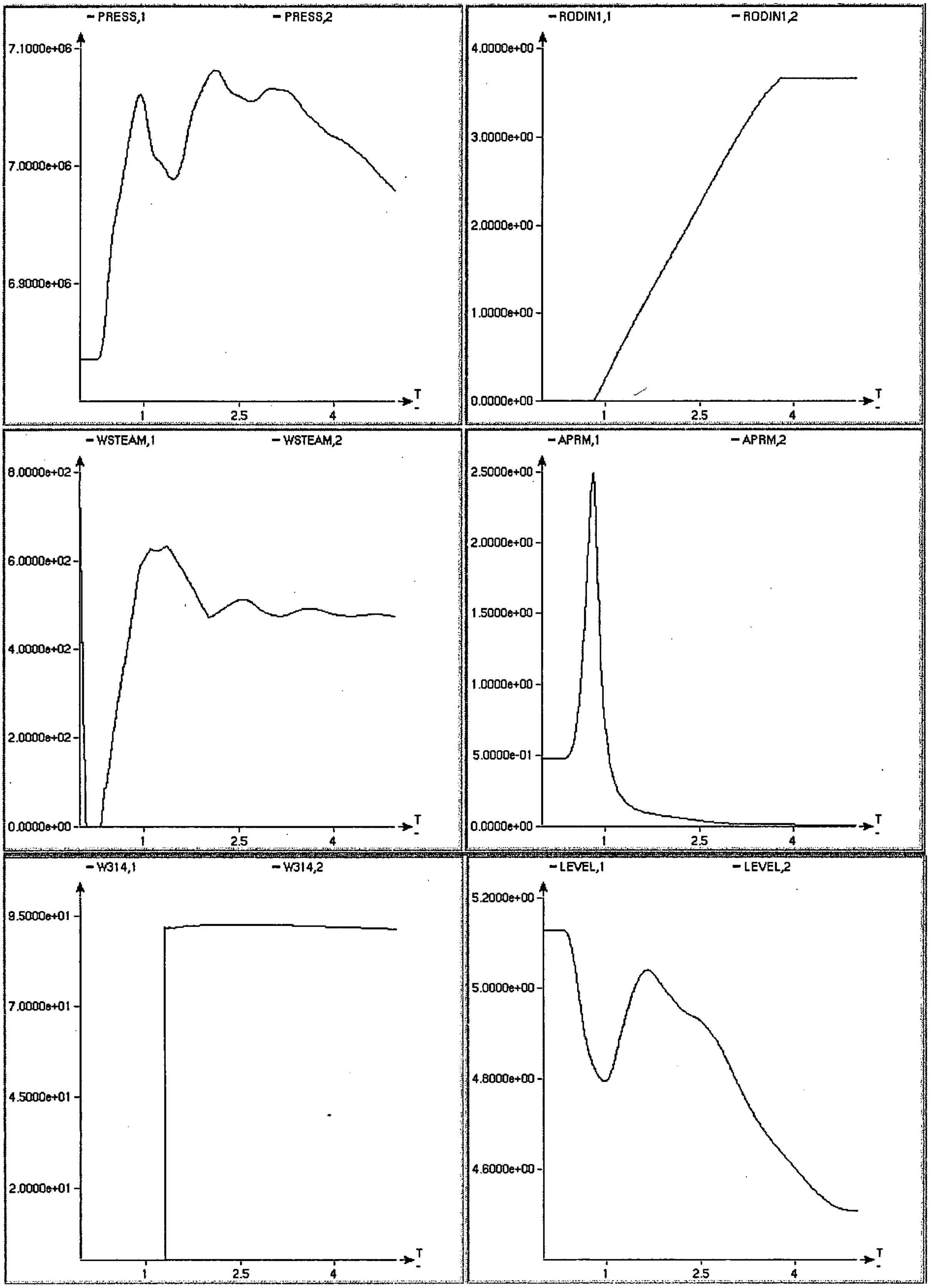
16S001a)

The change in the evaluation model consists in how the input to BISON model for the control systems is provided: in the current tabular form versus with SAFIR. Westinghouse has performed an assessment of the resulting output from the BISON code stand-alone and BISON in conjunction with SAFIR to model the control systems. This assessment has been performed for the following two transients: 1) turbine trip model based on the Peach Bottom BWR analysis from the original BISON topical report RPA 90-90-P-A and, 2) feedwater controller failure in the ABWR. These two transients scenarios were chosen to show applicability to both the previously approved models in RPA 90-90-P-A and the ABWR.

Turbine Trip Model

Figure 16a-1 below shows a comparison of BISON and BISON with the inclusion of SAFIR for the turbine trip transient. The first case is performed with BISON alone, using the tabular look-up for control systems from RPA 90-90-P-A. The second case includes the SAFIR control system modeling tool, which detects the RPS trip in the APRM system and initiates the reactor SCRAM. A simplified SAFIR RPS model was introduced to the BISON analysis to determine the impact, if any, the addition of SAFIR has on BISON. Figure 16a-1 shows the response of the steam dome pressure (PRESS), length of control rod insertion (RODIN), steam flow (WSTEAM), average power range monitor (APRM), safety valve steam flow (W314) and water level (LEVEL) during the transient.

Figure 16a-1 Results from the Turbine Trip Analysis



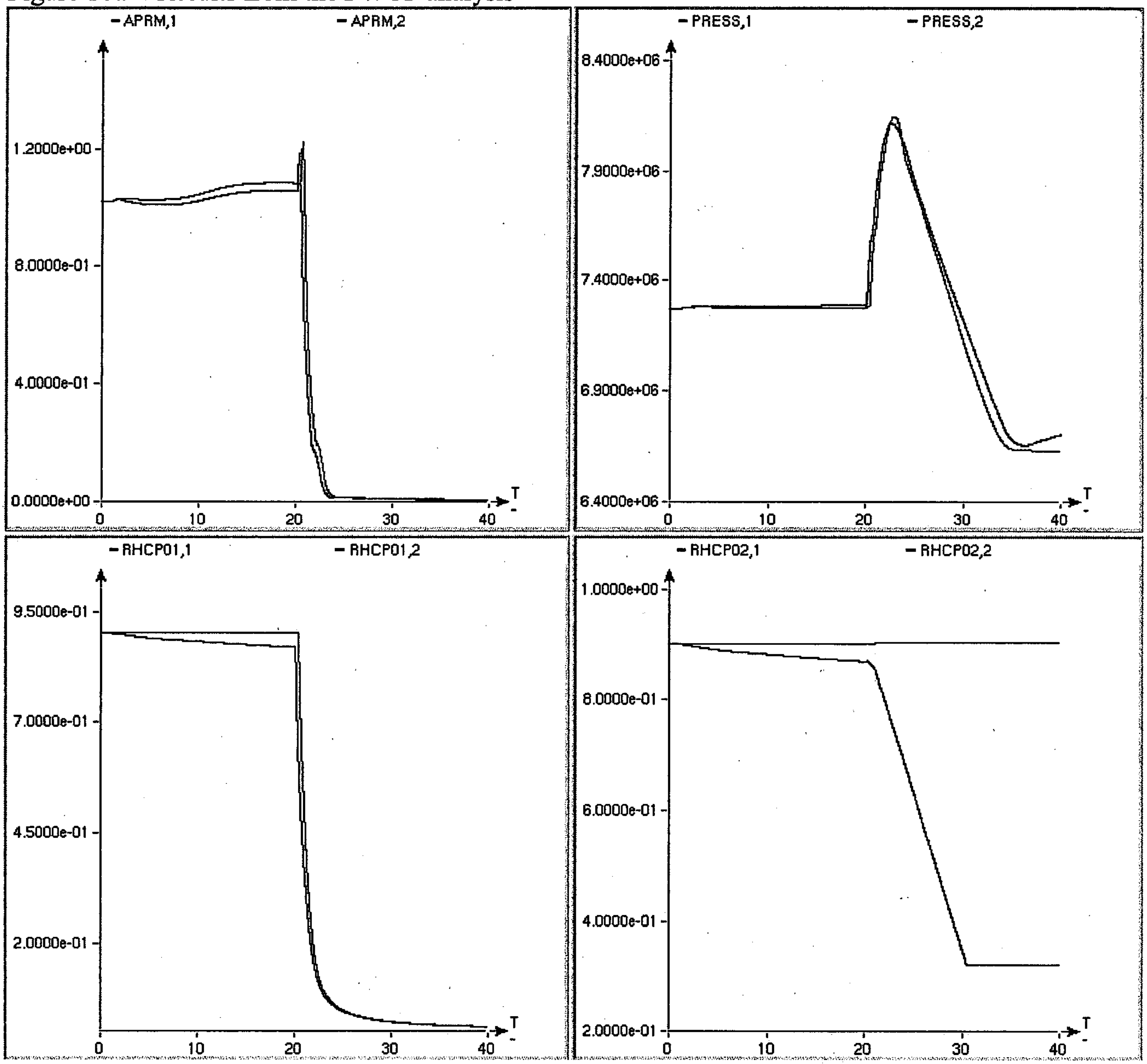
As can be seen from Figure 16a-1, the output from BISON produces identical results, confirming that the introduction of SAFIR to model the control systems does not change the functionality or results from BISON for this transient.

<u>Feed Water Controller Failure (FWCF)</u>

Figure 16a-2 below shows a comparison of BISON with the inclusion of SAFIR for the FWCF transient. As in the first transient, the FWCF was performed to demonstrate that enabling different models of SAFIR would still produce conservative results. Figure 16a-2 shows steam dome pressure (PRESS), average power range monitor (APRM), and relative recirculation pump speeds (RHCP01 and RHCP02).

As can be seen in the figures, there are small variations in the BISON results. These variations are expected due to the difference in case 1 versus 2. For case 1, also presented in the response to RAI-15, some of the non-safety functions were credited within SAFIR during the entire transient. For example, in case 2 there is no credit taken for the recirculation pump runback, RHCP02, at SCRAM and thus there is no change in the pump speed. Also the recirculation pumps are running at a constant speed in case 2 while the recirculation flow is adjusted to compensate for increasing power in case 1. Those slight differences in recirculation pump behavior during the transient produce different results in core power and steam dome pressure due to differences in transient modeling.

Figure 16a-2 Results from the FWCF analysis



This case demonstrates the ability of BISON to model transient behavior including the usage of SAFIR. The differences observed are a demonstration of the ability to model detailed system response, in this case the behavior of the flow controller during an event with increasing power.

Conclusion

As shown in the figures above, the introduction of SAFIR to model control systems in the BISON transient analysis code has no effect on the performance of the evaluation model within the BISON code for both safety and non-safety systems. The slight differences seen in the second example are due to transient modeling differences, not the introduction of SAFIR. Although this has been shown here for two transients as examples, this is applicable to all transients in the BISON code.

16S001b)

The high level systems as described in the ABWR DCD that can be analyzed with BISON including SAFIR include, but are not limited to:

- Safety Systems
  - Reactor Protection (Trip) System
  - Neutron Monitoring System
  - Nuclear Boiler System
- Systems Required for Safe Shutdown
  - Alternate Rod Insertion Function
  - Standby Liquid Control System
- Engineered Safety Feature Systems
  - Reactor Core Isolation Cooling system and High Pressure Core Flooder System from Emergency Core Cooling System
- ATWS Logic and Setpoints
- Control Systems not Required for Safety
  - Feedwater Control System
  - Recirculation Flow Control System
  - Rod Control and Information System
  - Steam Bypass & Pressure Control System
  - Process Computer System

The determination of whether SAFIR will be utilized in the modeling of individual ABWR systems will be made on a licensee-specific basis. The determination of the specific individual ABWR systems that will include the use of SAFIR for STP 3&4 will be documented in a license amendment request.

16S001c)

The control systems identified in the response to RAI-16S001b) will be implemented using the verification or validation process described in Section 4 of WCAP-17079-P. The primary means of quality assurance is through model verification (i.e., assurance that the modeled system behavior is as one would expect given its design parameters). At a minimum, all systems will be qualified through verification, however it is not possible to identify in the topical report the specific systems that will be qualified through validation against plant or test data. This would depend on factors such as the availability of data for individual systems. Section 4 and Section 5 of the topical report provide descriptions of the validation and verification process for either individual components in SAFIR or the BISON models, respectively. Additionally, Section 4.4 and Section 6 of the topical report provide several examples of the adequacy of the validation and verification processes for SAFIR and BISON. Specific determination of whether validation or verification will be used for the ABWR systems will be part of the detailed analysis documentation that supports the specific licensing application for the ABWR application at an individual site.

Supplementary Information to Provide Information Requested in the Summary of the September 2, 2010 Audit.

Item 1

A list of which system models described in RAI-16S001b) have quality assurance supported by validation against plant or test data is provided in the response to RAI-16S001c).

Item 4

The responses provided to RAI-16S001 and RAI-19S001 demonstrate that the results from BISON with SAFIR included are not significantly different from the results of the previously approved BISON models. See the responses to RAI-16S001 and RAI-19S001 for additional information.

Item 5

The BISON code has the capability to model the momentum balance equations for the feedwater system and condensate systems as described in the original BISON topical report RPA 90-90-P-A. The modeling of the momentum balance equations for the feedwater system is not important for almost all dynamic applications for transient progress, as the feedwater flow is primarily dependent upon the pressure change in the RPV.

The feedwater system response can be modeled with SAFIR by adding a pressure dependency on the flow rate determined by SAFIR using either tabular flow or equivalent calculations by SAFIR. Therefore, the modeling of the feedwater system, using tabular flow or equivalent calculations by SAFIR that maintain the overall characteristics of the systems, is adequate for transient analysis.

However, if it would be found necessary to model the momentum balance equation for the feedwater system and condensate system, a simplified momentum balance equation can be modeled with SAFIR in a single phase system. The pressure drop (i.e., frictional pressure drop, head loss, elevation pressure drop and feedwater/condensate pump head) over the feedwater piping from the feedwater pumps into the RPV can be calculated by SAFIR using the already described components in the SAFIR topical report. This information can then be used by the SAFIR pump component to determine the feedwater flow given the feedwater pump speed. Hence, feedwater and condensate pump dynamics change due to the pressure changes in the RPV. These flow changes can be modeled using the described components in SAFIR. This modeling approach is essentially equivalent to modeling feedwater system and condensate system using the BISON built in model that uses the momentum balance equations for a one phase fluid system.

Since the feedwater systems normally contains very sub cooled water, the SAFIR modeling approach as described above does not impose a limitation of the modeling ability for a feedwater system or condensate system during transient conditions.

Item 6

The numerical stability in BISON is not affected by the introduction of SAFIR. SAFIR feeds BISON with transient boundary conditions and BISON has its own time step control. The BISON time step control restricts BISON from using a time step that would cause too large derivatives in the state variables for the thermal hydraulics and neutron kinetics. Hence, in case SAFIR feeds BISON with transient boundary conditions that consequently cause too large of changes in BISON's state variables, the BISON time step would be adjusted. This process is independent of if SAFIR is used to generate transient boundary conditions or if prescribed boundary conditions are used from user supplied input. In addition, as before SAFIR was introduced, BISON is using semi-implicit integration schemes that will counteract numerical instabilities.

In the response to RAI 28, it was shown that SAFIR permits closed feedback loops, which does not pose the possibility of inconsistent solutions since SAFIR does not iterate within the models to calculate the output. Instead, SAFIR uses the input for each component and evaluates the output for each component in the order they are supplied. Note that the component is only allowed to update its state if the component's sampling time permits an update. Therefore, the usage of closed feedback loops within the SAFIR models does not impose any new numerical issues. Moreover, closed feedback loops are an important feature and are commonly used in control systems to feedback the output to the input to determine the deviation between the desired and the actual parameter value and from there, determine the mean to decrease the error in the control system's target parameter. This is an example of a closed feedback loop that is commonly used within control systems, and as in SAFIR, the control system does not iterate to find a stable solution.

For analog components or control systems, SAFIR is using the transient code's time step as the sampling time to update the components. For digital components, the components are updated in accordance to each components sampling time. In addition, if the digital components have a sampling time that is shorter than the transient code's time step, linear interpolation between two the latest time steps in the transient code are used to provide information to SAFIR for the states in between these two time steps. Hence, this provides numerical stability to the transient code since the linear interpolation between the two latest time steps governs continuous values for the interface variables between SAFIR and the transient code.

Item 7

Detailed documentation of a BISON-SAFIR example calculation is provided in the response to RAI-16S001.

RAI-19S001

QUESTION:

The previously approved BISON code (RPA 90-90-P-A and CENPD-292-P-A) contains the following component/system models:

- Steam Line model (RPA 90-90-P-A) or PARA Steam Line model (CENPD-292-P-A),
- Trip System model,
- Reactor Scram model,
- Turbine and Generator model,
- Feedwater System model, and
- Relief and Safety Valve model.

RAI-19 had requested more detailed information on how the modeling of each of these systems has changed following the integration of SAFIR into the evaluation model, and had requested specific qualification analysis, uncertainty analysis, and applicability range definition for each of these models. The STP response as documented in U7-C-STP-NRC-100127 states that SAFIR does not interact with the numerical solutions of the above BISON models and that only the boundary conditions to these models are provided by SAFIR. However, from the explanation provided in a response to RAI-15 (U7-C-STP-NRC-100127), it appears that SAFIR's contribution consists not only of true mathematical boundary conditions (such as constant or tabulated time-dependent functions independent of the system's state variables), but that there exists time-dependent feedback between BISON's and SAFIR's state variables, so the information originally requested in RAI-19 is relevant to performing an adequate review of the evaluation model. Therefore:

a) Provide a summary table explaining modifications to the originally approved BISON models, as well as to any associated boundary conditions or feedback between BISON and SAFIR, resulting from the introduction of SAFIR to the evaluation model (similar to Table 2-1 of CENPD-292-P-A).

b) Where BISON-SAFIR models for these components/systems differ from the previously approved BISON models, the review criteria of NUREG-0800 require specific documentation of their applicability in a number of areas. Therefore, please establish that the new models yield acceptable results by providing results of two or more BISONSAFIR test cases that had previously been examined for previous BISON LTRs and which utilize the appropriate system models.

RESPONSE:

19S001a)

Westinghouse has provided a summary table below, similar to Table 2-1 from CENPD-292-P-A, with a description of the modification made to the BISON models. In all cases, the BISON models previously reviewed and approved in RPA 90-90-P-A and CENPD-292 are unchanged with the introduction of SAFIR to model control systems. This is confirmed in the response to RAI-16S001, which shows that the introduction of SAFIR to model control systems has no effect on the results from the BISON transient analysis.

Table 2-1 BISON CODE DESCRIPTION MODIFICATIONS (repeated from CENPD-292-P-A)

Major Components	Description Status	Modification/Comment
Physical Model (Ref. 1, Vol. 1, Chapter 2)	Unchanged from Reference 1	None
Thermal-Hydraulic Model (Ref. 1, Vol. 1, Chapter 3)	Unchanged from Reference 1	None
Neutron Kinetic Model (Ref. 1, Vol. 1, Chapter 4)	Unchanged from Reference 1	None
Fuel Heat Transfer Model (Ref. 1, Vol. 1, Chapter 5)	Unchanged from Reference 1	None
Steam Lines Model (Ref. 1, Vol. 1, Chapter 6)	Unchanged from Reference 1	None
General Time Integration Method (Ref. 1, Vol. 1, Chapter 7)	Unchanged from Reference 1	None
System Models (Ref. 1, Vol. 1, Chapter 8)	Unchanged from Reference 1	None
SLAVE Channel Model for Core or Coolant Channel (Ref. 1, Vol. 1, Chapter 9)	Unchanged from Reference 1	None
Input Data Preparation (Ref. 1, Vol. 1, Chapter 10)	Unchanged from Reference 1	None
Application of BISON (Ref. 1, Vol. 1, Chapter 11)	Unchanged from Reference 1	None
Primary Variable Addresses on the General State Vector y (Ref. 1, Vol. 1, App. A)	Unchanged from Reference 1	None

References:

1) RPA 90-90-P-A, Rev. 0, "BISON – A One Dimensional Dynamic Analysis Code for Boiling Water Reactors," December 1991.

19S001b)

The results of two transient scenarios using the BISON code with SAFIR included, is described and documented in the response to RAI-16S001. The calculations show the acceptability of the results, as they produce identical results compared to the previous BISON LTRs.

RAI-24S001

QUESTION

The previously approved steam line model (described in RPA 90-90-P-A) or PARA steam line model (described in CENPD-292-P-A) calculates the mass flow and pressure for each of the modeled steam line assuming isentropic behavior of the steam. Furthermore, the PARA steam line model includes models for flow control valves (Main steam line isolation valve (MSIV), turbine bypass valve, and turbine stop valve), safety/relief valves, and the turbine assembly. The valves are modeled using user-specified tables representing changes in valve stem position, valve flow area, or valve flow rate with time. The SER limitation on this model as documented in CENPD-292-P-A states that:

> *With use of the PARA steamline model, the user has flexibility of modeling valves and control system functions through the use of user supplied table and control systems. Modeling of these systems greatly affects the amount of conservatism in the transient outcome in certain event analysis. Therefore as required in the original SER for BISON, ABB/CE is required to provide justification for these user controlled items, which include valve performance, to assure conservatism in licensing applications.*

Table 3-1 in Section 3.8 and Sections 5 and 6 of WCAP-17079-P indicate that SAFIR is used for modeling MSIV, turbine bypass valve, turbine stop valve, and safety/relief valves.

In RAI-24(a), STP had been requested to confirm whether SAFIR models for these components are in compliance with the above-noted SER limitation. STP responded in U7-C-STP-NRC-100078 that the limitation would be removed with the approval of WCAP-17079-P. However, neither the submittal nor the RAI response provided adequate documentation of the basis for the removal of the limitation. Therefore:

a) Provide documentation of the basis for removal of the limitation regarding the steam line or PARA steam line model.

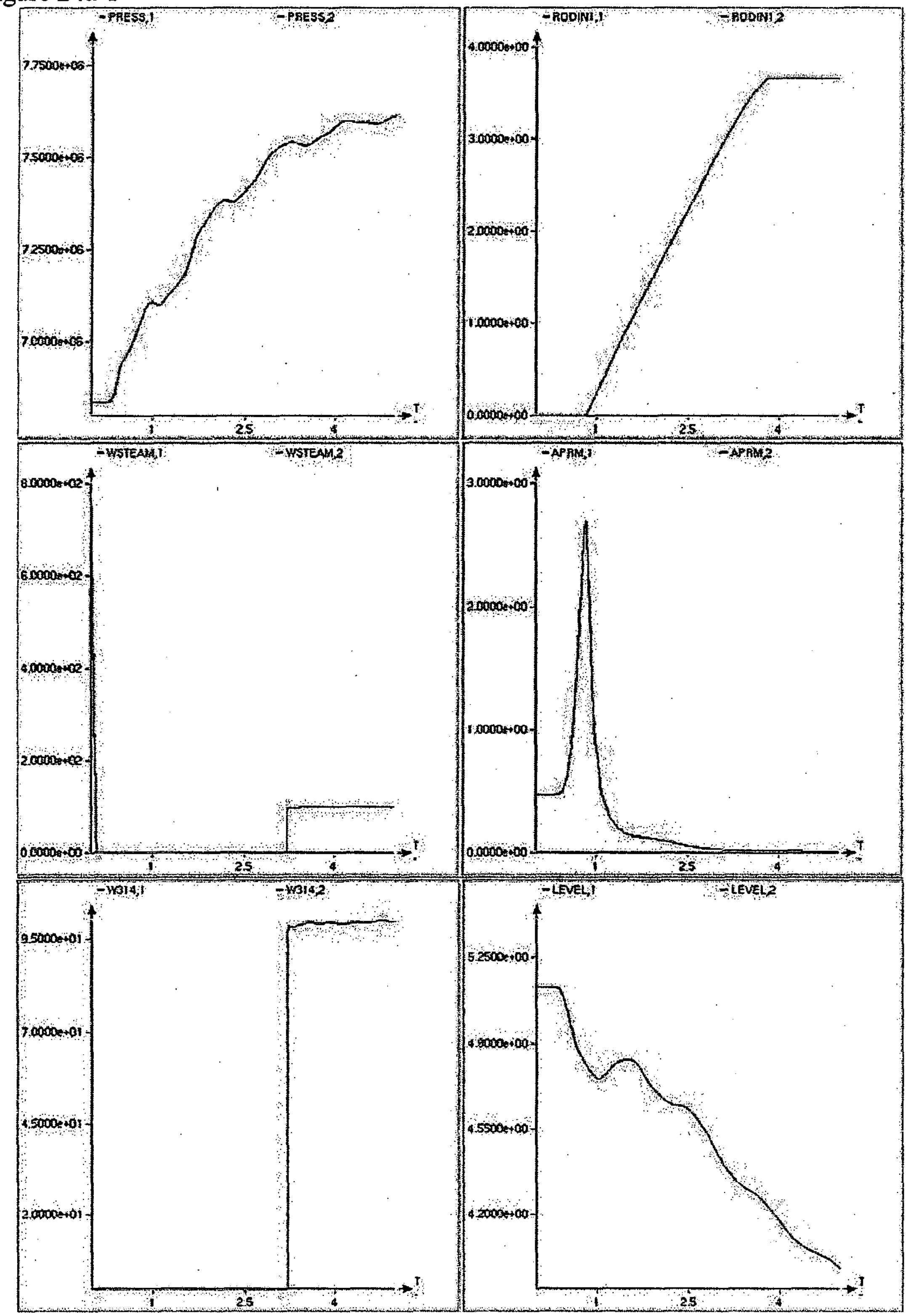
b) Provide details of the ABWR steam line model as implemented in BISON-SAFIR and demonstrate by means of the results of an appropriate calculation that the model accurately reproduces the real system's behavior or bounds it conservatively.

RESPONSE:

24S001a)

The removal of the PARA steam line model SER limitation is not a subject of the WCAP-17079-P. After examining the PARA steam line model it was determined to maintain this restriction. Hence, when SAFIR is used in conjunction with a PARA steam line model, valve performance will be modeled in compliance with the PARA SER limitation for US NRC approved fast transient or ATWS methodology. Figure 24a-1 shows the response of the steam dome pressure (PRESS), length of control rod insertion (RODIN), steam flow (WSTEAM), and average power range monitor (APRM) during the transient. These two cases can be seen in Figure 24a-1, the addition of SAFIR to the PARA model does not alter the ability to comply with the SER limitation from CENPD-292-P-A. Conservative modeling is still maintained with the implementation of SAFIR.

Figure 24a-1


PRESS,1
PRESS,2
7.7500e+06
7.5000e+06
7.2500e+06
7.0000e+06
RODIN1,1
RODIN1,2
4.0000e+00
3.0000e+00
2.0000e+00
1.0000e+00
0.0000e+00
WSTEAM,1
WSTEAM,2
8.0000e+02
6.0000e+02
4.0000e+02
2.0000e+02
0.0000e+00
APRM,1
APRM,2
3.0000e+00
2.0000e+00
1.0000e+00
0.0000e+00
W314,1
W314,2
9.5000e+01
7.0000e+01
4.5000e+01
2.0000e+01
LEVEL,1
LEVEL,2
5.2500e+00
4.9000e+00
4.5500e+00
4.2000e+00
1
2.5
4
T

RAI 24S001b)

As demonstrated in part a) of this response, SAFIR will continue to conservatively bound the control systems models in the PARA steam line model.