

**ORDER FOR SUPPLIES OR SERVICES**

**IMPORTANT:** Mark all packages and papers with contract and/or order numbers.

BPA NO.

1. DATE OF ORDER 09-10-2007	2. CONTRACT NO. (if any) <b>NRC-04-06-068</b>	6. SHIP TO:	
3. ORDER NO. <b>T004</b>	MODIFICATION NO.	4. REQUISITION/REFERENCE NO. RES-06-068-T004 dtd 7/10/2007	
5. ISSUING OFFICE (Address correspondence to) U.S. Nuclear Regulatory Commission Div. of Contracts Attn: H. (Eddie) Colón, 301-415-7135 Mail Stop T-7-I-2 Washington, DC 20555		a. NAME OF CONSIGNEE U.S. Nuclear Regulatory Commission	
		b. STREET ADDRESS Attn: Kirk Tien, 301-415-0736 Mail Stop: T10-K8 11555 Rockville Pike	
		c. CITY Rockville	e. ZIP CODE 20852
		d. STATE MD	f. SHIP VIA
7. TO:		8. TYPE OF ORDER	
a. NAME OF CONTRACTOR INFORMATION SYSTEMS LABORATORIES		<input type="checkbox"/> a. PURCHASE	<input checked="" type="checkbox"/> b. DELIVERY
b. COMPANY NAME ATTN.: MR. JAMES F. MEYER, MANAGER		REFERENCE YOUR Please furnish the following on the terms and conditions specified on both sides of this order and on the attached sheet, if any, including delivery as indicated.	
c. STREET ADDRESS 11140 ROCKVILLE PIKE STE 500		Except for billing instructions on the reverse, this delivery order is subject to instructions contained on this side only of this form and is issued subject to the terms and conditions of the above-numbered contract.	
d. CITY ROCKVILLE	e. STATE MD	f. ZIP CODE 208523106	
9. ACCOUNTING AND APPROPRIATION DATA 76015111205 N6452 252A 31X0200.760 <b>OBLIGATE: \$812,902.00</b> DUNS #: 107928806		10. REQUISITIONING OFFICE RES DRASP	

11. BUSINESS CLASSIFICATION (Check appropriate box(es))			12. F.O.B. POINT Destination
<input type="checkbox"/> a. SMALL	<input checked="" type="checkbox"/> b. OTHER THAN SMALL	<input type="checkbox"/> c. DISADVANTAGED	
<input type="checkbox"/> d. WOMEN-OWNED	<input type="checkbox"/> e. HUBZone	<input type="checkbox"/> f. EMERGING SMALLBUSINESS	
13. PLACE OF		14. GOVERNMENT B/L NO.	15. DELIVER TO F.O.B. POINT ON OR BEFORE (Date) N/A
a. INSPECTION	b. ACCEPTANCE		16. DISCOUNT TERMS Net 30

17. SCHEDULE (See reverse for Rejections) See CONTINUATION Page

ITEM NO. (a)	SUPPLIES OR SERVICES (b)	QUANTITY ORDERED (c)	UNIT (d)	UNIT PRICE (e)	AMOUNT (f)	QUANTITY ACCEPTED (g)
	<p><b>TASK ORDER NO. 004</b> entitled "<b>DEVELOPMENT OF PLANT INPUT MODELS FOR TRACE CODE</b>"</p> <p>Reference is made to your proposal dated 8/6/2007 in response to this effort.</p> <p>This confirms the email authorization provided to ISL on August 9, 2007 to begin work under the subject task order, effective August 9, 2007 with a temporary ceiling of \$65,000.</p> <p>In accordance with Section G.4 entitled "Task Order Procedures" of the subject contract, this order definitizes Task Order No. 004. This effort shall be performed in accordance with the enclosed SOW, and the terms and conditions of Contract No. NRC-04-06-068. Task Order No. 004 shall be effective August 9, 2007 - August 23, 2008 with a total cost ceiling of \$812,902. The amount of \$755,031 represents the reimbursable costs the amount of \$57,871 represents the fixed fee.</p>					

SEE BILLING INSTRUCTIONS ON REVERSE	18. SHIPPING POINT	19. GROSS SHIPPING WEIGHT	20. INVOICE NO.		17(h) TOTAL (Cont. pages)  17(i) GRAND TOTAL
	21. MAIL INVOICE TO:				
	a. NAME U.S. Nuclear Regulatory Commission Div. of Contracts, Mail Stop T-7-I-2				
	b. STREET ADDRESS (or P.O. Box) Attn: (NRC-04-06-068-T004) SUBMIT INVOICES IN TRIPLICATE				
	c. CITY Washington	d. STATE DC	e. ZIP CODE 20555	\$812,902.00	

22. UNITED STATES OF AMERICA  
BY (Signature)



23. NAME (Typed)  
Heriberto Colón, Jr.  
Contracting Officer  
TITLE: CONTRACTING/ORDERING OFFICER

**TEMPLATE - ADM001**  
AUTHORIZED FOR LOCAL REPRODUCTION  
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**SEP 18 2007**

**ADM001** (REV. 4/2006)  
GSA/FAR 48 CFR 53.213(f)

**ORDER FOR SUPPLIES OR SERVICES  
SCHEDULE - CONTINUATION**

PAGE NO.  
2

**IMPORTANT:** Mark all packages and papers with contract and/or order numbers.

DATE OF ORDER  
09-10-2007

CONTRACT NO.  
**NRC-04-06-068**

ORDER NO.  
**T004**

ITEM NO. (A)	SUPPLIES OR SERVICES (B)	QUANTITY ORDERED (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)	QUANTITY ACCEPTED (G)
	<p>The issuance of this task order does not amend any other terms or conditions of the subject contract.</p> <p>Please indicate your acceptance of this Task Order No. 004 <b>ACCEPTED:</b></p> <p>Name <u>SCOTT NEWBERY</u></p> <p>Title <u>VP</u></p> <p>Signature <u><i>Scott Newbery</i></u></p> <p>Date <u>9/10/07</u></p>					

TOTAL CARRIED FORWARD TO 1ST PAGE (ITEM 17(H))

**STATEMENT OF WORK  
NRC-04-06-068 TASK ORDER NO. 4**

**TITLE: DEVELOPMENT OF PLANT INPUT MODELS FOR TRACE CODE**

**I. BACKGROUND**

The TRACE code is being developed by the NRC to perform large and small break loss of coolant accident and system transient analysis for a wide range of nuclear plants. This code will be used as an audit tool to analyze transient and accident analyses submitted by vendors for licensing reactors. Plant safety analyses in support of licensing require a broad range of accident and transient scenarios to be analyzed to help understand the limiting conditions for safe operation of the plant. The analyses of these scenarios are performed with advanced computer codes. Timely response of the staff to analytic needs of the agency necessitates a source of input models from which to choose in performing systems safety analyses.

The US NRC Office of Nuclear Reactor Regulation (NRR) and the Offices of Nuclear Regulatory Research (RES) perform nuclear power plant safety analyses and desire enhanced capability to better address safety issues. The NRC staff intends to transition from using RELAP5 to using the TRACE code for all thermal-hydraulic analyses, including an initiative called the Risk Assessment Standardization Project (RASP). There are TRAC-BWR and TRAC-PWR input decks available for operating reactors. Some RELAP5 input decks are also available. Although TRACE can run TRAC-PWR and TRAC-BWR input decks, the input decks need to be upgraded to the TRACE native input format. Some models were also designed solely to compute specific transients or events so they may need to be upgraded to be applicable to a wider variety of transients.

**II. OBJECTIVE**

The objective of this work is to establish a library of TRACE nuclear plant input models, with documentation, for use by NRR and other NRC staff in addressing plant safety issues. Thirteen representative plants have been identified as priorities. The initial effort (task order no. 1) is to develop plant input models for four plants and scope the level of effort required for the remaining nine plants. This subsequent effort (task order no. 4) will develop plant input models for two of the remaining nine plants and continue development of the Seabrook (Model F SGs) input model for robustness.

**III. SCOPE OF WORK**

**Task 1: Scope Data Requirements for Additional Two Plants**

The two additional plants are North Anna (W-3 loop) and Palo Verde (CE-System 80). North Anna has a RELAP5 code input decks and documentation, and Palo Verde has a RELAP5 input deck and a two volume System 80 calculation notebook. A review of current plant modeling and documentation is required. Identification of additional data requirements is necessary to prepare complete TRACE code input models to be used for future staff analyses of LBLOCA, SBLOCA and anticipated plant transients. If requests for information

**NRC-04-06-068 TASK ORDER NO. 4 - Attachment #1**

from licensees or reactor vendors are required, they need to be identified during this initial review and time allowed to obtain the information for subsequent input deck preparation.

The broad spectrum of accidents and transients requiring modeling of reactor protection system controls and other features for a complete plant input deck are the same as described above in task order 1.

Estimated completion date: 3 weeks after start of contract

**Task 2: Prepare TRACE Code Plant Input Models**

Prepare complete TRACE code plant input models to be used for analyses of LBLOCA, SBLOCA and transients for Seabrook, North Anna and Palo Verde. Plant input models for Seabrook, North Anna and Palo Verde shall be fully completed during the contract period. The reactor vessels for all the listed plants shall be modeled using TRACE VESSEL components. All changes made to the code input files as a result of this work shall be documented in the calculation notebooks for each plant. If no existing calculation notebook exists, one shall be prepared. The TRACE calculation notebook and input model development shall follow the TRACE PWR and BWR Input Model Calculation Notebook Development outline and guidance documents contained in attachments to this SOW. Input model development shall also adhere to the guidance provided in the User's Manual for the TRACE 5.0 code. The table of contents for the calculation notebooks shall be similar to the one used in the CE System 80 calculation notebook.

Prepare well-structured and formatted SNAP input files and animation models in addition to the ASCII input files for the TRACE code. All TRACE input files, AVScript files, calculation notebook files, SNAP input files and other extraneous scripts or files necessary to reproduce the work shall be archived in the NRC data bank.

Estimated completion date: 12 months after start of contract

**Task 3: Run Demonstration Calculations and Prepare Report(s)**

Run representative analyses of LBLOCA, SBLOCA and a transient to be specified by the technical monitor for Seabrook, North Anna and Palo Verde. Reports for Seabrook, North Anna and Palo Verde shall be fully completed during the contract period. The cases associated with these TRACE code runs shall use AVScript input files and code input files prepared for each plant. Where applicable, results for each plant shall be compared to applicable experimental data and/or previous code cases. All calculations shall be documented in a TRACE Model User Description and Analysis Report written in Framemaker which shall follow the TRACE User Description and Analysis Report

## **NRC-04-06-068 TASK ORDER NO. 4 - Attachment #1**

Outline document contained in the attachment to this SOW. All figures present in the Framemaker assessment report documents shall exist as separate files on disk and linked to the files using the "import by reference feature" of Framemaker. Exceptions to this requirement where it makes sense shall be approved by the NRC TRACE code caretaker.

Estimated completion date: 12 months after start of contract

### **IV. RESEARCH QUALITY**

The quality of NRC research programs are assessed each year by the Advisory Committee on Reactor Safeguards. Within the context of their reviews of RES programs, the definition of quality research is based upon several major characteristics:

- Results meet the objectives (75% of overall score)
- Justification of major assumptions (12%)
- Soundness of technical approach and results (52%)
- Uncertainties and sensitivities addressed (11%)

- Documentation of research results and methods is adequate (25% of overall score)
- Clarity of presentation (16%)
- Identification of major assumptions (9%)

It is the responsibility of the contractor to ensure that these quality criteria are adequately addressed throughout the course of the research that is performed. The NRC project manager and technical monitor will review all research products with these criteria in mind.

### **V. REPORTING REQUIREMENTS**

1. Monthly letter status report (MLSR)

An MLSR should be submitted to the NRC project manager, William Krotiuk, by the 20<sup>th</sup> of the month following the month to be reported with a copy provided to the division management analyst, Sharon Haggerty, at Mail Stop T-10E50.

The MLSR shall identify the project title, job code, principal investigator, period of performance and reporting period; summarize each month's technical progress; and list monthly spending, total spending to date, and remaining funds. Any administrative or technical difficulties which may affect the schedule or costs of the project shall be immediately brought to the attention of the NRC project manager.

### **VI. DELIVERABLES AND DELIVERY SCHEDULE**

1. As described in task 1 requests for any additional data necessary to complete the TRACE code plant input models to be used for representative analyses shall be prepared and provided to the staff by 3 weeks after start of contract.

## **NRC-04-06-068 TASK ORDER NO. 4 - Attachment #1**

2. Three TRACE Model User Description and Analysis Reports documenting the results from the demonstration TRACE calculations as described in task 3, as well as all modified AVScripts, TRACE input files, SNAP input files, and three TRACE Input Model Calculation Notebooks as described in task 2 shall be prepared and provided to the staff. Deliverables for Seabrook, North Anna and Palo Verde shall be completed by 12 months after start of contract.

### **VII. MEETINGS AND TRAVEL REQUIREMENTS**

None.

### **VIII. TECHNICAL DIRECTION**

Technical direction will be provided by the project manager and technical monitor (William Krotiuk), who can be reached at:

Kirk Tien  
Mail Stop: T10-K8  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555-0001  
Phone: (301) 415-0736  
email: [kkt1@nrc.gov](mailto:kkt1@nrc.gov)

### **IX. PUBLICATIONS**

RES encourages the publication of the scientific results from RES-sponsored programs in refereed scientific and engineering journals as appropriate. If the contractor proposes to publish in the open literature or present the information at a meeting in addition to submitting the required technical reports, approval of the proposed paper or presentation should be obtained from the NRC project manager prior to expending effort on the writing of the paper or presentation. When the writing is completed, the NRC project manager will either approve the material as submitted, approve it subject to NRC-suggested revisions, or disapprove it. In any event, the NRC project manager may disapprove or delay publication or presentation of papers on information that is subject to Commission approval that has not been ruled upon or which has been disapproved. Additional information regarding the publication of NRC sponsored research is contained in NRC Management Directives 3.8, "Unclassified Contractor and Grantee Publications in the NUREG Series," and 3.9, "NRC Staff and Contractor Speeches, Papers, and Journal Articles on Regulatory and Technical Subjects."

If the paper or presentation is in addition to the required technical reports and the NRC project manager determines that it will benefit the NRC project, the project manager may authorize payment of publishing and/or travel costs, if any, from the project funds. If the project manager determines that the paper or presentation would not benefit the NRC project, the costs associated with the publication or presentation will be borne by the contractor. For any publications or presentations falling into this category, the NRC reserves the right to require that such publication or presentation will not identify the NRC's sponsorship of the work.

NEW STANDARDS FOR CONTRACTORS WHO PREPARE NUREG-SERIES MANUSCRIPTS

The U.S. Nuclear Regulatory Commission (NRC) is capturing its official records electronically. These records will be saved electronically in the Agency-wide Documents Access and Management System, known as ADAMS. The NRC is currently scanning each final NUREG-series publication from the printed copy. Therefore, submit your final manuscript that has been approved by your NRC project manager in both electronic and camera-ready copy.

All format guidance, as specified in NUREG-0650, Revision 2, will remain the same with one exception. You will no longer be required to include the NUREG-series designator on the bottom of each page of the manuscript. The NRC will assign this designator when we send the camera-ready copy to the printer and will place the designator on the cover, title page, and spine. The designator for each report will no longer be assigned when the decision to prepare a publication is made. The NRC's Publishing Services Branch will inform the NRC Project Officer for the publication of the assigned designator when the final manuscript is sent to the printer.

For the electronic manuscript, prepare the text in WordPerfect 8, and use any of the following file types for charts, spreadsheets, and the like.

File Types to be Used for NUREG-Series Publications	
File Type	File Extension
WordPerfect®	.wpd
Microsoft® PowerPoint®	.ppt
Corel® QuattroPro®	.wb3
Corel® Presentations	.shw
Lotus® 1-2-3	.wk4
Portable Document Format	.pdf

This list is subject to change if new software packages come into common use at NRC or by our licensees or other stakeholders that participate in the electronic submission process. If a portion of your manuscript is from another source and you cannot obtain an acceptable electronic file type for this portion (e.g., an appendix from an old publication), the NRC can, if necessary, create a tagged image file format (file extension.tif) for that portion of your report.

Note that you should continue to submit original photographs, which will be scanned, since digitized photographs do not print well.

If you chose to publish a compact disk (CD) of your publication, place on the CD copies of the manuscript in both (1) a portable document format (PDF); (2) a WordPerfect 8/9 file format, and (3) an Adobe Acrobat Reader, or, alternatively, print instructions for obtaining a free copy of

**NRC-04-06-068 TASK ORDER NO. 4 - Attachment #1**

Adobe Acrobat Reader on the back cover insert of the jewel box.

**X. QUALITY ASSURANCE**

Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554) directs the Office of Management and Budget (OMB) to issue government-wide guidelines (FR Vol. 67, No. 36, pp. 8452-8460) that "provide policy and procedural guidance to federal agencies for ensuring and maximizing the quality, objectivity, utility, and integrity of information (including statistical information) disseminated by federal agencies." NRC Information Quality Guidelines are provided in FR Vol. 67, No. 190, pp. 61695-61699.

The Contractor shall cite contractor quality assurance procedures used in the conduct of this work that provide for compliance with OMB and NRC guidelines.

**XI. NRC-FURNISHED MATERIALS**

Existing TRAC-BWR, TRAC-PWR and RELAP5 input decks for the two representative plants are to be furnished by the NRC during the performance of this work. Existing input decks and documentation are available on the NRC's TRACE Developer Information Exchange website. Additional required data identified by the contractor in tasks 1 and 3 and requested from licensees or reactor vendors is to be furnished by the NRC as it becomes available. If plant-specific information needed for modeling is unavailable, the contractor shall use generic information or models from a similar plant and note this as a limitation of the model. The NRC will also supply a copy of the CE System 80 calculation notebook.

**XII. TECHNICAL AND OTHER SPECIAL QUALIFICATIONS REQUIRED**

The contractor shall provide personnel that are experienced in thermal-hydraulic analysis.

It is the responsibility of the contractor to assign technical staff, employees, subcontractors, or specialists who have the required educational background, experience, or combination thereof to meet both the technical objectives of the work specified in this SOW. The NRC will rely on representations made by the contractor concerning the qualifications of the personnel assigned to this task order including assurance that all information contained in the technical and cost proposal, including resumes, is accurate and truthful. In addition, the contractor and personnel assigned to this work must be approved for handling and working with proprietary information.

The use of key personnel and any proposed change to key personnel on this contract is subject to the NRC project manager's approval. This includes proposed use of principal persons (i.e., key contributors) during the life of the contract.

For any work to be subcontracted or performed by consultants to the contractor, the contractor shall obtain the NRC project manager's written approval of the subcontractor or consultant prior to initiation of the subcontract effort. Conflict of interest considerations shall apply to any subcontracted effort.

**XIII. REFERENCES AND ATTACHMENTS**

The following guidance and outline documents are attached to this SOW and shall be used for preparation of the deliverable documents.

1. TRACE PWR Input Model Calculation Notebook Development
2. TRACE BWR Input Model Calculation Notebook Development
3. TRACE Model User Description and Analysis Report Outline

**XIV. CONFLICT OF INTEREST**

List any work in the proposal that is similar to that previously performed or is to be performed by the contractor on behalf of another sponsor that might give rise to an apparent (perceived) or actual organizational conflict of interest, including duplication of effort.

**XV. SUBCONTRACT/CONSULTING INFORMATION**

Describe any technical support effort that is proposed to be performed by a subcontractor or consultant. Identify the level of effort, by task, of any proposed subcontractor or consultant and provide an explanation of the need for subcontracting that portion of the effort. Note that "pass through" contracting is not allowed under the requirements of the DOE/NRC Memorandum of Understanding. For the purposes of this effort, a "pass through" contract is generally defined as subcontracting 50 percent or more of the technical effort. For any subcontract or consultant effort, describe the following:

- the necessity of subcontracting,
- the tasks and sub-tasks the subcontractor or consultant will perform,
- the level of effort proposed for the subcontract effort,
- the conflict of interest considerations to be taken into account,
- the status and expected time frame for selection,
- the method of selection of the subcontractor or consultant.

**XVI. LICENSE FEE RECOVERY**

The work specified in this SOW is not license fee recoverable.

**TRACE PWR Input Model Calculation Notebook Development for PWRs**

**Rev. 0**

**June 2007**

This document is a general guide for the preparation of a plant deck calculation notebook, and includes some specific guidance on modeling the reactor system. This document will eventually be included in the TRACE User's Guide.

The purpose of the plant input calculation notebook is to provide plant and input information to enable reviewers and analysts to verify that the plant is accurately modeled and that the input is appropriate for the TRACE version being used. The accuracy of many past input models was difficult to ascertain because the sources and/or bases of some of the inputs were not provided or were unclear. For example, the bases of the loss coefficients in many input decks are not provided. In order to understand code results or code problems it is essential to understand which input parameters were well documented and which were assumed by the input developer.

The input values and parameters associated with the plant geometry, the justification for the initial and boundary conditions, and the source or basis of the inputs describing modeled components (e.g., pumps, valves, etc.) are the most important parameters provided in a calculation notebook. Calculations used to develop these TRACE input values should be included in the calculation notebook. In some cases, drawings and reference material may not be available and development of a good basis for some input values may not be possible, particularly for loss coefficients or plant flow/pressure drops. Some K-factors may need to be set to obtain desired flows and pressure drops. In these cases, all assumptions should be clearly identified in the calculation notebook.

The calculation notebook shall be easily comprehensible. Therefore, the calculation notebook shall not contain text copied from the TRACE documentation (theory manual, theory manual supplement, and user input manual). Instead, the authors of the calculation notebook shall use conventional referencing. This ensures continued traceability as TRACE documentation evolves in subsequent versions of the code. Scans or cut/pastes from Excel spreadsheets are not acceptable. Similarly, cut and paste annotations from SNAP shall not be used. Nor shall excerpts copied from the input deck be included into the calc notebook. Instead the entire finalized input deck shall be included in Section 6 and the remainder of the calculation notebook shall discuss pertinent entries by referencing the corresponding card or component as labeled in the user's guide. These restrictions are imposed so that, at a later date, when the SNAP software package becomes fully developed for this purpose, the entire calculation notebook can be embedded in SNAP to further enhance user friendliness.

The calculation notebook must be provided to the NRC in a Microsoft Word and Adobe PDF file format.

**Cover Sheet**

A cover sheet must be provided. The following items must be included on the cover sheet: the plant name, author, affiliation, TRACE version used, computer and operating system used, reviewer, reviewer affiliation, and completion date. The ADAMS number shall be placed on the cover if known.

## **Table of Contents**

A Table of Contents should be included in the calculation notebook. As a minimum, the Table of Contents, and consequently the calculation notebook, should include the following topics

### **1.0 Introduction and Purpose**

Provide any information that an analyst or reviewer needs with regard to the background, purpose and scope of the analysis for which the input was developed. Discuss and reference any previous plant analyses with earlier versions of the input or with other thermal/hydraulic codes.

### **2.0 Plant Model Description and Modeling Assumptions**

#### **2.1 Plant Description**

Provide a brief description of the plant. Discuss the type of plant and containment (W 3-Loop PWR, dry containment, etc.), the type of fuel assumed in the model and any other pertinent general characteristics.

#### **2.2 Plant Initial Conditions**

Provide general information on the plant conditions including licensed core power level, and other items frequently listed in the plant Technical Specifications including: FQ, FdH, Thot, Tcold, core or loop flow rate, SG pressure, and initial system pressure.

#### **2.3 Safety System Description and Operation**

Describe the main safety systems and include any unusual features such as three accumulators in the four loop South Texas unit.

### **3.0 Missing Information**

A summary should describe the capabilities, limitations and major assumptions of the current plant input model, and provide a list of missing references and/or information needed for future development.

### **4.0 TRACE Model Input Description and Calculation**

#### **4.1 System Nodalization**

Provide and discuss briefly the system nodalization. One or more figures from SNAP may be used to present the system model.

#### **4.2 Component Nodalization**

Develop a table that lists the TRACE components used in the model and describe the plant components which they represent.

#### **4.3 Containment Description**

If included in the TRACE model, list the TRACE components used to model the containment and containment systems, as applicable. Provide figures which describe the modeling approach for the containment systems.

#### **4.4 Calculation of TRACE Inputs**

The purpose of the calculation notebook is to insure that the correct inputs are used to describe the plant geometry such as flow areas (fa), volumes (vol), metal mass, loss coefficients (fric or kfac), etc. In order to better organize the plant calculation notebook and keep it to a reasonable size, describe the TRACE component input preparation by plant "region". Take advantage of the fact many of the inputs are repeated in several places and avoid redundancy. Organizing the model by region will allow one to discuss input common to several components in just one place in the calculation notebook. For example, instead of separate listings and tabulations for each of four hot legs in a W 4-loop PWR, a section labeled "Hot Legs" shall be used to document the main input. Consolidate parameters such as initial void fraction, initial temperature, and initial pressure. Reference the source or assumption basis of the values used throughout the model. If, for example, the system is full of water at a given pressure, then just state void fraction (alp) = 0.0 and pressure (pn) = 2250 psi in all cells rather than listing the void and pressure for every single component. The same shall be used for parameters such as liquid velocity (vl), vapor velocity (vv), liquid temperature (tl), vapor temperature (tv), and most of the time for the TRACE flag for the TRACE pressure drop calculations (nff).

The heat structure input calculations should be included in the appropriate component regions.

The following "regions" are suggested to describe a PWR plant.

#### **4.3.1 Hot Legs and SG Input Elbow**

Reference the length, pipe thickness and any loss coefficient information, and show calculations used to obtain the control volume length (dx), hydraulic diameter (hd), vol, fric or kfac, and junction gravity flag (grav). Describe any heat structures in this region and reference the source of the wall thickness used. There should be uniformity between models with horizontal pipes and consistency with experimental assessments. The horizontal flow pattern assessment, as well as CCTF and SCTF assessments, specified cells with an L/D equal to about 4 or 5. The plant hot legs should also use L/D values about this magnitude. The BETHSY and ROSA assessments can be referenced to determine appropriate values to use.

#### **4.3.2 Pressurizer and Surge Line**

Reference the pressurizer information and show calculations for fa, vol, hd, dx, and fric or kfac. Describe the heat structures associated with the pressurizer and any input to describe the pressurizer sprays. Nodalization of the pressurizer and surge line should be similar to pressurizers as they were modeled in the BETHSY and ROSA assessments.

#### **4.3.3 Steam Generator Tubes**

Reference the number of tubes per SG, the assumed SGTP level (and if the model is assuming the same SGTP in each SG), the ID and OD of the tubes, and show the calculations to get total flow area (fa), volumes (vol) and the basis for the loss coefficient values. Provide information on the heat structure(s) representing the tubes and note the thermal connections to the fluid cells. The steam generator model should be similar to the assessment tests with full height SGs such as MB-2, BETHSY, ROSA, CCTF, and Semiscale.

#### **4.3.4 Steam Generator Secondary**

Provide the references used and show the calculations of the secondary side volumes and flow areas. Show the calculations for fa, vol, hd, and flow losses for the PIPE or TEE components representing the secondary side boiler region. Repeat this process for the SG downcomer and the PIPE or TEE Components in the separator region.

#### **4.3.5 Feedwater System**

## **NRC-04-06-068 Task Order 004**

### **XV. REFERENCES AND ATTACHMENTS 1.**

Describe the FW system components, the basis for the input assumptions, and the calculations used to determine the TRACE inputs.

#### **4.3.6 Loop Seals**

Reference the loop seal region piping length, area and elevation changes, and also the pipe ID. Show calculations for the fa, vol, hd, and grav inputs. The nodalization (number of nodes) should give an L/D in the loop seal region similar to BETHSY and ROSA.

#### **4.3.7 Reactor Coolant Pumps**

Reference the pump type in the plant (e.g. Type 93A). Describe the pump input, the reference or assumptions for the pump curves, and information on flow area into and out of the pump, pump irreversible loss coefficient (K) if modeled, and the volume.

#### **4.3.8 Intact Cold Legs**

Reference the length, pipe thickness and any loss coefficient information, and show calculations to obtain dx, hd, vol, fric or kfac, grav. Describe any heat structures in this region referencing the wall thickness used.

#### **4.3.9 Broken Leg and Break**

Provide a separate noding diagram to show the break geometry and describe the input. Include both the leg PIPE and BREAK components and describe the geometry, especially the dx, fa, nff, and loss coefficients, and the inputs for the critical flow flags.

#### **4.3.10 Reactor Vessel**

Break the reactor vessel into subregions, and focus on the important input in each. For a PWR, use the following:

- Downcomer
- Lower plenum
- Lower core plate
- Core
- Upper core support plate
- Core bypass region
- Upper plenum
- Guide tubes
- Upper head

In each subregion relate the actual flow areas and volumes to the TRACE input (using the r, z, theta dimensions and the volume and area fraction inputs). If a number of the levels in a VESSEL are similar as for the core, include the calculations that determine the values once. For items such as the loss coefficients, show the source or basis of values used at places like the core plates and grid spacer levels.

The VESSEL component model should be similar to the modeling used in most of the assessments. The downcomer and lower plenum models should reference the UPTF assessments, but based on those simulations, an additional level should be added below the bottom of the core barrel. The downcomer is located within one single radial ring. The number of theta sectors should depend on the number of horizontal loop components associated with the reactor vessel. Use 6 theta sections for a 3-loop PWR and 8 theta sections for a 4-loop PWR. For two-loop PWRs, and those with direct vessel injection, use either 6 or 8 theta sectors, whichever minimally models no more than one line into a vessel cell.

**XV. REFERENCES AND ATTACHMENTS 1.**

The core should be based on nodalization in tests like FLECHT-SEASET, RBHT, CCTF, and SCTF. That is, use the locations of the grid spacers to determine the axial nodalization. Put one level in between each grid spacer so that the cell height is about 10 inches. The flow area at each level in the core is the un-gridded flow area. Levels with grid spacers will have loss coefficients (cfzlz and cfzvz).

The flow area between the upper head and the downcomer in the upper head should be referenced and calculated appropriately. The basis for the loss coefficient needed to obtain the desired UH bypass flow should be specified.

**4.3.10 Accumulators**

Reference the accumulator design information and the initial volumes of water and nitrogen. Clearly specify the value of PIPETYPE and why it is appropriate.

**4.3.11 Safety Injection System**

Provide the reference for the safety injection (SI) FILLs, and describe the FILLs and how the safety injection gets to the model. The key is to reference the flow versus pressure table and the assumptions for that table (i.e., loss of one pump).

**4.3.12 Reactor Fuel**

Describe the fuel model and the heat structures, and the inputs representing the nuclear fuel.

**4.3.13 Power Component**

Describe the POWER Component and the input to achieve the intended power shape. Clearly indicate the basis or assumptions for burnup and peaking factors.

**4.4 Control Blocks and Signal Variables**

Describe the control blocks and signal variables calculated. For all plants, include that capability to plot:

- Core Collapsed Liquid Level (ref = bottom of active fuel)
- Upper Plenum Collapsed Liquid Level
- Upper Head Collapsed Liquid Level
- Pressurizer Collapsed Liquid Level
- Downcomer Collapsed Liquid Level
- SG Tube Uphill Side Collapsed Liquid Level (each SG)
- SG Tube Downhill Side Collapsed Liquid Level (each SG)
- SG Secondary Side Collapsed Liquid Level (each SG)
- Loop Seal Downhill Side Collapsed Liquid Level (each loop)
- Loop Seal Uphill Side Collapsed Liquid Level (each loop)
- Total Primary system mass (include pressurizer, exclude accumulators) =  $M(t)$   
(obtained by summing the mass in all cells)
- Total Vessel mass
- Mass Balance: Mass created =  $M(t)$  - [Initial primary mass - integrated break flows +  
sum of all safety injection flows]
- Core Inlet Flow Rate (sum of all flow into bottom of core)

The input for these and any other control blocks and signal variables should be listed in a table.

**4.5 Trips**

Discuss the trips assumed and describe the input related to trip logic. All trips should be listed in a table.

**4.6 Time Step Specification**

Explain the reasons for the choice of time step size and any iterations used to optimize run time.

**5.0 References**

All references used in developing the input model shall be listed.

**6.0 TRACE Input Listing**

A listing of the steady state and transient TRACE input files shall be included at the end of the calculation notebook.

**TRACE Input Model Calculation Notebook Development for BWRs**

**Rev. 0**

**June 2007**

This document is a general guide for the preparation of a plant deck calculation notebook, and includes some specific guidance on modeling the reactor system. This document will eventually be included in the TRACE User's Guide.

The purpose of the plant input calculation notebook is to provide plant and input information to enable reviewers and analysts to verify that the plant is accurately modeled and that the input is appropriate for the TRACE version being used. The accuracy of many past input models was difficult to ascertain because the sources and/or bases of some of the inputs were not provided or were unclear. For example, the bases of the loss coefficients in many input decks are not provided. In order to understand code results or code problems it is essential to understand which input parameters were well documented and which were assumed by the input developer.

The input values and parameters associated with the plant geometry, the justification for the initial and boundary conditions, and the source or basis of the inputs describing modeled components (e.g., pumps, valves, etc.) are the most important parameters provided in a calculation notebook. Calculations used to develop these TRACE input values should be included in the calculation notebook. In some cases, drawings and reference material may not be available and development of a good basis for some input values may not be possible, particularly for loss coefficients or plant flow/pressure drops. Some K-factors may need to be set to obtain desired flows and pressure drops. In these cases, all assumptions should be clearly identified in the calculation notebook.

The calculation notebook shall be easily comprehensible. Therefore, the calculation notebook shall not contain text copied from the TRACE documentation (theory manual, theory manual supplement, and user input manual). Instead, the authors of the calculation notebook shall use conventional referencing. This ensures continued traceability as TRACE documentation evolves in subsequent versions of the code. Scans or cut/pastes from Excel spreadsheets are not acceptable. Similarly, cut and paste annotations from SNAP shall not be used. Nor shall excerpts copied from the input deck be included into the calc notebook. Instead the entire finalized input deck shall be included in Section 6 and the remainder of the calculation notebook shall discuss pertinent entries by referencing the corresponding card or component as labeled in the user's guide. These restrictions are imposed so that, at a later date, when the SNAP software package becomes fully developed for this purpose, the entire calculation notebook can be embedded in SNAP to further enhance user friendliness.

The calculation notebook must be provided to the NRC in a Microsoft Word and Adobe PDF file format.

**Cover Sheet**

A cover sheet must be provided. The following items must be included on the cover sheet: the plant name, author, affiliation, TRACE version used, computer and operating system used, reviewer, reviewer affiliation, and completion date. The ADAMS number shall be placed on the cover if known.

## **Table of Contents**

A Table of Contents should be included in the calculation notebook. As a minimum, the Table of Contents, and consequently the calculation notebook, should include the following topics

### **1.0 Introduction and Purpose**

Provide any information that an analyst or reviewer needs with regard to the background, purpose and scope of the analysis for which the input was developed. Discuss and reference any previous plant analyses with earlier versions of the input or with other thermal/hydraulic codes.

### **2.0 Plant Model Description and Modeling Assumptions**

#### **2.1 Plant Description**

Provide a brief description of the plant. Discuss the type of plant and containment (e.g., GE BWR/4, GE Mark II, etc.), the type of fuel assumed in the model and any other pertinent general characteristics.

#### **2.2 Plant Initial Conditions**

Provide general information on the plant conditions including licensed core power level, and other items frequently listed in the plant Technical Specifications including: FQ, FdH, Thot, Tcold, core or loop flow rate, SG pressure, and initial system pressure.

#### **2.3 Safety System Description and Operation**

Describe the main safety systems and include any unusual features.

### **3.0 Missing Information**

A summary should describe the capabilities, limitations and major assumptions of the current plant input model, and provide a list of missing references and/or information needed for future development.

### **4.0 TRACE Model Input Description and Calculation**

#### **4.1 System Nodalization**

Provide and discuss briefly the system nodalization. One or more figures from SNAP may be used to present the system model.

#### **4.2 Component Nodalization**

Develop a table that lists the TRACE components used in the model and describe the plant components which they represent.

#### **4.3 Containment Description**

If included in the TRACE model, list the TRACE components used to model the drywell, suppression chamber and pool, vents lines and other containment systems, as applicable. Provide figures which describe the modeling approach for the containment systems including the approach for cooling the suppression pool.

#### **4.4 Calculation of TRACE Inputs**

The purpose of the calculation notebook is to insure that the correct inputs are used to describe the plant geometry such as flow areas (fa), volumes (vol), metal mass, loss coefficients (fric or kfac), etc. In order to better organize the plant calculation notebook and keep it to a reasonable size, describe the TRACE component input preparation by plant "region". Take advantage of the fact many of the inputs are repeated in several places and avoid redundancy. Organizing the model by region will allow one to discuss input common to several components in just one place in the calculation notebook. For example, instead of separate listings and tabulations for each main steam line, a section labeled "Steam Lines" shall be used to document the main input. Consolidate parameters such as initial void fraction, initial temperature, and initial pressure. Reference the source or assumption basis of the values used throughout the model. If, for example, parts of the system are full of water at a given pressure, then just state void fraction (alp) = 0.0 and pressure (pn) = 1100 psi in all cells rather than listing the void and pressure for every single component. The same approach shall be used for parameters such as liquid velocity (vl), vapor velocity (vv), liquid temperature (tl), vapor temperature (tv), and most of the time for the TRACE flag for the TRACE pressure drop calculations (nff).

The heat structure input calculations should be included in the appropriate component regions.

The following "regions" are suggested to describe a BWR plant.

#### **4.4.1 Reactor Vessel**

Break the reactor vessel into subregions, and focus on the important input in each. For a BWR, use the following:

- Steam separators
- Jet pumps
- Fuel channels

In each subregion relate the actual flow areas and volumes to the TRACE input (using the r, z, theta dimensions and the volume and area fraction inputs). If a number of the levels in a VESSEL are similar as for the core, include the calculations that determine the values once. For items such as the loss coefficients, show the source or basis of values used at places like the core plates and grid spacer levels.

The VESSEL component model should be similar to the modeling used in most of the assessments.

#### **4.4.2 Recirculation Piping and Valves**

Reference the length, pipe thickness and any loss coefficient information, and show calculations used to obtain the control volume length (dx), hydraulic diameter (hd), vol, fric or kfac, and junction gravity flag (grav). Describe any heat structures in this region and reference the source of the wall thickness used. The inputs for valves should be described and referenced. There should be uniformity between models with horizontal pipes and consistency with experimental assessments. The plant piping should also use L/D values equal to about 4 or 5.

#### **4.4.3 Recirculation Pumps**

Reference the pump type in the plant. Describe the pump input, the reference or assumptions for the pump curves, and information on flow area into and out of the pump, pump irreversible loss coefficient (K) if modeled, and the volume.

#### **4.4.4 Main Steam Line and Valves**

## **NRC-04-06-068 Task Order 004**

### **XV. REFERENCES AND ATTACHMENTS 2.**

Show calculations for fa, vol, hd, dx, and frics. Describe the heat structures associated with the piping. Provide the references, assumptions and inputs for the MSIVs, PCVs, bypass valves, SRVs and ADS valves.

#### **4.4.5 Feedwater System**

Describe the FW system components, the basis for the input assumptions, and the calculations used to determine the TRACE inputs.

#### **4.4.6 Broken Leg and Break**

Provide a separate nodding diagram to show the break geometry and describe the input. Include both the leg PIPE and BREAK components and describe the geometry, especially the dx, fa, nff, and loss coefficients, and the inputs for the critical flow flags.

#### **4.4.7 Safety Injection System**

Provide the reference for the high pressure coolant injection (HPCI), low pressure core injection (LPCI) and low pressure core sprays (LPCS) FILLs, and describe the FILLs and how the safety injection gets to the model. The key is to reference the flow versus pressure table and the assumptions for that table.

#### **4.4.8 Reactor Fuel**

Describe the fuel model and the heat structures, and the inputs representing the nuclear fuel.

#### **4.4.9 Power Component**

Describe the POWER Component and the input to achieve the intended power shape. Clearly indicate the basis or assumptions for burnup and peaking factors.

#### **4.4.10 Containment Components**

The approach for modeling and inputs for the following components should be provided.

- Drywell
- Suppression chamber and pool
- Vent lines
- Vacuum breakers
- Suppression pool cooling

Describe the drywell, suppression chamber and pool inputs. The input calculations should also be included for the vent lines and the vacuum breakers. The references and modeling approach for the vacuum breakers should be provided. It is also important to describe the modeling and inputs for providing suppression pool cooling.

### **4.5 Control Blocks and Signal Variables**

Describe the control blocks and signal variables calculated. For all plants, include that capability to plot:

- Core Collapsed Liquid Level (ref = bottom of active fuel)
- Total Primary system mass =  $M(t)$  (obtained by summing the mass in all cells)
- Total Vessel mass
- Mass Balance: Mass created =  $M(t)$  - [Initial primary mass - integrated break flows + sum of all safety injection flows]
- Core Inlet Flow Rate (sum of all flow into bottom of core)

The input for these and any other control blocks and signal variables should be listed in a table.

**4.6 Trips**

Discuss the trips assumed and describe the input related to trip logic. All trips should be listed in a table.

**4.7 Time Step Specification**

Explain the reasons for the choice of time step size and any iterations used to optimize run time.

**5.0 References**

All references used in developing the input model shall be listed.

**6.0 TRACE Input Listing**

A listing of the steady state and transient TRACE input files should be included at the end of the calculation notebook.

**TRACE User Description and Analysis Report Outline**  
**Rev. 0**  
**June 2007**

This document is a general guide for the preparation of a TRACE User Description and Analysis Report. The purpose of the report is to document the analyses performed to verify the usability of the developed TRACE input model, and to enable reviewers and analysts to verify that the plant is appropriately modeled and that the input is appropriate for the TRACE version being used.

Steady-state and transient analyses shall be run to verify the TRACE input model and shall be reported in the TRACE Model User Description and Analysis Report. The TRACE analyses and plots presented in this report shall be run using AVScripts files. The input preparation for the TRACE model used for these analyses shall be documented in the TRACE Input Model Calculation Notebook. Where applicable, results shall be compared to applicable experimental data and/or previous code cases. The TRACE Model User Description and Analysis Report shall be written in Framemaker. All figures present in the analysis report shall exist as separate files on disk and linked to the document file using the "import by reference feature" of Framemaker.

**Cover Sheet**

A cover sheet must be provided. The following items must be included on the cover sheet: the plant name, author, affiliation, TRACE version used, computer and operating system used, reviewer, reviewer affiliation, and completion date. The ADAMS number shall be placed on the cover if known.

**Table of Contents**

A Table of Contents should be included. As a minimum, the Table of Contents should include the following topics.

**1.0 Introduction and Purpose**

Provide any information that an analyst or reviewer needs with regard to the background, purpose and scope of the analysis. Discuss and reference any previous plant analyses with earlier versions of the input or with other thermal/hydraulic codes.

**2.0 Plant Model Description and Modeling Assumptions**

**2.1 Plant Description**

Provide a brief description of the plant. Discuss the type of plant (W 3-Loop PWR, GE Mark II, etc.) and the type of fuel assumed in the model.

**2.2 Plant Initial Conditions**

Provide general information on the plant conditions including licensed core power level, and other items frequently listed in the plant Technical Specifications including: FQ, FdH, Thot, Tcold, core or loop flow rate, SG pressure, and initial system pressure.

### **2.3 Safety System Description and Operation**

Describe the main safety systems and include any unusual features such as 3 accumulators in the 4 loop South Texas unit.

### **3.0 Missing Information**

A summary should describe the capabilities, limitations and major assumptions of the current plant input model, and provide a list of missing references/information needed for future development.

### **4.0 TRACE Model Input Description and Calculation**

Provide and discuss briefly the system nodalization. List the TRACE components used in the model and describe the plant components which they represent. One or more figures from SNAP may be used to present the system model. Also describe the control blocks and signal variables used in the calculation.

### **5.0 Simulation Results**

#### **5.1 Steady-state Simulation**

The report should include results of a steady-state simulation to show that the input produces the intended plant conditions. Use output from the steady-state execution to demonstrate that the input deck converges to the correct  $T_{hot}$ ,  $T_{cold}$ , pressure, flow rates, and the correct pressure drops around the flow circuit. The steady-state results must verify that the model obtains the intended flows. For example a steady-state PWR analysis should demonstrate that the bypass flows through the core bypass and upper head to downcomer flow paths are close to design, and that the model predicts the correct upper head initial temperature.

Use the steady-state output to verify that the correct power, peaking factor, and initial fuel centerline and average temperatures are being estimated.

#### **5.2 Transient Simulations**

The report should list the transient analyses used to verify the TRACE input model and provide a brief discussion of the results. The representative analyses should include a large break loss of coolant accident (LBLOCA), a small break loss of coolant accident (SBLOCA) and a transient to be specified by the technical monitor. This section should include transient plots of the important parameters calculated during the transient. Explain the reasons for the choice of time step size and any iterations used to optimize run time.

### **6.0 References**

All references should be listed.