UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SEP 22 2003

Information Systems Laboratories, Inc.
ATTN: James Meyer
11140 Rockville Pike, Suite 500
Rockville, MD 20852

SUBJECT: TASK ORDER NO. 12 UNDER CONTRACT NO. NRC-04-02-054

Dear Mr. Meyer:

This letter definitizes Task Order No. 12 in accordance with the enclosed statement of work. The period of performance for Task Order No. 12 is September 22, 2003 to February 28, 2004. The task order estimated cost and fixed fee is set forth as follows: Estimated Costs:$122,046 Fixed Fee:$9,419 CPFF Total:$131,465. $100,000 in funds is hereby allotted to this task order. The accounting data for this task order is set forth as follows: RES ID: RES-C03-459 APPN: 31X0200 B&R:36015115107 JCN:Y6831 BOC: 252A Amount Obligated This Action:$100,000.

Please indicate your acceptance of Task Order No.12 by having an official authorized to bind your organization execute three copies of this document, by signing in the space provided, and return two copies to me. You should retain the third copy for your records. All other terms and conditions of this task order remain unchanged.

Should you have any questions, regarding this task order, please contact me on (301) 415-8168.

Sincerely,

Stephen M. Pool, Contracting Officer
Division of Contracts
Office of Administration

ACCEPTED:
NAME

V.P.
TITLE

9/23/03
DATE

TEMPLATE - ADM001

ADM002

STATEMENT OF WORK
NRC-04-02-054 TASK ORDER 12

TITLE: TRACE Code Development and Assessment for ACR-700: Software Development Plan

I. BACKGROUND

To prepare for design certification of the ACR-700, the NRC staff needs to develop audit capability. This requires development and assessment of TRACE to establish its applicability to the ACR-700 design for evaluation of transients and breaks. The ACR-700 is a new design and will require new safety analyses. The NRC staff will need independent audit capability to evaluate the results predicted by AECL Technologies Inc., which is the applicant for ACR-700.

The transient and accident analysis of older CANDU designs has involved simultaneous evaluation of the thermal hydraulic condition within the reactor system with a three dimensional analysis of the reactor power. This is required because of the positive reactivity feedback from the heavy water coolant. ACR-700 is expected to have negative reactivity feedback from the coolant which will be ordinary water. However, there are transients such as flow blockage or LOCAs in which an individual channel may receive insufficient cooling but the reactor may not scram for some period of time. Therefore, coupled numeric remains an important attribute of the code development work.

In addition, the negative reactivity coefficient has not yet been independently confirmed, including accounting for uncertainty in the analyses of reactor power. The staff, therefore, needs to maintain three dimensional capability for audit purposes. TRACE must have the capability to interface with PARCS, the NRC's three-dimensional reactor power computer code, to perform coupled analysis.

Major thermal hydraulic issues for ACR-700 include:

1. Heat Transfer and Reflood of Horizontal Fuel Bundles. An assessment of the TRACE heat transfer models will be conducted to determine their applicability to the ACR-700. Some postulated accidents lead to fuel heatup where emergency core cooling water is relied on to return the fuel temperatures to a subcooled state. Those horizontal fuel pins that are well above the horizontal water level are surrounded by steam and radiate much of their heat to the pressure tube wall and onto the calandria tube which is cooled by the moderator water in the calandria tank. Just above the water level is a two-phase region caused by the rod quenching process as the water level rises following emergency core coolant (ECC) injection.

2. Flow Rates from Headers to Feeders. In the ACR-700 design, the pumps supply water to horizontal inlet headers. Feeder pipes are welded at various elevations on the lower half of each header to supply the fuel channels. An outlet feeder pipe from each channel connects to one of the outlet headers. When the two-phases in a header are stratified, cooling of a fuel channel is influenced by the elevation of its feeder connection on the header. When flow is out of the header, feeders connected near the bottom of the header receive water while those connected higher up on the header may receive steam. Special models are needed to treat this phenomenon.

3. Energy Transfer from Pressure Tube to Calandria Tube. During normal reactor operation, the gas gap between the pressure tube and the calandria tube insulates the hot primary fluid from the cold, low-pressure water in the moderator (calandria) tank. A heat exchanger is connected to the calandria vessel to provide moderator cooling. During some accidents, the moderator can act as an important heat sink if the pressure tube gets hot enough to sag and press against the calandria tube. The sagging and the increase in thermal conductance must be modeled in the codes.

4. Thermal-Hydraulic Phenomena in the Calandria Vessel. During steady-state operation, a detailed model of the calandria tank is probably not necessary because the energy transfer process is slow enough that the moderator heavy water can stay fairly well mixed. However, if a pressure tube should rupture, an accurate model is needed to determine the course of the accident. Complete condensation of the break effluent steam will occur if the pressure tube is sufficiently submerged. If a tube near the top of the moderator tank ruptures, thermal stratification could lead to incomplete condensation and over-pressurization of the tank. Rupture discs will then break, allowing the tank to blow down.

5. Natural Circulation Flow and Heat Transfer. Natural circulation flow rates and heat transfer around the primary loop and on the secondary side of the steam generator can be difficult to model. Flow between an inlet header and an outlet header has dozens of parallel flow paths to take. When the reactor is in a cool-down mode, with the primary pumps off and ECC on, the flow may be forward in one fuel channel and reversed in an adjacent fuel channel. This has been observed in the RD-14M experiment and is determined by gravity head and steam generation or condensation rate differences between channels.

This Task Order is the first step in the TRACE development process. Additional tasks are expected to follow, to implement the plan being developed herein.

II. OBJECTIVE OF PROPOSED WORK

To develop TRACE physical modeling capability, to perform the assessment necessary to validate the code for the highly ranked (and medium ranked, as appropriate) phenomena from the PIRT (Phenomena Identification and Ranking Technique). The ultimate objective is to establish the applicability and groundwork to be able to carry out Code Scalability, Applicability, and Uncertainty (CSAU) for TRACE for ACR700 analyses.

Note: PIRT development is currently underway in a related project at Brookhaven National Laboratory. Input deck development for TRAC-M/TRACE for ACR-700, RD14M, and the Cold Water Injection Facility is being accomplished through a related project at ISL. The TRAC-M/TRACE input deck development will support the TRACE development for applicability and assessment for ACR-700 applications.

III. SCOPE OF WORK:

Task 1. Prepare a Detailed Plan, Process, and Schedule for TRACE Development.

The TRACE code must be capable of modeling: a) the complete spectrum of LOCA break sizes and break locations, including feeder line breaks and pressure tube breaks; b) flow blockage of

a fuel channel inlet to differing degrees (approaching 100%); c) steam generator tube rupture; d) main steam line break; e) main feed line break; f) loss of feedwater; g) loss of feedwater heating, and; f) excess steam demand. The requirements for coupled modeling with PARCS, and PARCS development requirements, should be described along with those for TRACE.

Accidents that may occur in ACR-700 reactors include scenarios in which fuel damage or melting may occur in individual fuel channels. It is not entirely clear at present where these various scenarios would be categorized in traditional design-basis/beyond-design-basis space. Certainly, some appear to be within the design basis. In defining TRACE code development requirements and plans, some account must be taken for possible fuel damage modeling requirements. This includes heatup and melting of fuel in an individual channel, slumping of fuel, heatup and burst of a pressure tube, pressure tube/calandria tube gap closure due to pressure tube ballooning, etc. Model development requirements should be defined in terms of those to be undertaken in TRACE.

It is expected that significant model development will be necessary associated with: a) the header component with its ~100 off takes; and b) the horizontal fuel channel component. The fuel channel is expected to require development of a horizontal flow regime mapping capability for a heated rod bundle geometry. The capability to consider spacer grid effects and nonaligned fuel bundles should be included.

From existing background documentation, develop a detailed development and assessment plan for TRACE and a coupled PARCS code. The plan must consider whether adequate experimental data currently exists from past AECL experimental programs or from other sources, to develop and/or assess models in TRACE. Should there be insufficient data to adequately support any high or medium ranked phenomenological development or assessment, this will be highlighted.

In this regard, cognizance should be maintained with the ongoing ACR-700 PIRT activities underway through Brookhaven National Laboratories (Principal Investigator David Diamond). The Principal Investigator is expected to attend PIRT meetings.

To help understand current code performance, perform a scoping assessment of TRACE against RD-14M or other data. Use these scoping calculations to help prioritize the TRACE code development based on the significance of code deficiencies, the availability of improved physical models, and the level of effort required to implement improvements.

The plan should consider past work done on CANDU- 3 and other sources of information including

1. "Transient and Accident Analysis Methods," Draft Regulatory Guide DG-1120.

2. "A Plan for the Modification and Assessment of TRAC-PF1/Mod2 for Use in Analyzing CANDU-3 Transient Thermal Hydraulic Phenomena," Siebe, D.A., Boyack, B.E, Giguere, P.T, NUREG/ CR-6269, August 1994

3. "Letter Report on ACR-700 Brainstorming Meeting," Shumway, R., August 2002

4. "Assessment of Data Bases and Modeling Capabilities for the CANDU-3 Design," Carlson, D.E., Meyer, R.O., NUREG-15025.

5. "Systems Analysis of CANDU-3 Reactor," Wolfgang, J.R., Linn, M.A., Wright, A.L., NUREG/CR-6065, June 1993

6. Available information on documentation of CATHENA models and correlations, assessment

Estimated Completion Date: February 28, 2004
Estimated Level of Effort: 5 staff months

NEW STANDARDS FOR CONTRACTORS WHO PREPARE NUREG-SERIES MANUSCRIPTS

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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.

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V. MEETINGS AND TRAVEL REQUIREMENTS

Four two-day trips by ISL staff to Rockville, MD to attend PIRT meeting or for other purposes and one trip to Canada. Other travel may be considered if needed, but must be approved by the NRC Project Manager. Foreign travel must be approved by processing NRC Form 445, in addition to being provided as part of the approved proposal.

VI. PERIOD OF PERFORMANCE

The period of performance of this task order is September 22, 2003 through February 28, 2004.