SUPPLEMENTAL AGREEMENT
BETWEEN
GENERAL ELECTRIC COMPANY
AND
ELECTRIC POWER RESEARCH INSTITUTE, INC.
AND
THE U. S. NUCLEAR REGULATORY COMMISSION

THIS SUPPLEMENTAL AGREEMENT, effective the 23rd day of November, 1981, by and between the UNITED STATES OF AMERICA (hereinafter referred to as the "Government"), as represented by the UNITED STATES NUCLEAR REGULATORY COMMISSION (hereinafter referred to as the "Commission"), and GENERAL ELECTRIC COMPANY, a corporation duly organized and existing under the laws of the State of New York with its principal office in Fairfield, Connecticut (hereinafter referred to as the "Contractor"), and ELECTRIC POWER RESEARCH INSTITUTE, INCORPORATED, a not-for-profit corporation duly organized and existing under the laws of the District of Columbia, with its principal office in Palo Alto, California (hereinafter referred to as the "Institute"),

WITNESSETH THAT:

WHEREAS, the Contractor has been performing work under Contract No. NRC-04-79-184;

WHEREAS, the parties desire to modify Contract No. NRC-04-79-184 as hereinafter provided, and this Supplemental Agreement is authorized by law, including the Federal Property and Administrative Services Act of 1949, as amended, the Atomic Energy Act of 1959, as amended, and the Energy Reorganization Act of 1974, as amended:

NOW THEREFORE, said Contract, as amended, is hereby further amended as follows:

1) Regarding ARTICLE III - TOTAL ESTIMATED COST, OBLIGATION OF FUNDS AND LIMITATIONS

A. Part A. Estimate of Cost is modified to reduce the total estimate of cost for the contract by $760,000.00 from a previous total of $12,702,599.00 to the present total of $11,942,599.00. Of the total ($11,942,599.00), the cost to the Commission, the Institute and the Contractor is $4,753,154.00 (previously $5,055,000.00), $4,179,910.00 (previously $4,450,000.00), and $3,009,535.00 (previously $3,197,599.00) respectively.

B. Part B. Obligation of Funds is modified to increase the amount obligated by the NRC and EPRI for performance of this Contract as follows:

NRC

Year	Amount of Increase	From	To	Reference
FY 1982	$ 79,660.00	$4,645,000.00	$4,724,660.00	RFPA RES-79-18[illegible] dated April 29, 1982

EPRI

Year	Amount of Increase	From	To	Reference
FY 1982	$550,000.00	$3,282,000.00	$3,832,000.00	EPRI Letter of January 12, 1982
FY 1982	$290,000.00	$3,832.00.00	$4,122,000.00	EPRI Letter of February 26, 1982

C. Part E. Task Cost Limitations is modified to incorporate the following new task cost ceilings.

Task		From	To
4.1	Program Plan	$ 20K	$ 20K
4.2	Core Spray	$ 730K	$ 717K
4.3	Single Heated Bundle	$1,391K	$1,629K
4.4	30° Sector	$5,199K	$6,193K
4.5	360° Upper Plenum	$2,297K	$ 93K
4.6	Technical Support	$ 264K	$ 23K
4.7	Model Development	$1,556K	$2,055K
4.8	Model Qualification	$1,201K	$1,168K

2) Regarding ARTICLE I - STATEMENT OF WORK, APPENDIX B, BWR REFILL-REFLOOD PROGRAM WORKSCOPE dated February 12, 1979, Part 4., PROGRAM WORKSCOPE is modified as follows:

A. The following Task 4.3.20A is added to provide additional data analysis.

"4.3.20A Expanded data reduction and evaluation to compile a single bundle data base, and compile data into data bank."

B. To provide for no work beyond the initial facility design, Task 4.5 is deleted in its entirety and replaced by the following Task 4.5.

"4.5 360° UPPER PLENUM TESTS

Objective: Prepare a preliminary design for a test facility to study 30° Sector wall effects on CCFL breakdown as compared to 360° CCFL breakdown performance.

Scope:

4.5.1 Prepare a preliminary design including cost and schedule for a scaled 360° upper plenum mock-up.

The facility will be capable of demonstrating CCFL breakdown performance with and without 30° Sector walls and will be operated at near atmospheric pressure. Determine an appropriate minimum size active core diameter. The design will include a capability for visual observation of flow patterns. The following BWR features should be incorporated. Upper Plenum, core spray spargers (header nozzles), LPCI, upper core simulation and separator standpipes. Prototypical hardware will be used where possible.

4.5.2 Document the preliminary design prepared under 4.5.1."

C. Task 4.6 is deleted in its entirety and replaced by the following in order to reduce the effort required in this area.

"4.6 TECHNICAL SUPPORT TASKS

Objective: To provide technical support for the analytical and data interpretation efforts associated with various project tasks.

Scope:

4.6.1 Provide assistance to the NRC contractor (INEL) in the extension of the TRAC-BWR computer code for application to degraded transients. (The development of models for TRAC-BWR for LOCA analysis is included under Task 4.7, Model Development). Assistance will be provided in specifying specific modeling needs and plans for operational transient capabilities, and in supplying relevant BWR related information to INEL.

4.6.2 Follow up on the development of models for operational transients at INEL and implement and test these models. Coordinate these activities with INEL resulting in a common computer code with extended capabilities.

4.6.3 Survey ongoing LOCA programs in the nuclear industry. Determine which programs provide relevant experimental or analytical information to complement the BWR Refill/Reflood program. Factor this information into data interpretation or analytical modeling improvements."

D. Task 4.7 is deleted in its entirety and replaced by the following:

"4.7 MODEL DEVELOPMENT

This task consists of the following three subtasks:

4.7.1 Basic Models and Correlations

Objective: To provide models and correlations for realistic representation of governing basic phenomena that are suitable for incorporation into TRAC-BWR. Specifically 1) develop and implement models for CCFL and CCFL breakdown, 2) improve the constitutive correlations for interfacial heat and momentum transfer for BWR LOCA flow regimes, and 3) survey and improve bundle wall heat transfer models during blowdown and reflood conditions.

Scope:

4.7.1.1 Prepare an Analysis Task Plan, per Section 5.0, to achieve the Subtask 4.7.1 objectives.

4.7.1.2 Develop an approach to model CCFL and CCFL breakdown phenomena and review with the PMG. Upon PMG approval, implement the approach utilizing test data from Task 4.3, the 16° Upper Plenum Sector tests, and other appropriate data, for incorporation into the TRAC-BWR code. Assess a) the significance of assumptions, b) range of applicability, and c) uncertainties inherent in the model.

4.7.1.3 Develop appropriate interfacial shear relations, as needed for TRAC hydraulic

models, and drift flux parameters for BWR/LOCA flow regimes, consistent with available data and compatible with TRAC-BWR. Compare to other interfacial shear stress and drift flux relations, as appropriate, that are available in the open literature.

4.7.1.4 Review literature on interfacial heat transfer correlations and recommend appropriate relationships to be used in TRAC-BWR and the Single Channel Model (Subtask 4.7.2) for BWR LOCA calculations.

4.7.1.5 Identify and assess further data requirements for improved specification of constitutive relations for TRAC-BWR LOCA analyses. This includes the following:

a. Interfacial mass, meomentum and energy transfer between fluid phases.

b. Phase distributions and transitions.

c. Interfacial areas associated with various phase distributions.

d. Phase interactions with solid surfaces with the system.

Documentation recommendations to satisfy these requirements.

4.7.1.6 Review recent literature on bundle wall heat transfer mechanisms important during blowdown and reflood conditions, including radiative heat transfer, droplet production, quench front movement and convective heat transfer from the hot surfaces.

4.7.1.7 Develop appropriate mathematical models to describe bundle heat transfer mechanisms that are important during LOCA conditions, utilizing the results from Subtask 4.7.1.6.

4.7.1.8 Develop a realistic boiling transition (CHF) prediction routine, consistent with applicable data, suitable for implementation into TRAC. Assess a) the significance of assumptions, b) range of applicability, and c) uncertainties inherent in this routine.

4.7.1.9 Conduct developmental qualification on models from Task 4.7.1.8 using selected heat transfer data from Tasks 4.3 and other appropriate sources.

4.7.1.10 Prepare a Special Report, per Section 5.0, documenting the results from Subtask 4.7.1.2 through 4.7.1.9.

4.7.1.11 Survey the available models for entrainment and deposition. Entrainment and deposition associated with dispersed annular flow, inverse annular flow and pools will be considered. Recommendations will be made on models for use in TRAC prior to implementation.

4.7.1.12 Prepare a Task Topical Report which combines the Special Report required under Subtask 4.7.1.10 and the results from 4.7.1.11.

4.7.2 Development of Single Channel Model

Objective: To develop a single channel computer code for the transient thermal-hydraulic analysis of a BWR-type fuel bundle (or electrically heated simulation) that is capable of being driven by the BWR system model, TRAC. This single-channel code will be used for analysis of single bundle data and for parametric and sensitivity studies.

4.7.2.1 Prepare an Analysis Task Plan per Section 5.0.

4.7.2.2 Document technical specifications of the model, and transmit to the PMG for review and approval.

4.7.2.3 Develop the capability to store the boundary conditions for the upper and lower plena and the bypass region as a function of time on a file from a system calculation from TRAC.

4.7.2.4 Develop the capability to read these boundary conditions to execute TRAC in the single-channel mode.

4.7.2.5 Perform developmental qualification of the model using appropriate selected data. This will be performed as part of the TRAC developmental assessment.

4.7.2.6 Prepare a Task Topical Report, per Section 5.0. This report will contain a detailed technical description of the Single Channel Thermal-Hydraulic model and include sample calculations from the model.

4.7.2.7 Include instructions for using the single channel model as part of the TRAC user manual.

4.7.3 Support Development of TRAC-BWR

Objective: To support the development by the NRC of a comprehensive realistic (best estimate) system code (TRAC) for BWR/LOCA's. The GE contributions will consist of technical recommendations, development of suitable component and heat transfer models, and assistance on a faster running version.

Scope:

4.7.3.1 Prepare an Analysis Task Plan per Section 5.0.

4.7.3.2 Provide technical recommendations on TRAC-BWR needs and modeling techniques. Upon PMG approval, transmit these recommendations to the designated government contractor.

4.7.3.3 Develop a jet pump model, consistent with applicable data, suitable for incorporation into TRAC-BWR. Assess a) the significance of assumptions, b) range of applicability, and c) uncertainties inherent in the model.

4.7.3.4 Develop models for BWR steam separators and dryers consistent with applicable data, suitable for implementation into TRAC. Assess a) the signficance of assumptions, b) range of applicability, and c) uncertainties inherent in the models.

4.7.3.5 Prepare a Special Report documenting studies and models developed under Task 4.7.3.3 through 4.7.3.4.

4.7.3.6 Provide assistance to the designated government contractor in implementing the models from Tasks 4.7.3.3 through 4.7.3.4 into the TRAC-BWR code.

4.7.3.7 Develop a model for the upper plenum to predict the void fraction, flow and temperature distribution. This will include the development of models for the penetration of a submerged liquid jet into a two-phase mixture and for the distribution of the spray in a steam environment.

4.7.3.8 Perform developmental assessment studies of the upper plenum model against data from 16° sector upper plenum mixing tests.

4.7.3.9 Prepare a special report documenting the models and results obtained under Tasks 4.7.3.7 and 4.7.3.8.

4.7.3.10 Implement a model in TRAC for prediction of the location and movement of the two-phase mixture level. This involves development of logic to identify and trace the movement of levels, utilizing the entrainment models recommended in Task 4.7.1.11.

4.7.3.11 Modify the input/output stream in TRAC to improve user convenience. Also, modify TRAC to obtain a fast and reliable initialization of the code. This entrails inclusion of a feedback mechanism into the initialization process to allow the users to specify typical BWR operational characteristics such as downcomer level, power level, recirculation flow, steam dome pressure and steam flow.

4.7.3.12 Review with the designated government contractor the possibilities for reducing computational costs of TRAC-BWR. Report the conclusions in letter format, highlighting areas of most significant potential gain. Review actions with the PMG.

4.7.3.13 Undertake effort, agreed upon by the PMG under Task 4.7.3.12, to test recommended methods to improve TRAC-BWR running time and cost.

4.7.3.14 Prepare a Sppecial Report per Section 5.0 describing the changes made under Task 4.7.3.13 and defining the effects on predicted quantities and code running cost.

4.7.3.15 Prepare a Task Topical Report by combining the Special Reports required under Subtask 4.7.3.5, 4.7.3.9, and 4.7.3.14."

IN WITNESS WHEREOF, the parties have executed this document.

GENERAL ELECTRIC COMPANY

BY: H. H. Klepfer
General Manager
Nuclear Fuel Engineering Dept.
(Name and Title)

DATE: July 30, 1982

ELECTRIC POWER RESEARCH INSTITUTE, INC.

BY: Richard C. Hertz
Richard C. Hertz
Director, Contracts Department
(Name and Title)

DATE: August 5, 1982

UNITED STATES OF AMERICA

U. S. NUCLEAR REGULATORY COMMISSION

BY:
Kellogg V. Morton, Chief
Research Contracts Branch
(Name and Title)

DATE: 8-10-82