AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

BPA NO.	1. CONTRACT ID CODE	PAGE	OF P/
		1	

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
M003	08/21/2006	RES-03-048	

6. ISSUED BY CODE

U.S. Nuclear Regulatory Commission
Division of Contracts
Attn: T-7-I-2
Contract Management Branch No. 2
Washington DC 20555

7. ADMINISTERED BY (If other than Item 6) CODE

U.S. Nuclear Regulatory Commission
Div of Contracts
Mail Stop: T-7-I-2

Washington, DC 20555

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)

PURDUE UNIVERSITY

SPONSORED PROGRAM SERVICES
302 WOOD ST. (YOUNG HALL)
W LAFAYETTE IN 479072108

CODE 072051394 FACILITY CODE

(X) | 9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

10A. MODIFICATION OF CONTRACT/ORDER NO.
NRC-04-03-048 T006

X | 10B. DATED (SEE ITEM 13)
09-24-2003

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.
Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:
(a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)
660-15-111-205 Y6589 252A 31X0200.660
FFS: RES-C06-361 OBLIGATE: $90,000.00

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS, IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

(X)	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation data, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
X	D. OTHER (Specify type of modification and authority) Bilateral Mutual Agreement Between the Parties

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return two (2) copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

This confirms the verbal authorization that was given on 8/21/06, with a temporary ceiling of $25,000.00. This also confirms the 9/22/06 verbal that extended the period of performance through 9/30/06. The purpose of this modification is to:(1) revise the level of effort in accordance with the enclosed SOW, at no additional cost to NRC; (2)provide incremental funding in the amount of $90,000.00; and (3)extend the period of performance through 7/31/07. There is no change in the estimated ceiling amount of the task order. A summary of obligations, from the award date through the date of this action, is given below:
Total FY 2003 Obligated Amount: $75,800.00; Total FY 2004 Obligated Amount: $154,962.00.
Total FY 2005 Obligated Amount: $20,000.00; Total FY 2006 Obligated Amount: $90,000.00.
Cumulative Total of NRC Obligations: $340,762.00. All other terms and conditions of this task order remain the same, including the task order ceiling amount of $350,765.00.

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)	16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)
Rick Evans Assistant Director	Mona C. Selden Contracting Officer
15B. CONTRACTOR/OFFEROR (Signature of person authorized to sign)	15C. DATE SIGNED SEP 29 2006
16B. UNITED STATES OF AMERICA BY (Signature of Contracting Officer)	16C. DATE SIGNED 9/28/06

STANDARD FORM 30 (REV. 10-83)

SUNSI REVIEW COMPLETE

TEMPLATE - ADM001

ADM002

STATEMENT OF WORK
MODIFICATION NO. 3 TO TASK ORDER NO. 6
UNDER
NRC-04-03-048

Task Order Title:	Post-CHF Heat Transfer and Hydrodynamics
Contractor:	Purdue University
Site:	University of California at Los Angeles (UCLA)
Principal Investigator:	V. J. Dhir (310-825-8507) Vdhir@seas.ucla.edu
Period of Performance:	Date of Award through July 31, 2007
NRC project Manager:	Shawn O. Marshall (301-415-5861) som@nrc.gov

This statement of work replaces the existing statement of work.

I. BACKGROUND

The TRACE code is being developed by the NRC to perform large and small break loss of coolant accident and system transient analyses for a wide range of nuclear plants. This code will be used as an audit tool to analyze transient and accident analyses submitted by the vendors and licensees. Two-fluid codes such as TRACE frequently use ad hoc models for wall and interfacial heat transfer as well as interfacial shear in the inverted annular film boiling flow regime. The inverted annular film boiling regime is of particular importance as its precursory cooling largely governs the quench front progression and provides the initial conditions for the dispersed flow film boiling regime where the peak clad temperature occurs.

Previous work under this task completed the fabrication and testing of a flat plate film boiling tests facility. Tests conducted to date have confirmed the existence of a large flow rate dependence of inverted annular film boiling in contrast to the commonly used Bromley model. In addition, further tests with the flat plate facility will provide the information needed to estimate the interfacial heat transfer rates. Finally, to provide steady state low quality film boiling data in a rod bundle geometry, a test loop using a refrigerant has been constructed.

II. OBJECTIVE

The accurate prediction of two-phase thermal-hydraulics is a key requirement for the audit calculations for which the TRACE code is being developed. Specifically, the cooling in the inverted annular film boiling regime establishes the initial conditions for the dispersed film boiling regime during which peak clad temperatures occur. Therefore, accurate inverted annular film boiling regime drag/heat transfer computations are a prerequisite for the accurate computation of figures of merit for typical TRACE audit calculations: peak clad temperature and, eventually, clad oxidation.

Specifically, the objective of this task is to generate an experimental database sufficient to develop improved models and correlations for inverted annular flow film boiling heat transfer and interfacial shear in the region just downstream of the quench front. An experimental study of conditions near the quench front on a flat plate and 9-rod bundle will be used. To facilitate model development, the rod bundle experiments will employ a "hot patch" technique to freeze the quench front thereby allowing for steady state film boiling tests to be conducted at low quality conditions. To assist in understanding these phenomena, visual observations of the

quench process are to be made using high speed photography. Local thermodynamic non-equilibrium in both the liquid and vapor phases are to be determined. Mechanistic models of the wall heat flux partitioning into the liquid and vapor phases are to be developed for incorporation into TRACE.

III. WORK REQUIREMENTS

Add the following to the existent statement of work:

This work builds upon the effort of the previous year. It consists of the following three tasks: Hot Patch Testing, Construction of the Rod Bundle Test Section, and Steady-State Low-Quality Film Boiling Tests. Task 4 will provide the necessary information to design the hot patch to be used to freeze the quench front in the rod bundle tests. Task 5 is to complete the construction and shakedown testing of the rod bundle test section in the refrigerant loop. Task 6 is to conduct steady state film boiling tests to provide the data base for model development and assessment.

Task 4: Hot Patch Testing

The contractor shall conduct single tube tests in the refrigerant flow loop to determine the requirements for effective operation of a "hot patch" for the rod bundle test facility. The role of the hot patch is to freeze the quench front so that steady state film boiling can be established at low quality (subcooled) conditions without using elevated rod powers that would lead to non-prototypic conditions. The goal of this task is to design and test a hot patch that will effectively freeze the quench front but without significantly distorting the inlet conditions. This requires that the hot patch be as short as possible, use the minimum power, and be instrumented well enough that the deposition of heat into the fluid can be accurately calculated.

Deliverables	Level of Effort	Completion Date
Letter report documenting hot patch design and required operating conditions.	1 Staff Month (10% PI, 20% Research Associate, 49%-60% Graduate Student)	On, or about 2 months from issuance of task order modification

Task 5: Construction of the Rod Bundle Test Section

The contractor shall complete design, construction and shakedown testing of a 3x3 rod bundle in the refrigerant flow loop. This test section shall be capable of performing both steady state film boiling and quench experiments. Appropriate instrumentation shall be provided for:

1. Bundle inlet conditions: flow rate and temperature,
2. Applied bundle and hot patch powers,
3. Bundle exit pressure,
4. Axial profile of rod temperatures and heat fluxes downstream of the hot patch,
5. Subcooled liquid temperatures downstream of the hot patch at a minimum of two axial locations,
6. Superheated vapor temperatures for each subchannel at one or more axial elevations, and
7. Axial profile of void fraction in the film boiling region.

A bundle design and instrumentation review meeting shall be held with the NRC technical monitor prior to bundle construction. Finally, shakedown tests shall be conducted to demonstrate the ability of the bundle hot patch to freeze the quench front and operate in a steady state mode.

Deliverables	Level of Effort	Completion Date
Letter report documenting the bundle design and shakedown tests	3.0 Staff Months 1 Staff Month (10% PI, 20% Research Associate, 49%-60% Graduate Student)	On, or about March 31, 2007

Task 6: Steady-State Rod Bundle Low-Quality Film Boiling Tests

The contractor shall conduct a series of steady-state film boiling tests in the 3x3 rod bundle geometry with low-quality (subcooled) inlet conditions. The test matrix shall include at least two pressure levels, four inlet velocities and three inlet subcoolings. The test matrix shall be proposed in a letter report and concurred upon by the NRC project manager. Data generated from these matrix tests shall be provided to the NRC in electronic format to facilitate model development. Specifically, a MS Excel workbook shall be provided with the data from each individual test comprising one worksheet. Also, functions to calculate the refrigerant thermodynamic and transport properties shall be included as user defined functions in a Visual Basic module.

Deliverables	Level of Effort	Completion Date
Film boiling data to be provided in electronic format (see above).	5 Staff Months (2% PI, 20% Research Associate, 50-60 percent Graduate assistant)	On, or about July 31, 2007

IV. REPORTING REQUIREMENTS

No change.

V. MEETINGS AND TRAVEL

For domestic travel, It is estimated that the principal investigator and researchers will travel to the NRC (one trip for up to two persons) to report on progress in Tasks, and participate in meetings. Each trip will be of approximately two day's duration. All trips have to obtain approval from the NRC project manager in advance.

VI. TECHNICAL DIRECTION

No change.