

**ORDER FOR SUPPLIES OR SERVICES**

PAGE OF PAGES  
1 7

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

BPA NO.

1. DATE OF ORDER <b>8/21/2012</b>		2. CONTRACT NO. (if any) NRC-HQ-12-C-04-0086		6. SHIP TO:	
3. ORDER NO. NRC-HQ-12-T-04-0001		4. REQUISITION/REFERENCE NO. RES-12-177 FAIMIS: 122085		a. NAME OF CONSIGNEE U.S. Nuclear Regulatory Commission	
5. ISSUING OFFICE (Address correspondence to) U.S. Nuclear Regulatory Commission Div. of Contracts Attn: Jeffrey R. Mitchell; 301-492-3639 Mail Stop: TWB-01-B10M Washington, DC 20555				b. STREET ADDRESS Attn: Kirk Tien Mail Stop: CSB-3A07M 11555 Rockville Pike	
7. TO:				c. CITY Rockville	d. STATE MD
e. NAME OF CONTRACTOR PENNSYLVANIA STATE UNIVERSITY, THE PENN STATE				e. ZIP CODE 20852	
b. COMPANY NAME ATTN: DANELLE KISSELL				f. SHIP VIA	
c. STREET ADDRESS 101 HAMMOND BUILDING				8. TYPE OF ORDER	
d. CITY UNIVERSITY PARK		e. STATE PA	f. ZIP CODE 168021505	<input type="checkbox"/> a. PURCHASE <input checked="" type="checkbox"/> b. DELIVERY	
9. ACCOUNTING AND APPROPRIATION DATA 2012-60-11-6-174 V6016 252A 31x0200 Obligate \$423,869 2012-60-17-6-161 V6385 252A 31x0200 Obligate \$206,131 DUNS: 003403953 NAICS: 541990 PSC: AG55		10. REQUISITIONING OFFICE RES		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.	
11. BUSINESS CLASSIFICATION (Check appropriate box(es))		12. F.O.B. POINT N/A			
<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. SERVICE-DISABLED VETERAN-OWNED <input type="checkbox"/> g. WOMEN-OWNED SMALL BUSINESS (WOSB) ELIGIBLE UNDER THE WOSB PROGRAM <input type="checkbox"/> h. EDWOSB		13. PLACE OF		14. GOVERNMENT B/L NO.	
a. INSPECTION		b. ACCEPTANCE		15. DELIVER TO F.O.B. POINT ON OR BEFORE (Date)	
				16. DISCOUNT TERMS	

17. SCHEDULE (See reverse for Rejections)

ITEM NO. (a)	SUPPLIES OR SERVICES (b)	QUANTITY ORDERED (c)	UNIT (d)	UNIT PRICE (e)	AMOUNT (f)	QUANTITY ACCEPTED (g)
	In accordance with Section G.4 entitled "Task Order Procedures" of the subject contract, this order definitizes Task Order No. 1. This effort shall be performed in accordance with the enclosed Statement of work.  Task Order No. 1 entitled "Rod Bundle Heat Transfer (RBHT) Refurbishment, Boiloff Tests, and Data Evaluation"  The issuance of this task order does not amend any other terms or conditions of the subject contract.					

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 Department of Interior / NBC NRCPayments_NBCDenver@NBC.gov		b. STREET ADDRESS (or P.O. Box) Attn: Fiscal Services Branch - D2770 7301 W. Mansfield Avenue		PHONE: FAX:		
c. CITY Denver		d. STATE CO	e. ZIP CODE 80235-2230		\$1,456,571		
22. UNITED STATES OF AMERICA BY (Signature) 						23. NAME (Typed) Jeffrey R. Mitchell Contracting Officer TITLE: CONTRACTING/ORDERING OFFICER	

AUTHORIZED FOR LOCAL REPRODUCTION PREVIOUS EDITION NOT USABLE

OPTIONAL FORM 347 (REV. 2/2012)  
PRESCRIBED BY GSA/FAR 48 CFR 53.213(f)

**TEMPLATE - ADM001**

**SUNSI REVIEW COMPLETE**

SEP 18 2012

**ADM002**

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**GENERAL TERMS**

**A.1 GENERAL TASK ORDER TERMS**

This Task Order No. 1 (NRC-HQ-T04-0001) is issued in accordance with Section G.4, Task Order Procedures, of Contract No. NRC-HQ-12-04-0086. The effort shall be performed in accordance with Statement of Work in Section A.5 below.

The issuance of this Task Order does not amend any terms or conditions of the subject contract.

Your contacts during the course of this Task Order are:

Technical Matter: Kirk Tien  
Contracting Officer Representative  
Email: Kirk.Tien@nrc.gov  
Phone: 301-251-7536

Contractual Matters: Jeffrey Mitchell  
Sr. Contract Specialist  
Email: Jeffrey.Mitchell@nrc.gov  
Phone: 301-492-3639

**A.2 CONSIDERATION AND OBLIGATION—TASK ORDERS**

(a) The total current estimated ceiling for the services ordered, delivered, and accepted under this task order is \$1,456,571.00, representing the estimated reimbursable costs. This is a NO FEE type contract.

(b) The amount presently obligated with respect to this Task Order is \$630,000.00. This obligated amount may be unilaterally increased from time to time by the Contracting Officer by written modification to this contract. The obligated amount shall, at no time, exceed the Task Order ceiling as specified in paragraph (a) above. When and if the amount(s) paid and payable to the Contractor hereunder shall equal the obligated amount, the Contractor shall not be obligated to continue performance of the work unless and until the Contracting Officer shall increase the amount obligated with respect to this contract. Any work undertaken by the Contractor in excess of the obligated amount specified above is done so at the Contractor's sole risk.

This is an incrementally-funded contract and FAR 52.232-22 - "Limitation of Funds" applies.

**A.3 DURATION OF TASK ORDER**

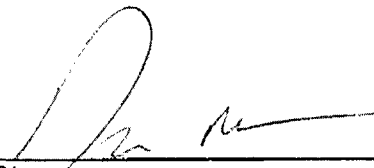
This order shall commence on date of Task Order Issuance and will expire on November 1, 2014.

**A.4 CONTRACTOR ACCEPTANCE OF TASK ORDER 01**

Acceptance of Task Order No. 01 shall be made by having an official, authorized to bind your organization, execute two copies of this document in the space provided and return one copy to the Contracting Officer. You should retain the other copy for your records.

Accepted Task Order No. 01:

David W. Richardson  
Associate VP for Research and  
Director of Sponsored Programs  
Printed Name & Title

  
\_\_\_\_\_  
Signature

09/17/2012  
Date

## A.5 STATEMENT OF WORK TASK ORDER 01

**TITLE:** RBHT Refurbishment ,  
Boiloff Tests, and Data Evaluation

### **BACKGROUND**

NRC has sponsored many experiments to obtain high quality data to assess the TRACE code, which NRC uses to perform audit calculations of Loss-of-Coolant Accident (LOCA) scenarios. The Rod Bundle Heat Transfer (RBHT) Test Facility at Pennsylvania State University is especially pertinent to the reflood period of a LOCA transient. The RBHT has been in service for more than ten years. The heater rods and instruments need to be repaired to restore the test section to original specifications to guarantee the quality of the data. This task order is to provide funding to refurbish the RBHT facility and perform a series of two-phase boiloff tests. In addition, NRC will initiate development of Data Evaluation Reports, which will assess data collected from reflood, steam cooling, steam cooling with droplet injection, and interfacial drag tests. In addition spacer grid effects on the local thermal-hydraulics and their enhancement of heat transfer within the bundle will be investigated and documented..

### **TASK ORDER OBJECTIVES**

The contractor shall be required to accomplish the following objectives:

- Plan and schedule the refurbishing of the RBHT rod bundle. Because the test facility is over 10 years old, the test section requires disassembly, cleaning and reassembly. Fouled heater rods need to be replaced and damaged thermocouples needs to be repaired.
- Conduct a series of tests to increase database for spacer grid thermal-hydraulics under reflood and steam-cooling conditions.
- Develop Data Evaluation Reports based on data gathered from tests previously performed, by PSU for the NRC, and tests performed as part of this contract.
- Develop improved models for the interaction of spacer grids with entrained droplets. The models are to account for droplet breakup on dry grids, droplet generation from films on wet grids, and for prediction of conditions at which the grid may rewet.
- Develop improved models to account for enhancement of heat transfer downstream of a spacer grid. The models are to account not only for the enhancement to convective heat transfer of single-phase steam but also the enhancement when flow downstream of the spacer grid contains droplets.
- Develop improved models of interfacial area transport from all RBHT data obtained from past experiments and tests performed as part of this contract. Develop correlations that are suitable for implementation in TRACE code.

### **SCOPE OF WORK**

#### **Task 1: Refurbishment of RBHT Rod Bundle**

Develop and implement a plan for refurbishment of the RBHT rod bundle. This includes at least replacing the fouled heater rods in the inner 5x5 array and repairing any damaged thermocouples. In addition, this includes replacing the rectangular quartz windows with windows of a round design in a removable port for better service life and reduce downtime.

Identify and document the components that need to be replaced and put in an order with the vendor. Upon receipt of the replacement components, install the components and take all actions necessary to restore the rod bundle and test facility to operating condition. Perform shakedown tests to confirm operability and full functionality of the system.

**Task 2: Instrumentation Improvement and Calibration**

Investigate the feasibility of adapting the conductivity probe for a steam-water system. The new probe or other improved instrumentation will have to function at a higher temperature than that used in an air water system. Test the effects of water chemistry on the probe durability. Test the effects of elevated temperatures on the probe's functioning and stability. Ensure that the new experimental setup and new probes function adequately to enable all necessary measurements including measurements of local void history and void distribution. Explore the feasibility of installing additional instruments such as pitot-tube-based instruments for better local steam velocity measurements. Upgrade the older camera in the laser/mirror/camera system. Ensure the new components meet the technical specifications of the existing data acquisition system.

**Task3: Two-Phase Bolloff Tests**

Perform a series of two-phase bolloff tests, with a minimum of 6 tests to be defined in a test matrix after task order award. The purpose of the tests is to gather more detailed characterization of axial void distribution in a rod bundle. This data is expected to supplement void data generated from other test sites, such as ORNL-THTF, FRIGG, and Westinghouse G-2. Data generated will be valuable to generate interfacial area transport information and provide additional assessment basis for model development.

**Task4: Verify Oscillatory Reflood and Droplet Injection Tests**

PSU shall repeat at least one from each of the following test series: (1) constant rate flood, (2) oscillatory reflood and (3) steam cooling with droplet injection. With the installation of the new heater rods the hydraulic characteristics may need to be re-calibrated. NRC is interested in expanding the reflood rate higher than previously achieved (6 inches per second) without major redesign of the test loop and associated accumulator tanks. Selective cases will be tested to find a new baseline for the two-phase drag and quenching characteristics.

**Task 5: Develop RBHT Data Evaluation Reports**

The objective of this task is to perform data evaluation and to coordinate and consolidate previous efforts, which resulted in experimental data reports that included the following logical topical groupings: reflood, steam cooling, steam cooling with droplet injection, and interfacial drag tests. The goal is the publication of a series of Data Evaluation Reports. Unless otherwise directed by the NRC COR, all Data Evaluation Reports will be delivered in NUREG/CR format.

Data evaluation is the analysis of the data to observe trends and behavior of key physical properties in response to system conditions. Data evaluation also includes model building. Typical activities include assessment of the data and comparison of the data with other similar tests. For example, one might study and document the RBHT data with other reflood and blowdown separate-effect tests. The effects of flooding rate, system pressure and initial subcooling on the heater rod temperature rise, quench time and heat transfer coefficients could be investigated and compared with findings from other experiments. Data Evaluation Reports shall also illustrate methods to determine and measure the thermal hydraulic phenomena of importance to performance of the rod bundle. Error analysis and uncertainty analysis is performed as part of Data Evaluation. For example, entrainment, carryover fraction, droplet size, and void fraction measurements may be used to build models to predict the behavior of the quench front and two-phase loss coefficient at the grid spacers. Assessment of the new models developed in this task and comparing the new models with other models in the open literature is another aspect of Data Evaluation. In addition spacer grid effects on the local thermal-hydraulics and their enhancement of heat transfer within the bundle will be investigated and documented.

**TECHNICAL AND OTHER SPECIAL QUALIFICATIONS REQUIRED**

This project requires a densely instrumented, full height (12 ft.) rod bundle test section with pressurized steam supply and data acquisition system. To be able to heat the test rods to realistic temperatures, the power supply for this facility is required to have a capacity of 14,000 Amp DC and higher. The test section is to simulate the thermal-hydraulic conditions in a reactor core and downcomer during the reflood stage of the LOCA scenario. In addition, the project requires computer capabilities to perform model development and code validation. Finally, experience and knowledge of multiphase flow and experimental techniques are essential to the performance of this type of work.

The contractor is responsible for assigning technical staff, employees, subcontractors, or specialists who have the required educational background, experience, or combination thereof to meet the technical objectives of the work specified in this statement of work. NRC will rely on the contractor to verify the qualifications of the personnel assigned to this contract including assurance that all information contained in the technical and cost proposals (including resumes) is accurate and truthful.

**MONTHLY LETTER STATUS REPORT**

A Monthly Letter Status Report (MLSR) is to be submitted to the NRC Project Manager by the 15<sup>th</sup> of the month following the month to be reported with copies provided to the following:

Resource Name: RESDSAMLSR.Resource@nrc.gov

The MLSR will identify the title of the project, the job code, the Principal Investigator, the period of performance, the reporting period, summarize each month's technical progress, list monthly spending, total spending to date, and the remaining funds and will contain information as directed in NRC Management Directive 11.1. 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.

**DELIVERABLES/SCHEDULES AND/OR MILESTONES**

Deliverables and specific milestones are listed as following:

1. Task 1: A schedule for refurbishing the facility and cost estimates for each task in the process shall be submitted within 2 months of the task order award.
2. Task 3: A test matrix for the two-phase boiloff tests shall be submitted within 1 month of task order award.
3. Task 3: A quick look report for each boil off test shall be submitted within 1 month after each test.
4. Task 3: All of the qualified raw data shall be provided on CDs/electronic media, together with a converted copy conforming to the NRC data bank format (pib), within 1 month after the last test data of the test series are obtained. This includes all channel output from the data acquisition system and the droplet measurement records. The data of certain selected tests may be requested earlier than the last test.
5. Task 5: All data evaluation reports shall be submitted twenty months after task order award. Draft version may be requested earlier for staff comment. Contents of these report shall include the following subjects, for example: (1) comparison to previous reflood tests such as the FLECHT series, illustrating the effects of flood rate, pressure, inlet subcooling and initial cladding temperature on rod temperature rise, quench time and heat transfer coefficient (HTC); (2) two-phase hydraulics information and data such as entrainment and carryover fraction, droplet size measurement, void fraction below quench front and two-phase loss coefficient at grid spacers; (3) develop a new correlation and comparison of the newly-developed correlation with those available in the open literature on HTC under dispersed flow film boiling (DFFB), inverted annular film boiling (IAFB), saturated flow boiling and (4) information on obtaining the minimum film boiling temperature ( $T_{min}$ ), parameter for determination of grid rewet and HTC enhancement downstream of the spacer grids.

**MEETINGS AND TRAVEL**

Up to two annual project review meetings will be scheduled at PSU. Additional meetings will be called for when major technical issues develop that necessitates a meeting in person. A monthly telephone conference is required to keep the staff up to date on the project status.

**NRC-FURNISHED MATERIAL**

None

**OTHER TASK ORDER TERMS AND CONDITIONS (NOT SPECIFIED IN THE CONTRACT)**

**A.6 COMPLIANCE WITH U.S. IMMIGRATION LAWS AND REGULATIONS (AUG 2011)**

NRC contractors are responsible to ensure that their alien personnel are not in violation of United States immigration laws and regulations, including employment authorization documents and visa requirements. Each alien employee of the Contractor must be lawfully admitted for permanent residence as evidenced by Permanent Resident Form I-551 (Green Card), or must present other evidence from the U.S. Department of Homeland Security/U.S. Citizenship and Immigration Services that employment will not affect his/her immigration status. The U.S. Citizenship and Immigration Services provides information to contractors to help them understand the employment eligibility verification process for non-US citizens. This information can be found on their website, <http://www.uscis.gov/portal/site/uscis>.

The NRC reserves the right to deny or withdraw Contractor use or access to NRC facilities or its equipment/services, and/or take any number of contract administrative actions (e.g., disallow costs, terminate for cause) should the Contractor violate the Contractor's responsibility under this clause.