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

January 11, 2001

Purdue Research Foundation
ATTN: Edie Doland
1063 Hovde Hall, Purdue University
West Lafayette, IN 47907-1063

Dear Mr. Doland:

SUBJECT: MODIFICATION NO. 6 TO TASK ORDER NO. 1 ENTITLED "INTERFACIAL AREA TRANSPORT" UNDER CONTRACT NO. NRC-04-97-046

In accordance with Section G.4, Task Order Procedures, of the subject contract, this letter definitizes Task Order No. 1 modification no. 6. This effort shall be performed in accordance with the enclosed Statement of Work and the contractor technical proposal dated November 21, 2000. This letter confirms written authorization given to Mr Thomas Wright, of Purdue Research Foundation, by Mr Donald A. King, NRC Contracting Officer, on November 30, 2000, to continue performance of task order number 1. This letter also confirms verbal authorization given by Mr. King to Mr. Wright, on December 19, 2000, that established a temporary spending limit of $50,000 pending completion of the task order modification.

The period of performance for Task Order No. 1 is changed to run from September 30, 1997 through November 30, 2002. The total estimated cost for full performance of this task order is changed by $298,648 from $1,194,611 to $1,493,259. Funds obligated for performance of this task order are increased by $298,648 from $1,194,611 to $1,493,259 to fully fund this task order. The Contractor shall not incur costs for this task order which exceed the cumulative obligated amount of $1,493,259.

Accounting data for Task Order No. 1 Mod 6 is as follows:

B&R No.: 16015110135
Job Code: W-6749
BOC Code: 252A
RES ID: RES-C01-317
Appropriation No.: 31X0200.160
Obligated Amount This Action: $298,648
FY 97 Obligated Amount:$ 406,734
FY 98 Obligated Amount:$ 208,000
FY 99 Obligated Amount:$ 280,000
FY 00 Obligated Amount:$ 299,877
FY 01 Obligated Amount:$ 298,648
Total Cumulative Obligations:$1,493,259

Template ADM-001

ADM 01

The issuance of this task order does not amend any terms or conditions of the subject contract. All other terms and conditions of the task order remain unchanged

Your contacts during the course of this task order are:

Technical Matters: James Han, Project Officer
(301) 415-6773

Contractual Matters: Donald A. King, Contract Specialist
(301) 415-8168

Please indicate your acceptance of this task order modification by having an official, authorized to bind your organization, execute three copies of this document in the space provided and return two copies to the Contract Specialist. You should retain the third copy for your records.

Sincerely,

Donald A. King, Contracting Officer
Division of Contracts and Property Management

Enclosure:
As stated

ACCEPTED: TASK ORDER NO. 1 Mod 6

Peter E. Dunn — JAN 19 2001

NAME — DATE

Peter E. Dunn
Assistant Vice President for Research

TITLE

Modification (No. 6) to the Statement of Work of Task Order #1, "Interfacial Area Transport," under Contract # NRC-04-97-046 and Job Code W6749, "Thermal-Hydraulic Research"

Additional Work Requirements (12/1/00 - 11/30/01)

Continue Tasks 13, revise the completion dates for Tasks 14 and 15, and add new Tasks 16 through 18. The revised Tasks 13 through 15 and new Tasks 16 through 18 are listed below.

Task 13. Provide Technical Support

Provide technical support in terms of making presentations, attending meetings, and reviewing technical reports as requested by the NRC Technical Monitor. Provide administrative support including contract modifications and fund transfer to the subcontractors under this contract.

Estimated Level of Effort: 1 staff-month (for this performance period)
Estimated Completion Date: November 30, 2001 (new date)

Task 14. Perform Third Stage of Experiments in Horizontal Pipes

This task performs third stage of experiments in 2" and 4" horizontal pipes. The purpose is to produce a database for flow regime transitions from bubbly flow to stratified flow and from stratified flow to slug flow, respectively. Measurements of interfacial parameters will be made to characterize and quantify the development of two-phase flow regimes in horizontal pipes. Data collected will be used to evaluate and improve the one-dimensional interfacial area transport equation.

Subtask 14.1. Design and Construct a 4" Horizontal Test Section

This subtask designs and constructs a 4" horizontal test section and installs it onto the test loop.

Estimated Level of Effort: 4 staff-months (from the previous performance period)
Estimated Completion Date: October 15, 2000 (new date)

Subtask 14.2. Perform Experiments in Horizontal Test Sections

This subtask performs experiments in both 2" and 4" horizontal pipes. Prepare a letter report in both text and electronic format to describe the design of the test loop, data obtained, and phenomena observed. Detailed test data will also be prepared electronically in the NRC databank format.

Estimated Level of Effort: 3 staff-months (for this performance period)
Estimated Completion Date: march 31, 2001 (new date)

Task 15. Develop Model for Horizontal Flow Data

This task analyzes the horizontal flow data obtained under Task 14 and develops physical models for the processes that govern the creation and destruction of interfacial area and the

constitutive relations to correlate the interfacial area. The focus of the task is on those processes that are different than those encountered in the vertical flow experiments. Prepare in both text and electronic format a letter report to summarize the models and correlations developed and the process of development.

Estimated Level of Effort: 2 staff-months (for this performance period)
Estimated Completion Date: April 15, 2001 (new date)

Task 16. Perform Experiments and Develop Models for Interfacial Area Transport in Horizontal 45° Elbows and in the Vessel Downcomer

This task performs experiments and develops models for interfacial area transport in horizontal 45° elbows (at 2" and 4" ID, respectively) and in a scaled vessel downcomer. These configurations can be found in the prototypical nuclear reactor designs, and the knowledge on two-phase flow regime transition in the configurations is needed for small-break LOCA analyses.

Measurements of interfacial area and void fraction at the inlet and outlet of the configurations will be made. The data will be used to develop correlations for the variation of the interfacial area concentration in the configurations, and they will provide a sufficient database for the interfacial area transport as applied to the constitutive relations for the two-fluid model formulation. Furthermore, flow visualization through transparent test sections will provide information to understand the phenomena of two-phase flow inside the configurations.

45° elbows and a scaled downcomer will be installed onto the existing air-water flow loops available at the University of Wisconsin-Milwaukee. Since the probes for measuring local interfacial area and void fraction for the bubbly, stratified, and plug/slug two-phase flow patterns have already been developed, they will be used in the experiments under this task.

Estimated Level of Effort: 10 staff-months
Estimated Completion Date: November 30, 2001

Task 17. Perform Fourth Stage of Experiments in Vertical Pipes

This task performs fourth stage of experiments to measure interfacial area concentrations in the air-water, co-current flow in vertical pipes at 2" and 4" inside diameters (ID), under churn turbulent flow conditions up to the transition region before the formation of the annular flow. Prepare a letter report in both text and electronic format to summarize the test results. Detailed test data will also be prepared electronically in the NRC databank format.

Local parameters of the churn turbulent flow can be acquired by using two four-sensor conductivity probes, each facing opposite direction. This new approach is necessary to take into account the downward motion of recirculating bubbles. Signals from the probes will be processed by the newly developed software for this type of probe application.

[Note that the fourth stage of experiments are complementary to the previously-performed first, second, and third stages of experiments. In the first stage of experiments, data for interfacial area concentrations were obtained in vertical pipes (2" and 4" ID) for bubbly and slug flow and in horizontal pipes (2" and 4" ID) for off-take from a large vessel to horizontal pipes. In the second stage of experiments, data for interfacial area concentrations were obtained in vertical

pipes (0.5" and 6" ID) for bubbly and slug flow; data were also obtained in horizontal pipes (2" and 4" ID) to investigate the effects of entrance, elbow, and counter-current flow on interfacial area transport. In the third stage of experiments, data were obtained for bubbly, cap, and limited churn turbulent flow conditions in vertical pipes (0.5", 2", 4", and 6" ID).]

Estimated Level of Effort: 17 staff-months
Estimated Completion Date: November 30, 2001

Task 18. Perform Experiments and Develop Models for Adiabatic Counter-Current Flow in Vertical Pipes

This task performs experiments to investigate adiabatic, counter-current flow in the small-diameter, vertical pipes. The task also develops detailed flow regime map and interfacial area transport model from the data obtained for the counter-current flow. Since the models developed in the previous performance periods were for the vertical co-current flow, those models should also be evaluated using the data for the counter-current flow conditions to be obtained under this task.

Experiments will be conducted at the vertical, air-water counter-current test loop under construction at the Thermal-Hydraulics and Reactor Safety Laboratory at Purdue University. The loop consists of two vertical pipe test sections — at 1" and 2" ID, respectively. Both test sections have three axial measurement ports. (Existing instrumentation is sufficient to perform this task, and it includes a high-speed digital movie camera, impedance meters with self-organized neural network, and conductivity probes.)

Estimated Level of Effort: 7 staff-months (for this performance period)
Estimated Completion Date: November 30, 2002

Meetings and Travel:

The contractor will attend two meetings at the NRC office in Rockville, Maryland. For planning purpose, each meeting will involve two people and last for two days. The contractor will also be allowed to attend two domestic technical meetings sponsored by ANS, ASME, or other national organizations. However, any travel must be approved in advance by the NRC Technical Monitor.