

<b>AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT</b>			1. CONTRACT ID CODE	PAGE 1 OF PAGES 2
2. AMENDMENT/MODIFICATION NO 3	3. EFFECTIVE DATE January 1, 2000	4. REQUISITION/PURCHASE REQ. NO. RES-98-045 dtd 12/16/99	5. PROJECT NO. (If applicable)	
6. ISSUED BY U.S. Nuclear Regulatory Commission Division of Contracts and Property Mgt. Attn: T-7-1-2 Contract Management Branch 1 Washington DC 20555	CODE	7. ADMINISTERED BY (If other than 18FM 6)	CODE	

004106

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)  Purdue Research Foundation ATTN: Ms. Edie Doland Sponsored Program Services 38 Howde Hall West Lafayette, IN 479-7-1063	(X)	9A. AMENDMENT OF SOLICITATION NO
		9B. DATED (SEE ITEM 11)
		10A. MODIFICATION OF CONTRACT/ORDER NO Con# NRC-04-98-045
	X	10B. DATED (SEE ITEM 13) 07-28-1998
CODE	FACILITY CODE	

**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 of 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) APPN: 31X0200.060 B&R: 06015110135 BOC: 252A  
JCN: W6698 OBLIGATE: \$181,800.00

**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 date, 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) Mutual agreement of the parties

4. IMPORTANT: Contractor  is not,  is required to sign this document and return 2 copies to the issuing office.

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

MODIFICATION FOLLOWS ON THE ATTACHED PAGE

Except as provided herein, all terms and conditions of the document referenced in Item 8A or 10A, as heretofore changed, remains unchanged and in full force and effect.

13A. NAME AND TITLE OF ENGINEER (Type or print) <i>Peter E. Dunn</i>	13B. NAME AND TITLE OF CONTRACTING OFFICER (Type or print) Mary H. Mace Contracting Officer
15B. CONTRACTOR/OFFEROR Peter E. Dunn Assistant Vice President for Research (Signature of person authorized to sign)	15C. DATE SIGNED DEC 31 1999
	15D. UNITED STATES OF AMERICA BY <i>Peter E. Dunn</i> (Signature of Contracting Officer)
	15E. DATE SIGNED 12-30-1999

STANDARD FORM 30 (REV. 10-83)

Duplicate Original  
DFO 2

PDR CONTR NRC-04-98-045

Contract No. NRC-04-98-045  
Modification No. Three (3)  
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The purpose of this modification is to: (1) exercise Option Year 2 (Task 4.(1)), thereby extending the period of performance until December 31, 2000 and increasing the total estimated amount (ceiling) for performance of the subject contract by \$191,800 from \$545,072 to \$736,872; (2) obligate FY2000 funds in the amount of \$191,800; (3) revise Section B.3, Consideration and Obligation to reflect a downward adjustment in the estimated cost for Option Year 2; and (4) modify Section C to add work requirements for Task 4.(1) and revise the reporting requirements and deliverables reflected in Section F.4 for Task 4, per the attached Statement of Work. Accordingly, the following changes are hereby made:

1. See the attached Statement of Work for work requirements to be performed during Option Year 2 (performance of Task 4. (1), and revisions to Section F.4, "Reporting Requirements and Deliverables" for Task 4.(1) of this contract.
2. Under Subsection B.3, "Consideration and Obligation -- Cost Reimbursement," delete paragraphs (a), (c), and (f) in their entirety and substitute the following in lieu thereof:
  - "(a) The total estimated amount of this contract (ceiling) is \$736,872, which includes the basic contract (\$303,072), Option Year 1 (242,000), and Option Year 2 (\$191,800)."
  - "(c) Option Year 2 is hereby exercised at a total estimated cost to the Government of \$191,800."
  - "(f) The amount obligated by the Government with respect to this contract is \$736,872."
3. Under Section F - "DELIVERIES OR PERFORMANCE," paragraph F.8 entitled "DURATION OF CONTRACT PERIOD" is hereby deleted in its entirety and the following is substituted in lieu thereof:

"F.8 DURATION OF CONTRACT PERIOD (MAR 1987)  
ALTERNATE 2 (MAR 1987)

The contract shall commence on July 28, 1998 and will expire on December 31, 2000. The term of this contract may be extend at the option of the Government for 2 additional one-year options."

All other terms and conditions remain unchanged.

A summary of obligations under this contract is as follows:

Total FY1998 Obligations:	\$303,072
Total FY1999 Obligations:	\$242,000
Total FY2000 Obligations:	\$191,800

Total Obligations under this contract: \$736,872.

**STATEMENT OF WORK FOR  
MODIFICATION 3 TO CONTRACT NO. NRC-04-98-045**

**Task 4.(1) Option Year 2 - PERFORM AND ANALYZE SEPARATE-EFFECTS TESTS**

The contractor will perform a series of critical flow tests. The objectives of these tests are to:

- (i) Obtain critical flow data in a pipe having an orifice or nozzle as a break with well defined upstream and downstream boundary conditions, and advanced two-phase instrumentation.
- (ii) Obtain data on critical flow for high inlet flow quality (~100%), medium inlet flow quality (5-80%) and low inlet flow quality (~0-5%).
- (iii) Evaluate the hydrodynamic aspect of the critical flow model in the TRAC-M code using new adiabatic (air-water) critical flow data.
- (iv) Evaluate the thermal non-equilibrium aspect of the critical flow model in the TRAC-M code using new steam-water critical flow data with two different break geometries (orifice and nozzle).
- (v) Develop a new critical flow model based on critical flow data at low pressures using a relaxation model.

**WORK REQUIREMENTS:**

The contractor shall perform and analyze separate-effects tests providing low-pressure data for single-phase and two-phase critical mass flow rates. These data are needed for TRAC-M model development and code assessment.

The contractor shall use the data obtained to assess current models in TRAC-M, identify deficiencies, and propose corrections to the models. The main purpose of collecting the data is to use it to correct current TRAC-M models, not to develop new models.

The critical flow model in TRAC-M shall be assessed in two ways. First, adiabatic data (air-water data) shall be used to assess the hydrodynamic part of the critical flow model. This eliminates the effects of thermal non-equilibrium in the assessment process. Second, steam-water data shall be used to assess the thermal non-equilibrium critical flow model in the code. The effect of thermal non-equilibrium on critical flow at low pressure conditions shall then be obtained by comparing with the hydrodynamic model. The required empirical constants to account for thermal non-equilibrium shall be first obtained from the data, and then a new relaxation model developed by modifying the model in TRAC-M.

The contractor shall ensure cleanliness of the boundary conditions by using on-line instruments to make measurements just upstream of the choking plane. Measurements shall also be taken just downstream of the choking plane because of the possibility of thermal non-equilibrium at the choking plane. Mass flow shall be measured downstream of the choking plane as well as upstream.

The effects of non-condensibles on two-phase flow and the non-equilibrium aspect of two-phase flow shall be determined by injecting air into a two component discharge line, taking appropriate measurements, and analyzing the data.

Four kinds of critical flow tests shall be considered: (1) air-water critical flow at various pressures (150 psia and less), (2) steam critical flow at various pressures (150 psia and less), (3) two-phase (steam/liquid) critical flow at various pressures (150 psia and less), and (4) subcooled and saturated liquid critical flow at various pressures (150 psia and less, with various degrees of subcooling)

The contractor will measure the following parameters, which are the same as those used in the TRAC-M code to calculate critical flow: individual phase velocities, void fraction, flow quality, pressure, temperature, and enthalpy. Instantaneous mass flow rate will also be measured. Measurements shall be taken mainly upstream of the critical flow location using on-line instrumentation. The contractor will specify the instrumentation to be used and their accuracy.

As critical flows in a nozzle and abrupt orifice are different, experiments shall be conducted using both a nozzle and an orifice. Two-phase flow through an orifice is much more likely to be in thermal non-equilibrium than through a nozzle.

The proposed test matrix is:

Test	Break Type	RPV Pressure (psia)	No. of Tests
Air/Water Critical Flow	Two Component Discharge Line	150, 100, 50, 30	8 (one each for an orifice and a nozzle with L/D<1.5) + 2 repeats at 100 psia (one each for an orifice and a nozzle) + 1 at 100 psia with nozzle, L/D > 1.5
Steam Critical Flow	Main steam line/or any single phase steam line	150, 100, 50, 30	8 (one each for an orifice and a nozzle with L/D<1.5) + 2 repeats at 100 psia (one each for an orifice and a nozzle) + 1 at 100 psia with nozzle, L/D > 1.5
Steam/Liquid Mixtures Critical Flow	Two Phase Discharge Line	150, 100, 50, 30	8 (one each for an orifice and a nozzle with L/D<1.5) + 2 repeats at 100 psia (one each for an orifice and a nozzle) + 1 at 100 psia with nozzle, L/D > 1.5
Subcooled/Saturated Liquid Critical Flow	Two Phase Discharge Line	150, 100, 50, 30 0, 2, 5, 10°C	12 (one each for an orifice and a nozzle with L/D<1.5, 150 psia, 50 psia, 30 psia, saturated, 5°C) + 8 (one each for an orifice and a nozzle with L/D<1.5, 100 psia, saturated, 2, 5, 10°C) + 2 repeats at 100 psia (one each for an orifice and a nozzle) + 1 with nozzle, L/D>1.5, 100 psia, 5°C.

Total Tests: 46

**REPORTING REQUIREMENTS AND DELIVERABLES**

The contractor will prepare a final report to summarize and analyze the test data. This report should include: (1) a state-of-the-art survey of all the low-pressure critical flow data available in the open literature including the PUMA data, (2) a description of the PUMA components (e.g., RPV, drywell, and connecting piping) and instrumentation involved in the tests, (3) detailed figures showing the exact location of each instrument, (4) measurement uncertainty of each instrument, (5) test conditions such as pressure, temperature, gas quality, and mass flow rate, (6) comparison between the PUMA data and code models, and (7) conclusions and recommendations for model improvement.

**PERIOD OF PERFORMANCE**

Task 4.(1) shall be completed by December 31, 2000.