

SUPPLEMENTAL AGREEMENT
BETWEEN
NORTHWESTERN UNIVERSITY
AND
THE U. S. NUCLEAR REGULATORY COMMISSION

THIS SUPPLEMENTAL AGREEMENT, effective the 1st day of March , 1979, 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 NORTHWESTERN UNIVERSITY

(hereinafter referred to as the "Contractor"),

WITNESSETH THAT:

WHEREAS, the parties desire to modify Contract No. NRC-04-77-052 as hereinafter provided, and this supplemental agreement is authorized by law, including the Energy Reorganization Act of 1974, as amended, and the Atomic Energy Act of 1954, as amended.

NOW, THEREFORE, said contract is hereby modified as follows:

1. Appendix A, attached to this supplemental agreement and made a part hereof, supersedes in its entirety the Appendix A of Modification 2, 3, and 4 of this contract and provides for the research to be performed by the Contractor during the contract period specified therein.
2. In Article II - The Period of Performance, the date "February 29, 1980 " is substituted for the date " August 31, 1979 " .
3. In Article III - Consideration, the sum "\$282,626.00" is substituted for the sum "\$265,626.00".

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IN WITNESS WHEREOF, the parties have executed this document.

UNITED STATES OF AMERICA

BY: [Signature]
Kellogg V. Morton, Chief
Research Contracts Branch
(title)

Nuclear Regulatory Commission

NORTHWESTERN UNIVERSITY
BY: [Signature]
DAVID MINTZER
VICE PRESIDENT FOR RESEARCH
and DEAN OF SCIENCE (title)

I, James M. Perry, certify that I am the
(attester)

Assistant Secretary of the Contractor named
(title)

under this document; that DAVID MINTZER
(signatory)

who signed this document on behalf of said Contractor was then
VICE PRESIDENT FOR RESEARCH
and DEAN OF SCIENCE of said Contractor; that

this document was duly signed for and on behalf of said Contractor by
authority of its governing body and is within the scope of its legal
powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and the seal of
said Contractor.

[Signature: James M. Perry]

(SEAL)

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CONTRACTOR: NORTHWESTERN UNIVERSITY

APPENDIX A

For the Contract period March 1, 1978 through February 29, 1980

Article A-I RESEARCH TO BE PERFORMED BY CONTRACTOR

- (a) The scope of work under this contract is unclassified and shall be in accordance with Contractor's proposal entitled, "Steam-Water Interfacial Transport," dated 3/1/78, incorporated herein and made a part hereof. The following work shall be performed during the period March 1, 1978 thru February 28, 1979:
1. Horizontal Section: Condensation Rate Measurements
 - a. Traverses through the vapor space with Pitot tubes for velocity measurements.
 - b. Traverses through the liquid region with microthermocouple-conductivity probes and Pitot tubes for temperatures and velocity profiles, and mean interface locations.
 - c. Determination of local condensation rates at several axial locations by enthalpy and mass balances on the liquid and vapor control volumes. Verify by overall heat/mass balances.
 - d. Repeat the above measurements for several values of the following parameters:
 1. Liquid level in the test section
 2. Steam flow rate
 3. Water flow rate
 4. Water temperature
 - e. Compare the data against existing correlations and analyze the difference, if any.
 2. Vertical Test Section
 - a. Design and construct vertical test section for counter-current steam-water flow.
 - b. Determine flow regimes as a function of steam and water flow rates and water temperature.
 - c. Measure local condensation rate over a range of conditions in non-oscillatory flow. Test matrix to be worked out between Northwestern University and NRC.
 3. Instrumentation Development and Application (horizontal test section)
 - a. Use LDA for mean liquid velocity and interface location. Measurements will be made using system in back-scattering mode.
 - b. Measure local wall shear stress in the liquid region by means of flush-mounted hot-film probes.

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In accordance with the Contractor's proposal entitled, "Steam-Water Interfacial Transport: Holographic Methods for Interfacial Area Measurement," the following work shall be performed during the period August 25, 1978 thru August 24, 1979:

1. Survey the existing laser holographic methods and select or develop a method most suitable for study of vapor condensation on droplets.
2. Construct test section for holographic measurements
3. Check the holographic methods using water sprays in air
4. Show feasibility of measuring droplets size distribution, size change rate, number density, interfacial area, and droplet velocities in sprays during condensation in steam at 1 atm.

The unclassified scope of work under this contract entitled, "Steam-Water Interfacial Transport," as follows, shall be performed during the period March 1, 1979 through February 29, 1980:

1. Condensation in horizontal section
 - Measure velocity profile and turbulence intensity in horizontal condensing flow
 - Provide data to LASL for code developers to use
2. Steam supported bubbly pool
 - Study the CCFL as function of steam superheat, compressible volume, liquid flow rate, subcooling, hydrostatic head and point of cold water introduction
 - Study the effect of hot surfaces on CCFL
3. Instrumentation
 - Improve pitot tube
 - Improve Laser Doppler system
 - Develop holographic methods to measure condensing droplet populations and velocities for the wide range of droplet found in reflood.

(b) The Principal Investigator expects to devote the following approximate amount(s) of time to the contract work:

- S. G. Bankoff - 100% of time for 1 summer month in 1979 and 5% of time for each 9 months academic year for 2 academic years
- R. S. Tankin - 100% of time for 1½ summer months in 1979 and 5% of time for each 9 months academic year for 2 academic years
- M. C. Yuen - 100% of time for 1 summer month in 1979 and 5% of time for each 9 months academic year for 2 academic years

ARTICLE A-II WAYS AND MEANS OF PERFORMANCE

(a) Items for which support will be provided as indicated in A-III, below

- (1) Salaries and Wages \$ 106,725.00
- (2) Equipment to be purchased or fabricated by the Contractor \$ 46,230.00
 - 1 camera with oscilloscopic attachment
 - Two Strip Chart Recorders
 - Double-Pulse, Singel Oscillator
 - Holographic, Laser
- (3) Travel
 - (i) Domestic \$ 4,000.00
 - (ii) Foreign \$ -0-
- (4) Other direct costs including benefits
- (5) Indirect costs based on a predetermined rate of 70 percent applicable to direct salaries and wages including vacation, holiday and sick pay for the period of performance March 1, 1978 through February 28, 1979; and a predetermined rate of 77 percent applicable to direct salaries and wages including vacation, holiday and sick pay for the two period of performances August 25, 1978 through August 24, 1979 and March 1, 1979 through February 29, 1980.

(b) Items, if any, significant to the performance of this contract, but excluded from computation of Support Cost and from consideration in proportioning costs:

NONE

- (c) Time or effort of Principal Investigator(s) including indirect costs and fringe benefits contributed by Contractor but excluded from computation of Support Cost and from consideration in proportioning costs:
- S. G. Bankoff: 5% of time for each 9 months academic year for two academic years
 - R. S. Tankin: 5% of time for each 9 months academic year for two academic years
 - M. C. Yuen: 5% of time for each 9 months academic year for two academic years

Article A-III

The total estimated cost of items under A-II(a) above for the contract period stated in this Appendix A is \$276,390.00 ; the Commission will pay 100 percent of the actual costs of these items incurred during the contract period stated in this Appendix A, subject to the provisions of Article III and Article B-XXVIII. The estimated NRC Support Cost for the contract period stated in this Appendix A is \$276,390.00 .

The estimated NRC Support Cost is funded as follows:

- | | |
|---|---------------|
| (a) Estimated unexpended balance from prior period(s) | \$ -0- |
| (b) New funds for the current period | \$ 187,072.00 |
| (c) Funds to be provided subject to their availability in FY 80 | \$ 89,318.00 |
| (d) The new funds being added in A-III(b) constitute the basis for advance payments provided under Article B-X. | |