NRC Research and Technical Assistance Report

LETTER REPORT

June 10, 1981

Accession No.___________
Contractors Report No.___________

Contract Program or Project Title: Investigation of Accident-Induced Flow and Material Transport in Nuclear Facilities

Subject of this Document: Progress reported for April 1981

Type of Document: Informal monthly progress report

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Date of Document: June 10, 1981

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Washington, D.C. 20555

NRC FIN NO. A7029

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LETTER REPORT

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In reply refer to: WX-8-4225 (R673)
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June 10, 1981

Mr. D. E. Solberg
US Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Transportation and Materials Risk Branch
Standards Section
MS NL 5650
Washington, DC 20555

NRC Research and Technical Assistance Report

Dear Don:

SUBJECT: R673 MONTHLY STATUS REPORT FOR APRIL 1981--INVESTIGATION OF ACCIDENT-INDUCED FLOW AND MATERIAL TRANSPORT IN NUCLEAR FACILITIES

The monthly status report for April 1981 is enclosed. Please call if you have questions or need clarification.

Sincerely,

Dick Martin

R. A. Martin

Bill

W. S. Gregory

RAM/WSG:kmt

Enc: As cited above

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CRMO (2), MS 150
WX-8 File, MS 777

PROGRAM STATUS REPORT

TITLE: Investigation of Accident-Induced Flow and Material Trans in Nuclear Facilities

PROJECT NO: R673

FIN NO: A7029

CONTRACTOR: Los Alamos National Laboratory

MONTH COVERED: April 1981

BUDGET STATUS: Annual Budget $510 k (includes FY 1980 carryover of $85 k supplemental FY 1981 funding of $25 k)

Monthly spending :	$ 35.5 k
Cumulative Spending:	$291.0 k
Funds Remaining :	$219.0 k

I. PROGRAM DESCRIPTION

The objective of this research is to develop the capability to pred accident-induced flow and material transport within a fuel-cycle facilit will develop techniques and conduct experiments to provide supportive da transport of internal accident releases throughout a facility. The prog will be limited to providing source-term characterization at a plant's a spheric boundary. The primary pathway to the atmosphere is a facility's ventilation system, and techniques developed in this investigation will designed for, but not limited to, ventilation system pathways. Level On accident analysis computer codes for fire, explosion, and tornado will b developed this fiscal year. We will perform tasks in the analytical and experimental areas to support these program deliverables. As required, will provide the necessary support to design and provide data for an acc analysis user's handbook.

II. HIGHLIGHTS/SIGNIFICANT MONTHLY ACTIVITIES

Fire Code Development (A.1, B.1.a, B.1.d)*

- Duct Heat Transfer - The duct heat transfer model was incorporated the FIRE CODE this month. This module's primary purpose is to calculate energy removal (or addition) from the flowing duct gas at all points in the duct as a function of time. This term is then included in the duct gas energy equation. A secondary output of this module is the prediction of the duct wall temperature as well as the effects of such items as insulation added to the wall.

The basic duct heat transfer module is composed of four separate heat transfer modules that have been identified as necessary to model one-dimensional duct heat transfer. These are natural convection and radiation from the duct wall to the surroundings (outside) and forced convection and radiation from the combustion products to the duct wall (inside).

For the case of a capacitance in a duct wall, a set of linear algebraic equations for the duct wall temperatures is obtained. This set of equations is tri-diagonal and may be solved directly. For the case of a noncapacitance in a duct wall, a nonlinear equation for the duct wall temperature is obtained; this equation is solved by an iterative process. In either case, the heat transferred from the gas may then be obtained from the wall temperatures and the gas properties.

• Compartment Fire Modeling - A progress report on the development of the Los Alamos fire model was given in April. The report included descriptions of the flow chart, inputs, subroutines, outputs and preliminary comparison with three Lawrence Livermore National Laboratory (LLNL) burn tests of compartment fires that produce most of their heat in the presence of smoke. The initial verification was satisfactory. Work was initiated to explain the special fluid mechanics shortcuts that extend fire modeling to forced ventilation and hovering smoke.

Fire Experiments (B.2.a) - The objective of this task is to design, construct, and instrument a high efficiency particulate air (HEPA) filter fire-combustion product loading test facility. This facility will be used to (1) obtain data to check existing filter plugging models or to develop new ones, (2) prepare for tests with typical fuel cycle materials, and (3) prepare for system

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*These symbols indicate the location of the deliverables and supporting tasks shown in Fig. 1, the Program Development Schedule.

studies. We are making progress in several pretest areas. The smoke injector for tests with typical fuel cycle materials, and (3) prepare for system studies. We are making progress in several pretest areas. The smoke injector system design is complete and the system is being fabricated. The superstructure of our filter weighing system is complete but a number of smaller pieces have yet to be fabricated. We received the two Shaevitz force transducers. We ran a comparison number concentration check with our Royco particle size analyzer to check out our new TSI Electrical Aerosol Analyzer. The test aerosol consisted of oil droplets produced by a laboratory vacuum pump. In the size overlap region of about 0.3 to 1.0 ?m, we obtained agreement within a factor of 2. We hope to run our first filter plugging test before the end of the first week in June 1981.

<u>LLNL Add-On Measurements or Experiments (C.3)</u> - The objective of this task is to propose and coordinate add-on measurements or experiments to be conducted in the LLNL fire test facility. This experimental facility is operated by the LLNL Fire Science Group, which is lead by Dr. N. J. Alvares. The fire test facility has been used for extensive fire containment system studies. It is well instrumented for fluid, thermal, gas, and particulate studies. The add-on measurements that we propose are intended to benefit project R673 by taking advantage of one or more tests in a series of about 13 more crib fire experiments already scheduled at LLNL during FY 1981. Dr. D. L. Fenton from New Mexico State University (NMSU) has been helping LLNL with their aerosol sampling and dilution system to reduce smoke aerosol concentrations to levels measurable with an optical particle size analyzer. Fenton has suggested the use of boundary layer modification by transpiration of dilution air through a porous wall. In this way a particle-free boundary layer is maintained and wall deposition is eliminated. Such methods have been developed for use by the Environmental Protection Agency for stack sampling.

<u>Material Transport Modeling (B.1.b)</u>

- <u>Source/Sink Models</u> - The purpose of this task is to obtain equations for entrainment (source) and deposition (sink) from the literature or from selected experiments that we are conducting in areas where data are lacking.

These equations will apply to specific surface, flow, and material cha tics. They are to be programmed and incorporated in the material tran portions of our computer codes. We now have a simple computer code, D that will calculate aerosol depletion because of gravitational settlin turbulent duct flow at a steady mean velocity. The inputs to DEPOS ar particle, duct, and flow parameters. The output includes concentratio tion and integrated mass deposition rate as a function of distance. W working on another code called TURBID to compute deposition from turbu inertial deposition in duct flows. New equations for the particle tra coefficient are being programmed in TURBID. These equations will prov smooth transition for all values of dimensionless stop distance; that can now estimate the transfer coefficient in the turbulent boundary la turbulent core, buffer region, and laminar sublayer. We plan to perfo sensitivity studies with both codes.

Material Transport Experiments (B.2.b) - The objective of this task is obtain experimental data on heavy-metal powder entrainment resulting f aerodynamic stress. Under accident conditions, such stresses could g to an aerosol source term. Correlations of these data will be used in computer codes. Our tests are being conducted under conditions dynam similar to those that may be expected in fuel cycle facilities. We h pleted 23 experiments using aluminum (ρ = 2.4 g/cm^3), copper (ρ = 8.9 molybdenum (ρ = 10.2 g/cm^3), and tungsten (ρ = 19.3 g/cm^3) powders. free-stream velocities of 7, 10, 13, and 15 m/s over "monolayer" test 2 g of powder distributed over a 14-cm by 182-cm area. The data obta horizontal flux and mass median height are summarized in the followin tables.

Horizontal Flux

Q_h, g/cm^{2}s

U	Al	Cu	Mo	W
10 m/s	5×10^{-6}	4×10^{-6}	3.7×10^{-6}	$1.2 \times 10^{-}$
13		12×10^{-6}	16×10^{-6}	
15		9.8×10^{-6}	14×10^{-6}	$1.7 \times 10^{-}$

Mass Median Height

MMH, cm

U	Al	Cu	Mo	W
10	3.6	6.7	2.2	2.2
13		7.0	3	
15		5.8	2.9	2.3

Filter Modeling (B.1.i) - We have successfully modified the filter model that the pressure drop is the sum of the linear and quadratic dependence the flow rate. The coefficient pertaining to the nonlinear term must be specified through input under filter function; the default is zero. The linear coefficient can be calculated with the given pressure and flow information, but it can also be specified by the input option in a manne similar to the nonlinear one. We have tried several cases, and the mode works as expected. A portion of the experimental effort in filter combu product loading will be directed towards finding these coefficients.

Wind Tunnel Facility (B.2.c) - Work is continuing at NMSU on the new 70- 120-ft building. Projected completion is about the end of May.

Engineered Safeguards (B.1.c) - We are reviewing engineered safeguards l ture. Initial emphasis is on describing HEPA filter fire protection sys This effort will include tabulating existing techniques, as well as list proposed new techniques for providing filter protection.

III. PROGRAM DEVELOPMENT VARIANCE

The completion of the building that will house the wind tunnel is rescheduled for the end of May 1981. This delay is caused primarily by type of construction used for the walls (concrete slab rather than meta are showing completion of the joint PNL/Los Alamos planning document, a we have not received the complete draft with PNL contributions (Fig. 1).

We are adding support task B.3 to the program development schedule. This task involves examination of the possibility of an inadvertent excursion in a spent fuel storage pool. This task is scheduled for completion by the end of June 1981.

IV. BUDGET VARIANCE

The variance in the operating costs continues because of the timing of NMSU's subcontract costs. We are adding the $25 k for support task 3 and plan to use the funds over the next 2 months. We have purchased a T. S. I. Model 1050-2C dual channel, linearized, research anemometer with correlator. This anemometer will be used to obtain mean flow velocity, turbulence, and Reynolds stress data both at Los Alamos and at our wind tunnel test facility at NMSU. This new anemometer equipment is modular in design with plug-in power supplies, signal conditioning, and linearizer modules (Fig. 2).
(Cost: $14,900.00)

Our purchase of the HP data acquisition system last month together with the purchase of hot wire gear this month brings our capital equipment expenditures for FY 1981 up to $64.5 k as shown in Fig. 3.

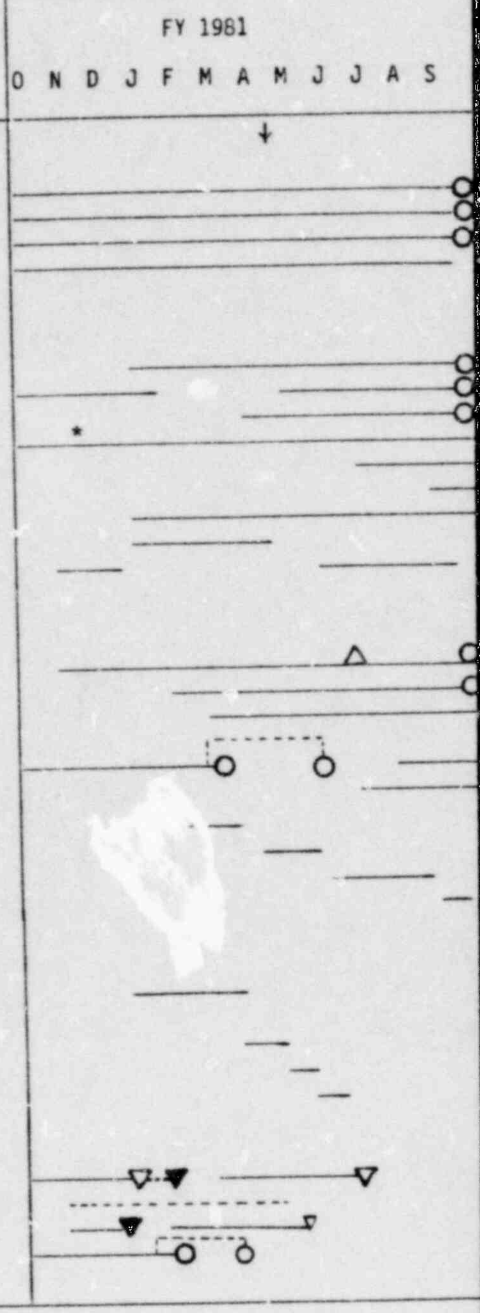
V. PROBLEMS AND ISSUES

We have telephoned Oak Ridge National Laboratory (ORNL) and given them our comments on their Chap. 4. We understood that this was the appropriate action and also the quickest. However, we have noted that ORNL stated in their March 1981 monthly report that written comments from all reviewers are necessary before they will take any steps to address the comments. We will transmit our written comments as quickly as possible.

Fig. 1.

FY 1981 PROGRAM DEVELOPMENT SCHEDULE

DELIVERABLES & MAJOR SCHEDULED/UNSCHEDULED TASKS



A. DELIVERABLES
   1. Level One Fire Code Development
   2. Level One Explosion Code Development
   3. Level One Tornado Code Development
   4. User Handbook Support

B. SUPPORTING TASKS (SCHEDULED)
   1. Analytical
      a) Compartment Fire Model Development
      b) Basic Material Transport
      c) Engineered Safeguards Literature Review
      d) Code Structure/Application/Assessment
      e) 2-D Flow Dynamics
      f) 2-D Material Transport
      g) Material Interaction Model Development
      h) Material Transport/Flow Dynamics Coupling
      i) Filter Plugging Model Development

   2. Experimental
      a) Fire Experimentation
         • Filter Plugging Tests
         • Characterization of Combustion Products
         • Blower Response
      b) Material Transport
         • Entrainment Tests
         • Depletion/Interaction Tests
      c) Wind Tunnel Facility
         • Building Construction
         • Installation
         • Calibration
         • First Test Run

   3. Fuel Pool Inadvertent Excursion
      a) Basic Input Developed
      b) Minimum Critical Masses for Various Configurations
      c) Reactivity Insertion Rate Effects
      d) Peak Power and Energy Determinations

C. SUPPORTING TASKS (UNSCHEDULED)
   1. Define/Design Representative Facility*
   2. Review/Consider PNL Experimentation
   3. Recommendations on Livermore Experiments
   4. Joint PNL/Los Alamos Planning Document

LEGEND

○ Topical Report, ● Topical Report Completed

△ Progress Report, ▲ Progress Report Completed

↓ Time Now

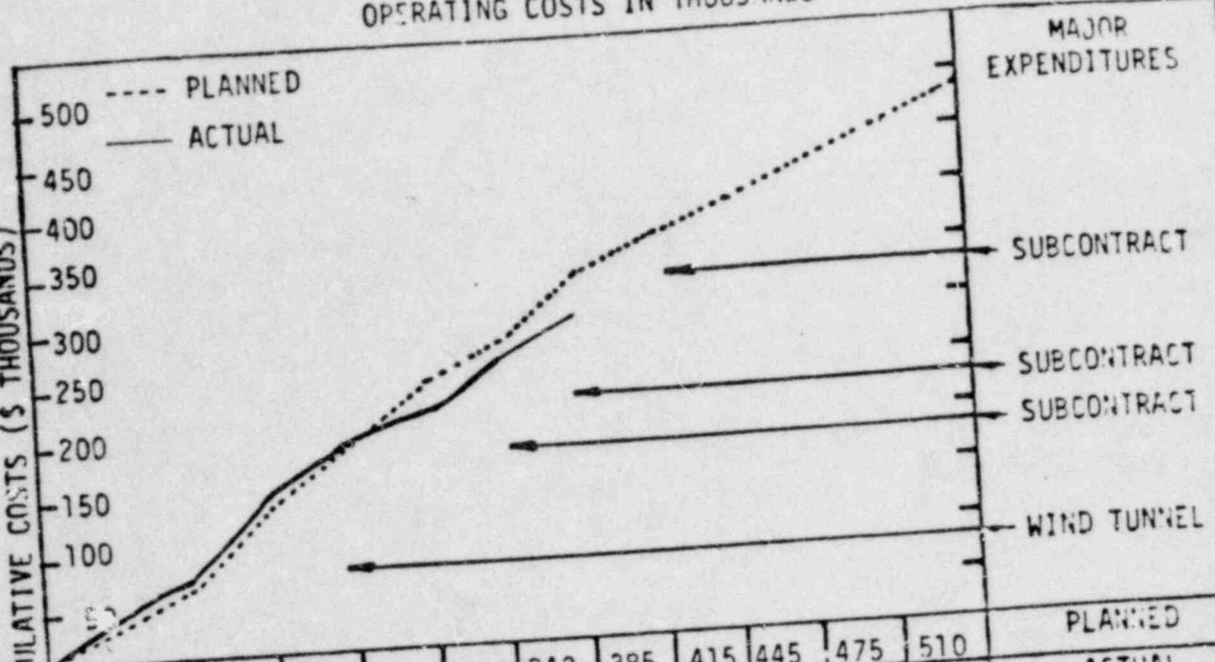
▽ Intermediate Milestone, ▼ Intermediate Milestone Completed

* Identification of Task Causing Variation

___ Activity Line

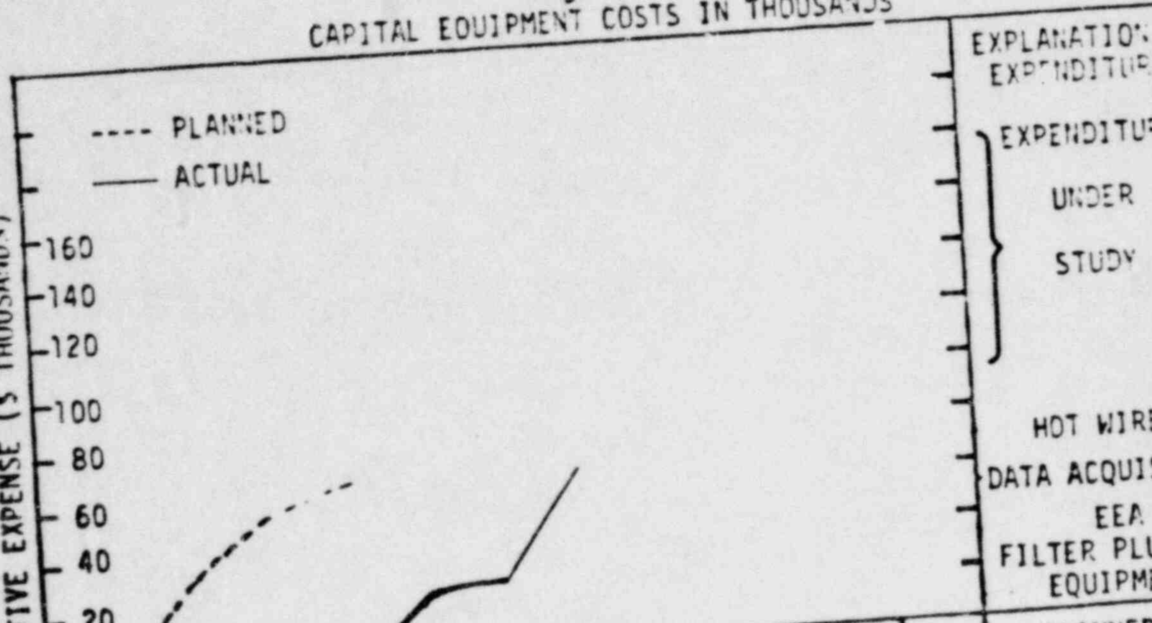
--- Scheduled Variation

Fig. 2.
OPERATING COSTS IN THOUSANDS



PLANNED	30	60	135	185	240	270	342	385	415	445	475	510
ACTUAL	34.5	67.7	149.2	186.1	217.3	255.6	291.0					
VARIANCE (OVER	(4.5)	(7.7)	(14.2)	(1.1)	22.7	14.4	51.0					
MONTH	O	N	D	J	F	M	A	M	J	J	A	S

Fig. 3.
CAPITAL EQUIPMENT COSTS IN THOUSANDS



PLANNED	0	33	56	63	63	63	63					
ACTUAL	0	0	0	0	22.5	23	64.5					
VARIANCE (	0	33	56	63	40.5	40	(1.5)	M	J	J	A	S
MONTH	0	N	D	J	F	M	A					