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DEC 14 1982

MEMORANDUM FOR: Those on Attached List

FROM: Steven Bernstein
Transportation and Materials Risk Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

SUBJECT: MINUTES OF THE NINTH RESEARCH REVIEW GROUP (RRG) MEETING FOR THE FUEL CYCLE FACILITY SAFETY RESEARCH PROGRAM

Enclosed are the minutes of the subject meeting held on September 16-17, 1982. The primary purpose of this meeting was to discuss new roles for Los Alamos National Laboratory and Battelle Pacific Northwest Laboratories in the FCFSRP and to review the laboratories' cost and schedule estimates for the performance of the FY83 tasks. The action items resulting from the meeting are identified in item six of the enclosed minutes. Regarding action item one, the establishment of criteria for use in the compartment fire model assessment program, I have held discussions with Dr. Gregory, Los Alamos, and these criteria are being developed and should be available for NRC review shortly.

ORIGINAL SIGNED BY

Steven Bernstein
Transportation and Materials Risk Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

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DATE	12/14/82	12/14/82				

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

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Donald E. Solberg for
Steven Bernstein
Transportation and Materials Risk Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

DEC 1 4 1982

Addressees for Memorandum Dated:______________________

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F. Fisher, NMSS
R. Grill, RES
K. Steyer, RES
W. S. Gregory, Los Lamos
R. A. Martin, Los Alamos
P. C. Owczarski, PNL
J. Mishima, PNL
M. Siman-Tov, Union Carbide
J. Quintere, NBS
PDR

FUEL CYCLE FACILITY SAFETY RESEARCH PROGRAM
RESEARCH REVIEW GROUP (RRG) MEETING #9

1. INTRODUCTION

On September 16-17, 1982 the ninth RRG meeting on the Fuel Cycle Facility Safety Research Program (FCFSRP) was held at the offices of the Division of Risk Analysis, Office of Nuclear Regulatory Research, NRC, located in Rockville, Maryland. Attendees are shown in Enclosure A and meeting agenda in Enclosure B.

1.1 Purpose of Meeting

The purpose of the meeting was to:

- o discuss new roles for Los Alamos National Laboratory (Los Alamos) and Battelle Pacific Northwest Laboratories (PNL) in the FCFSRP;
- o receive presentations from Los Alamos and PNL on their cost and schedule estimates for performing FY83 tasks;
- o discuss, if time permits, the status of the PNL spill model development program;
- o examine an outline of the revised user guidance for FIRAC input;
- o review available Lawrence Livermore National Laboratory (LLNL) fire test data;
- o discuss fire code options for the Fuel Cycle Facility Accident Analysis Handbook (AAH).

1.2 Background

On August 24, 1982 S. Bernstein, NRC program manager of the FCFSRP, sent a letter to the contractor principal investigators of the FCFSRP outlining new roles for Los Alamos and PNL. A copy of this letter is included as Enclosure C. The reason for this change and the new roles for the contractors are explained in the letter. The letter also stated that a meeting will be held to discuss the new roles and requested the contractors to prepare an estimate of the cost and schedule for performing certain tasks specified in enclosures to the letter.

1.3 Meeting Introduction

S. Bernstein opened the meeting by outlining the new roles for Los Alamos and PNL and the rationale behind making this change in the program. This presentation reiterated the discussion in the letter included as Enclosure C and will not be repeated here.

2. PNL FY83 PROGRAM

2.1 Overview

P.C. Owczarski, PNL, presented an overview of the PNL FY83 program. The FY83 work priorities, provided by NRC, are shown on Page D-1. PNL plans to initiate the work on modifying the material prepared by ORNL after delivering the user manual for FIRIN 1 and the revision to chapters two, three and four of the AAH. On page D-2 the FY83 funding is broken down by task. The deliverables for FY83 and the anticipated delivery dates are shown on pages D-3 and D-4. The sensitivity analysis of radioactivity released in fires will provide information to support the development of the experimental and analytical plan for the FY83 fire effort.

In developing their budget estimates for FY83, PNL had taken the approach of dividing the projected funding level of $350K between the FY83 tasks. S. Bernstein, NRC, requested that PNL prepare reasonable cost estimates for performing the FY83 tasks without regard for the FY83 funding level of $350K.

This would allow the NRC to decide on whether lower priority tasks would need to be deferred to FY84. [Subsequent to the meeting PNL submitted revised cost estimates as shown on pages D-5 and D-6.]

2.2 Radioactive Source Terms in Fires

Dr. Owczarski identified the major mechanisms that release radioactive materials from fires as shown on page E-1. He then reviewed the models developed by PNL for each of these mechanisms. This was a review of the material presented at the July 82 RRG meeting. The details of these models can be found in the minutes of that meeting contained in a memorandum from S. Bernstein, NRC, dated November 18, 1982. PNL will rank the release mechanisms according to their importance for fuel cycle facility fires. They will also examine the experimental conditions used in the tests that form the basis for the radioactive material release models to determine their relevancy to fuel cycle facility fire scenarios. PNL plans to use their fire code, FIRIN 1, to establish the range of conditions that can exist in these fires. It was suggested that since the program is being redirected to use the Harvard Computer Fire Code (CFC), PNL should use this code in determining these fire conditions or at least compare FIRIN 1 results with those from the Harvard CFC. PNL indicated that they will examine the possibility of using the Harvard CFC in this investigation, but may use FIRIN 1 to support their early studies.

PNL is in the process of developing a plan for assessment of FIRIN 1. Since the Harvard CFC will be used, it was agreed to defer the development of this plan.

J. Mishima, PNL, outlined the PNL approach for development of the improved radioactive material fire source terms. PNL is considering two approaches, a mechanistic approach and a parametric approach. The mechanistic approach is outlined in page E-2. Mr. Mishima provided some examples of how the mechanistic approach would be used. On page E-3 is a diagram showing some of the mechanisms involved in the burning of contaminated solid combustibles. On page E-4 and E-5, some of the important parameters involved in these mechanisms are identified. On pages E-6 and E-7, the mechanisms and parameters for the burning of contaminated combustible liquids are shown. This information for the heating of unpressured radioactive liquids are shown on pages E-8 and E-9. The parametric approach is outlined on pages E-10 and E-11 where some of the important parameters for the burning of contaminated solids and liquids are identified.

2.3 Other FY83 PNL Work

Mr. Mishima outlined some of the additional work to be performed in FY83. On page E-12 are some of the tasks to be conducted in the free fall spill and pressurized release program. On page E-13 some of the material that will be examined as part of the literature search for radioactive explosion source terms are identified. On page E-14 some of the ideas to be examined in developing the experimental plan for release of radioactive material from explosions are shown.

S. Bernstein, NRC, commented that the PNL approaches may be too sophisticated considering the time and funding constraints. It is the NRC's intention that the development of these improved radioactive material source items for fires be completed in FY83. It may be necessary to defer the explosion work to FY84 so that sufficient funds are available to complete the fire work in FY83. Another consideration in the FY83 funding for PNL is the task of supplementing the material prepared by ORNL on spent fuel storage, reprocessing, and waste solidification facilities. The FY83 PNL program will include tasks to rework this ORNL material and to identify the material needed for the AAH that is not included in the ORNL material. At the present time no funds have been programmed to develop the AAH material missing from the ORNL material. Until PNL completes the task of identifying what is missing, the amount of funds needed cannot be determined.

3. MODELS FOR FREE FALL SPILLS OF LIQUIDS AND POWDERS

Dr. Owczarski, PNL, presented the status of the task to develop models for free fall spills of liquids and powders. A table comparing the properties of the experimental liquids with those of water is shown on page F-1. PNL performed a dimensional analysis using the independent and dependent variables shown on pages F-2 and F-3. As a result of this analysis, the dimensionless groups shown on page F-4 were identified. PNL is attempting to determine the relationships outlined on page F-5. PNL has correlated a power law relationship using some of the dimensionless groups with the experimental data as shown on the graph on page F-6. Some of the details of the regression analysis is given on page F-7. The distribution parameters for the drop size is given on page F-8.

For the powder spills, two scenarios need to be examined. In one scenario the beaker empties before the powder impacts the floor. In the other scenario the powder impacts the floor before the beaker empties. These scenarios are shown schematically on page F-9 and F-10. Also included on these pages are definitions of some of the parameters used in the model development. PNL is basing its model on the assumption that most of the airborne material comes from entrainment from the falling column. Material made airborne from impaction with the floor is being neglected. This assumption is supported by examining the high speed photographs taken during the spill experiments.

The PNL model is based on the work by L. Cheng who examined the formation of airborne, respirable dust produced by coal falling from a conveyor belt. The assumptions used in developing the model and the derivation of the mathematical formulations are shown on pages F-11 through F-17. The range of variables used in the free fall powder experiments is shown on page F-18. A comparison of the two experimental powders for some of the model parameters is shown on page F-19. The results of using Cheng's approach is shown on the graph on page F-20. Finally, on page F-21, some of the additional analyses needed for model development are identified.

4. LOS ALAMOS FY83 PROGRAM

W.S. Gregory, Los Alamos, presented an outline of the Los Alamos presentation as shown on page G-1.

4.1 FY 83 Work Priorities

Dr. Gregory identified the FY83 work priorities as provided in the NRC letter included as Enclosure C. He identified the funding requirements for each task as follows:

Task	Funding Requirement ($K)
Modify Harvard CFC	100
Integrate Harvard CFC with FIRAC	120
Prepare chapters 4 & 5 for AAH	55
Develop assessment plan	28
Sensitivity analyses	28
NMSU fire verification tests	50
FY83 LLNL fire tests	20
Explosion literature review	28
Plan for near field explosion model	28
Computer costs	45
Project management	25
TOTAL	527

Dr Gregory indicated that the total cost could be lowered by deferring the explosion work to FY84 and reducing the size of the assessment program. In response to a question from A.N. Tse, NRC, Dr. Gregory outlined the required modifications to the Harvard CFC so that it can address fuel cycle facility fire scenarios. These include inclusion of forced ventilation, interaction with the ventilation portion of the code to allow system feedback, and possibly material transport aspects. J. Quintiere, NBS, suggested the NRC be flexible in its adoption of the Harvard CFC. He recommended that initially the Harvard CFC could be linked with the Los Alamos fire analysis code. S. Bernstein, NRC, stated the NRC's objective of integrating the two codes with minimum required modifications to the Harvard CFC so that the work would be completed in FY83.

4.2 "Revised" User Guidance

Dr. Gregory outlined the approach Los Alamos is planning to use in the development of their fire code. Three options will be available to the user to provide the input for the ventilation portion of the code. In the first option the user provides a description of the fire. The second option involves use of the Los Alamos guidelines. The third option would use a fire compartment model to describe the fire conditions in the burn room.

Dr. Gregory provided some details of the Los Alamos user guidance. This guidance was prepared by J. W. Bolstad and F. R. Krause from Los Alamos. The purposes of these guidelines are identified on page G-2. The inputs will be in the form of step functions that include changes in burn mode as shown on page G-3. Dr. Gregory outlined how the guidelines have been revised from the version in the March 82 FIRAC user manual as shown as on page G-4. On page G-5 is the table of contents of the revised guidelines. Some of the special features of the guidelines are identified on pages G-6 and G-7. Dr. Gregory emphasized that several sample problems would be documented in the guidelines and the methods have been compared with experimental data whenever possible. The information the user will supply in using the guidelines is identified on page G-8. The guidelines will address nine fire types as shown on page G-9. Los Alamos has used the revised guidelines to analyze the B&W Fire Scenario discussed at the July 82 RRG meeting. [The minutes of this meeting are contained in a memorandum from S. Bernstein, NRC, dated November 18, 1982.] The analysis using the revised guidelines results in a more reasonable burn room temperature of about 500°F. Dr. Gregory identified the limiting factors applied to several fire parameters used in the guidelines. These limiting factors are shown on page G-10. Dr. Gregory outlined some of the methods used to check the guidelines as shown on page G-11. Some comparisons were made with experimental data from the LLNL fire tests. The results for some of these comparisons are given on pages G-12 and G-13.

Dr. Gregory stated that the revised guidelines would be submitted to the NRC in December 1982. (Subsequent to the meeting, Dr. Gregory decided to submit the revised guidelines at the same time the complete improved fire code is being submitted. The current due date for this submission is July 1983. This delay will allow Los Alamos to perform a thorough checkout of the revised guidelines.)

4.3 Preview of LLNL Compartment Fire Tests

The spray fire tests have been completed. The next series of tests, to be performed shortly, are the pool fires.

Some preliminary data has been made available by LLNL. These are the temperatures approximately two feet down from where the exhaust duct exits the fire test cell. Dr. N. Alvares, LLNL, estimates that these temperatures would be approximately 20-25°F less than the hot layer temperature. The Los Alamos and Harvard fire codes both predicted temperatures that are below the experimental value with the Los Alamos value being closer to the actual value.

There are significant differences in the Los Alamos and Harvard predictions for the pool fires. The comparison of these predictions with the experimental data from the upcoming pool fire tests should provide part of the basis for choosing between these two fire compartment models.

5. FUEL CYCLE FACILITY ACCIDENT ANALYSIS HANDBOOK (AAH)

S. Bernstein, NRC, identified some of the options available for the AAH fire code. Four options are shown on page H-1. In the first option the PNL fire code, FIRIN 1, would be integrated with the Los Alamos ventilation code, FIRAC. In option two, the Los Alamos guidelines discussed in item 4.2 would be merged with FIRAC. Option three involves modifying the Harvard CFC. Option four represents the original concept for the AAH fire code.

During the discussion the question arose as to whether Los Alamos should continue with their fire compartment model assessment program in light of the NRC decision to use the Harvard CFC. It was agreed to continue the assessment program as a means of confirming this decision and evaluating alternatives in case problems arose in modifying the Harvard CFC and integrating it with FIRAC. S. Bernstein, NRC, pointed out that to complete development of the fire code in FY83 it is necessary to initiate immediately the work on the

Harvard CFC. He suggested that criteria be established beforehand for use in the assessment program. Some recommended criteria were identified as shown on page H-2.

6. SUMMARY OF ACTION ITEMS

The following action items resulted from this meeting.

1 - Los Alamos will develop draft criteria to be used in the fire compartment model assessment program. These criteria will be submitted to the NRC for review within a few weeks.

2 - PNL will submit a revised cost estimate for performance of FY83 tasks. (This action item has been completed. See pages D-5 and D-6.)

3 - Development of a plan for assessment of PNL's FIRIN 1 computer code is deferred.

FUEL CYCLE FACILITY SAFETY RESEARCH PROGRAM

RESEARCH REVIEW GROUP MEETING

SEPTEMBER 16-17, 1982

NAME	ORGANIZATION	TELEPHONE
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PETE OWCZARSKI	PNL	(509) 375-3852
BEN BUCHBINDER	NRC/RES/DRA	443-5997
BILL GREGORY	LOS ALAMOS	843-6231
ROY HAARMAN	LOS ALAMOS	843-6231
DICK MARTIN	LOS ALAMOS	843-6231
MOSHE SIMAN-TOV	UCC-ND, OR	624-6515
ANTHONY TSE	NRC/RES	443-5825
DON SOLBERG	NRC/RES	443-5825
PETER LOYSEN	NRC/NMSS	427-4205
JIM QUINTIERE	NBS	921-3242
TOM CLARK	NRC/NMSS	427-4205
FRED FISHER	NRC/NMSS	427-4135
JOFU MISHIMA	PNL	(509) 375-3850

AGENDA

For

FUEL CYCLE FACILITY SAFETY RESEARCH PROGRAM

RESEARCH REVIEW GROUP MEETING

Date: September 16-17, 1982

Location: Room 013
5650 Nicholson Lane
Rockville, Maryland

TIME	ITEM	BY
September 16, 1982		
1:00	Introduction: Outline of New Roles for PNL and Los Alamos	NRC
1:30	Overview of PNL FY 83 Program	PNL
2:30	Plans for Improvement of Radioactive Source Terms in Fires	PNL
4:30	Adjourn	

TIME	ITEM	BY
September 17, 1982		
8:30	Overview of Los Alamos FY 83 Program	Los Alamos
9:30	Revised User Guidance For FIRAC Input	Los Alamos
10:00	Preview of LLNL Fire Test Results (Tentative)	Los Alamos
10:30	Discussion of Level 1 Accident Analysis Handbook	NRC PNL Los Alamos
12:00	Lunch	
1:30	Closing Summary	NRC
2:00	Adjourn	

Smiley

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

AUG 24 1982

P. C. Owczarski
Atmospheric Sciences Dept.
Battelle Pacific Northwest Laboratories
P.O. Box 999
Richland, WA 99352

Dear Mr. Owczarski:

This is to follow-up on our recent discussions at the Air Cleaning Conference in Denver concerning the future direction of the research program. As a result of the Research Review Group (RRG) meeting held at Factory Mutual Research Center in July 1982 and subsequent discussions with the RRG, I have concluded that certain changes must be made in the scope of the Los Alamos National Laboratory (Los Alamos) and Battelle Pacific Northwest Laboratories (PNL) work in the research program. The role of Union Carbide in the research program remains unchanged. The changes outlined here would be initiated in the FY 83 program.

Our overall program objective is to complete and publish, in FY 83, the Fuel Cycle Accident Analysis Handbook (AAH) including:

(1) A single, unified code that will analyze near field, compartment, and far field effects of fires utilizing the Harvard fire code modified as needed, and integrated with FIRAC,
(2) Improved versions of the radioactive source terms for fires, and
(3) The accident analysis information in chapters two and three of the AAH for all the fuel cycle facilities within the scope of the program.

THE NRC staff has concluded that a major source of uncertainty in the accident analysis methods being developed for us is in the radioactive source term and that this area should be receiving more emphasis. Accordingly, I am directing that a major portion of the PNL program will be to develop improved analytical models for predicting the radioactive source term resulting from fires and explosions with the principal work in FY 83 to be on radioactive source terms from fires. The FY 83 work will begin with development of an analytical and experimental plan which will assess the uncertainties in the predictive capability and recommend an experimental program needed to support development of improved analytical models for characterizing the radioactive materials made airborne for representative fuel cycle facility fire scenarios. The plan will be modified as required by NRC and then implemented. Additional tasks could be performed in FY 83 depending upon the level of funding needed to develop significant improvements in the important radioactive fire source term methods. Enclosure 1 contains a more detailed outline of these additional PNL FY 83 tasks, in priority order, for the revised program.

Since the primary emphasis of the PNL program in FY 83 will be on the radioactive source term, the FY 83 Los Alamos program must focus on the development of models to describe the other important phenomena associated with fires. Using the terminology that we have been employing in the program, this task would consist of developing models for the near field, compartment effects, and far field analysis. Specifically the highest priority work will be to integrate the Harvard Fire Code with FIRAC to produce a single, unified fire analysis code for use in our program. This will entail only minimal modification of the Harvard Fire Code as needed to (a) accept the PNL radioactive source terms, (b) analyze systems with forced ventilation flow and (c) provide compatible operation with FIRAC.

This work would be followed with a program to assess the fire code, including sensitivity studies, to determine the limitations and uncertainties in the code and provide a basis for future improvements. Additional tasks could be performed in FY 83 depending upon the level of funding available. Enclosure 2 contains a more detailed outline of these additional Los Alamos FY 83 tasks, in priority order, for the revised program.

I have outlined new roles for PNL and Los Alamos in the FY 83 research program. I have scheduled a meeting at our offices in Rockville, Maryland for September 16 and 17, 1982 to discuss these new ideas, roles and the tasks involved. Please be prepared to present your estimates for the cost and schedule for performing the tasks listed in the enclosures.

Sincerely,

Donald E. Solberg for

Steven Bernstein
Transportation and Materials Risk Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

Enclosures: As stated

Identical ltr sent to: WS Gregory, Los Alamos
M. Siman-Tov, UCC

C-2

Enclosure 1

FY 83 PNL Work Priorities

1. Experimental and analytical program to develop radioactive source term models for fires.
2. Complete report of analytical models for free fall and pressurized spills.
3. Modify ORNL-prepared material for inclusion in Accident Analysis Handbook.
4. Review literature related to radioactive source terms for explosions.
5. Develop experimental and analytical plan for explosion radioactive source terms.
6. Continue glove box experimental program.

Enclosure 2

FY 83 Los Alamos Work Priorities

1. Modify Harvard fire code as indicated in memorandum.
2. Incorporate modified Harvard code into FIRAC.
3. Revise chapter 5 and user manual in AAH and write parts of chapter 4 as required.
4. Develop plan for assessment of Harvard/FIRAC code.
5. Implement assessment plan after necessary modifications based on NRC comments.
6. Review literature on near field explosion data and models.
7. Develop experimental and analytical plan for near field explosion phenomena.

FY 83 PNL Work Priorities

1. Experimental and analytical program to develop radioactive source term models for fires.
2. Complete report of analytical models for free fall and pressurized spills.
3. Modify ORNL-prepared material for inclusion in Accident Analysis Handbook.
4. Review literature related to radioactive source terms for explosions.
5. Develop experimental and analytical plan for explosion radioactive source terms.
6. Continue glove box experimental program.

FY 83

Task A.	Accident Analysis Handbook	$50K
Task B.	Experimental Radioactive Aerosol Generation in Fires.	120
Task C.	Radioactive Aerosol Generation in Explosions (Literature Search and Experimental Plan)	30
Task D.	Failed Compartment Experiments	40
Task E.	Modeling Efforts (Press. Rel., Radioact. in Fires and Explosions	80
Project Management		30
		$350K

FY 83 FORMAL DELIVERABLES

FMR Final Report	Dec 82
Free Fall Spills Models	Oct 82
Pressurized Releases Exp. Data	Nov 82
Pressurized Releases Models	4th Qtr
Explosions Literature Search	3rd Qtr
ORNL Material Into AAH	2nd Qtr
Revisions of AAH	

FY 83 INFORMAL DELIVERABLES

Sensitivity Analysis of Radioactivity Release from Fires	Dec 82
Experimental Plan for Radioactivity Release from Fires	2nd Qtr
Recommendations on ORNL Material	2nd Qtr
Preliminary Models for Radioactivity Release in Explosions	1st Qtr-3rd Qtr
Experimental Plans for Radioactivity Release in Explosions	4th Qtr

Telefaxed 9/21/82

S. Bernstein/D. Solberg
RES/DRA/TMRB
U.S. Nuclear Regulatory Commission
Nicholson Lane
Rockville, MD

SUBJECT: Alternative Cost Estimates - FY-83

AEROSOLIZED RADIOACTIVE MATERIALS RELEASED FROM LWR FUEL CYCLE FACILITY ACCIDENTS

1. Basis: Experimental and Analytical Source Term for Fires
   a. Burning contaminated combustible solids
   b. Burning contaminated combustible liquids
   c. Heating contaminated non-combustible surfaces
   d. Heating of unpressurized radioactive liquids
   e. Pressurized release of radioactive powders and liquids
   f. Free fall spills of radioactive powders and liquids
   g. Burning of pyrophoric metals
2. Delay experiments of e. and f. for heated liquids. Use literature and RART data for cold materials to develop models for e. - heated liquids. Ignore g. and c. (small values).
3. Include analysis of uncertainty in present data for a-g. Prioritize importance of mechanisms or parameters from fires (Scoping Analysis).
4. Determine feasibility of mechanistic model for heating of contaminated liquids and burning of contaminated combustible liquids. Literature search necessary.
5. Begin immediately burning of contaminated combustible solids experiments.
6. Experiment on 3 scales - adequate parameter variation
   a. Bench scale - 120 experiments
   b. RART - 60 experiments
   c. LLNL or equivalent - 5-10 experiments.
7. Cost of 2-6: $670K (includes $50K non-capital equip.)
   A.A.H. Activities: $50K
   Press. Rel. Models: $30K (bare minimum)
   Project Mgmt: $50K
   TOTAL $800K

8. Do bare minimum parametric experiments. Use only most prevalent combustibles and contaminants.
   a. Bench scale - 60 experiments
   b. RART - 30 experiments
   c. LLNL or equivalent - 2-5 experiments
9. Cost of 2-5, 8: $420K
   A.A.H. Activities: $50K
   Press. Rel. Models: $30K
   Project Mgmt: $40K

   TOTAL $540K

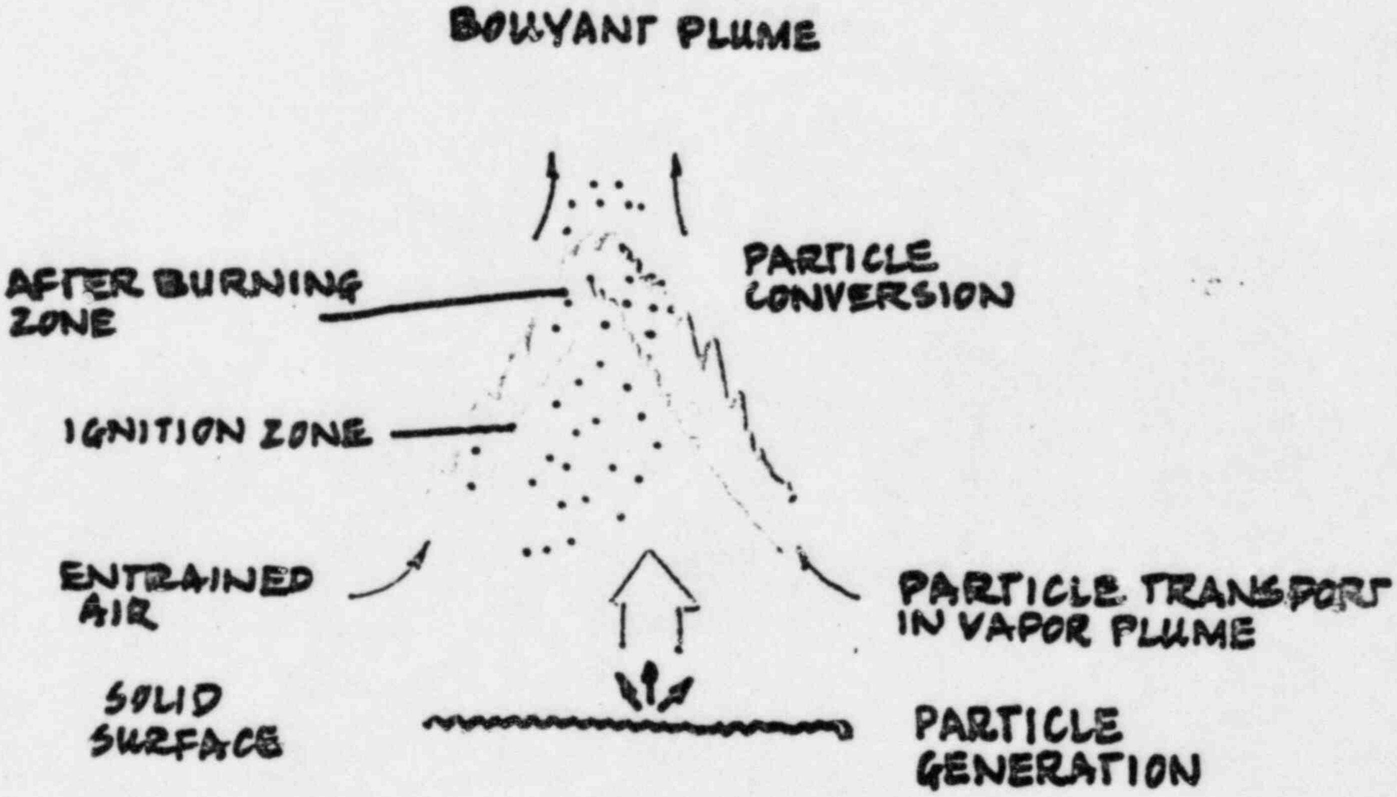
P.C. Owczarski/J. Mishima

Major Mechanisms of Release During a Fire

- Burning Contaminated Combustible Solids
- Burning Contaminated Combustible Liquids
- Heating Noncombustible Contaminated Surfaces
- Heating Unpressurized Radioactive Liquids
- Pressurized Releases of Radioactive Powders or Liquids
- Spills of Radioactive Powders or Liquids
- Burning Radioactive Pyrophoric Metals

APPROACH

- LITERATURE SEARCH FOR APPLICABLE MODELS AND DATA
- ASSESS FEASIBILITY OF MECHANISTIC MODEL-- DETERMINE IF MISSING PIECES CAN BE OBTAINED EXPERIMENTALLY
- DESIGN EXPERIMENTAL PROGRAM



MECHANISTIC APPROACH
BURNING CONTAMINATED SOLID COMBUSTIBLES

PARTICLE GENERATION:

- SOLIDS -- INITIAL SIZE DISTRIBUTION,
  CONVERSION/SUBDIVISION DURING GENERATION
- LIQUIDS* — DRYING (EFFECT ON $\dot{M}$)
  VOLUME-CONCENTRATION-DISTRIBUTION-CONVERSION
- ENERGY OF INJECTION* — MANY POSSIBLE PROCESSES

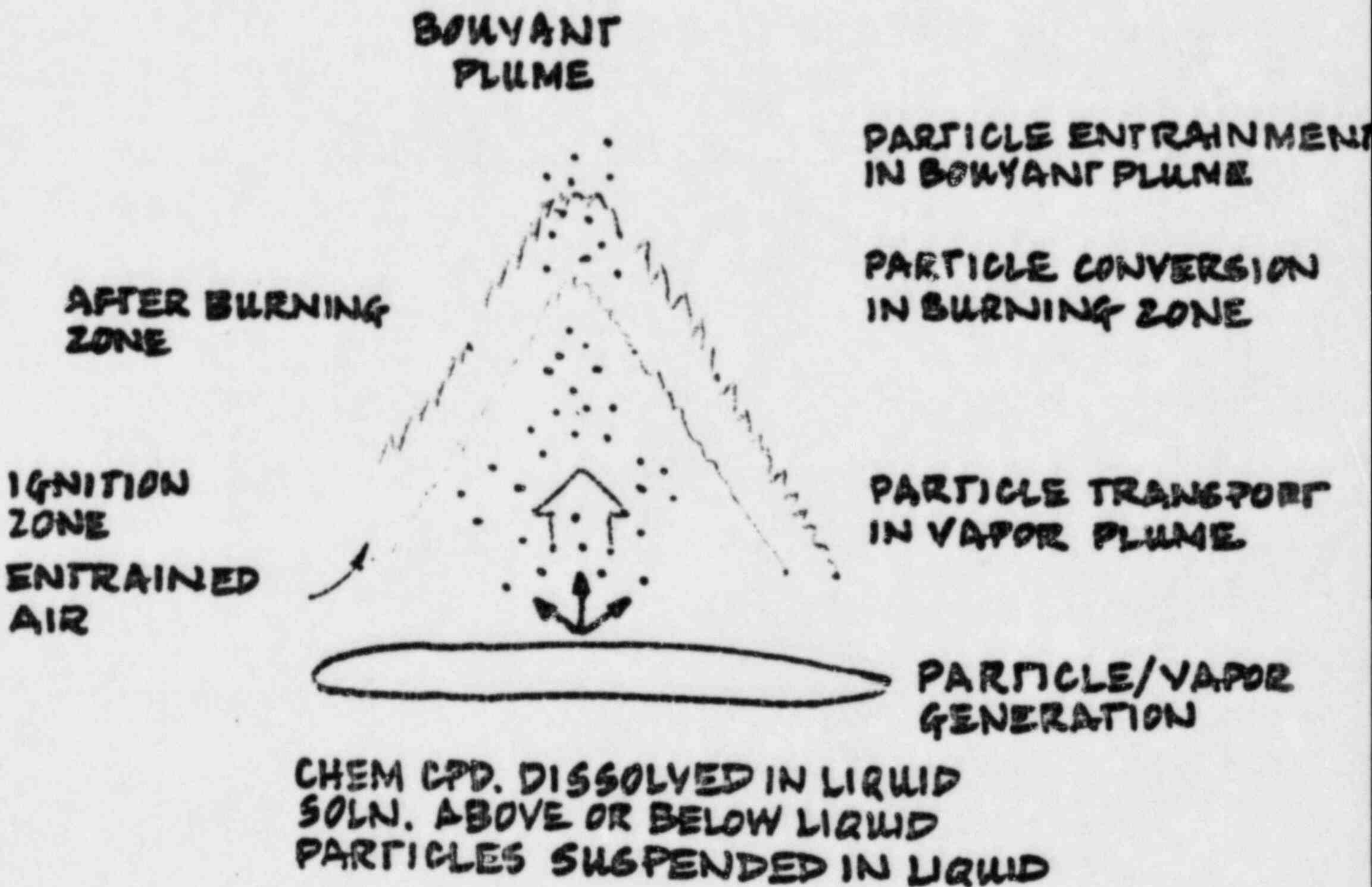
PARTICLE TRANSPORT & BEHAVIOR IN VAPOR PLUME:

- VELOCITY OF VAPOR -- MASS LOSS RATE, $\dot{M}$
  CHEM CHARACTERISTICS VAPORS
  RADIANT ENERGY FLUX
- VAPOR CONDENSATION ON PARTICLE

PARTICLE CONVERSION IN IGNITION & AFTER BURNING ZONES: *

PARTICLE TRANSPORT BY BOUYANT PLUME:

- PLUME VELOCITY — INITIAL GAS VELOCITY.
  CHEM SPECIES GASES & VAPOR
  CONVECTIVE ENERGY FLUX



MECHANISTIC APPROACH
BURNING OF CONTAMINATED COMBUSTIBLE LIQUIDS

PARTICLE GENERATION:

- MIGRATION RADIOACTIVE MATERIAL TO SURFACE --
  INDUCED PHASE
  TWO PHASED FLOW*

- FILM FORMATION & BREAK UP AT LIQUID SURFACE* --

PARTICLE/DROPLET TRANSPORT & BEHAVIOR IN VAPOR PLUME:

⋮

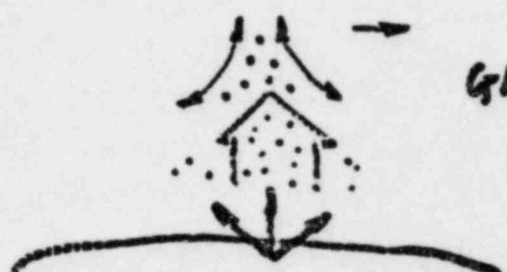
- EVAPORATION/CONDENSATION --- MAEROS

PARTICLE CONVERSION:

⋮

- PHYSICAL FORM

PARTICLE TRANSPORT IN BOUYANT PLUME:



MECHANISTIC APPROACH
HEATING OF UNPRESSURIZED RADIOACTIVE LIQUIDS

PARTICLE/DROPLET FORMATION:

- FORM RADIOACTIVE MATERIAL — CHEMICAL CPD, IN SOLUTION OR AS SUSPENDED PARTICLES
- MIGRATION PARTICLES TO SURFACE
- FILM FORMATION AND BREAK UP

PARTICLE TRANSPORT & BEHAVIOR IN VAPOR PLUME

- EVAPORATION LIQUID -- CHEM. CPD, ENERGY INPUT RATE
- PARTICLE EVAPORATION/CONDENSATION

PARAMETRIC APPROACH

BURNING OF CONTAMINATED SOLIDS AND LIQUIDS

PARAMETERS

- MASS LOSS RATE, $\dot{M}$
- CHEMICAL COMPOSITION of COMBUSTIBLES
- CHEMICAL AND PHYSICAL FORM OF RADIOACTIVE MATERIAL
- BURN MODES
- OXYGEN RICH/DEFICIENT

APPROACH:

- DETERMINE "REALISTIC" RANGE OF VALUES USING FIRIN I & HARVARD CFC (IF AVAILABLE)

- SELECT COMBUSTIBLES (i.e. cellusic, rubber, PMMA, kerosine, etc)

- SELECT SOLIDS & LIQUIDS (1 SOLID, 2-3 LIQUIDS at 2-3 concentrations at 2-3 distributions)

- BURNING MODES -- FLAMMING, SMOLDERING, CHARING

- OXYGEN RICH / DEFICIENT

SCALING EFFECT

- BENCH, RART ... LARGER

ADDITIONAL WORK

FREE FALL SPILLS AND PRESSURIZED RELEASES

EXCERCIZE MODELS TO DETERMINE IMPORTANT PARAMETER

DETERMINE FEASIBILITY OF PERFORMING EFFECTIVE EXPERIMENTAL PROGRAM

DETERMINE FEASIBILITY OF MECHANISTIC APPROACH

INVESTIGATE SCALING EFFECTS

PRESSURIZED RELEASE OF HEATED LIQUIDS INTO HEATED ATMOSPHERES

4. LITERATURE SEARCH, RADIOACTIVE SOURCE TERMS FOR EXPLOSIONS

- NUREG/CR-2651. Sutter 1982. ACCIDENT GENERATED MATERIALS AND THEIR CHARACTERISTICS...
- Steindler and Seefeldt. Airborne releases from detonations
- Sutter. Pressurized release
- LANL Aerodynamic Entrainment (WIND TUNNEL)

5. EXPERIMENTAL PLANS -- RELEASE of RADIOACTIVE MATERIAL FROM EXPLOSIONS

- RELEASE OF HEATED LIQUIDS INTO HEATED ATMOSPHERES
- ADDITIONAL EFFORT, AS REQUIRED, AFTER INITIAL EVALUATION RANGE OF CONDITIONS PREDICTED BY CODES
- REMAINING STRESSES COVERED BY PREVIOUS STUDIES

Comparison of Properties - Experimental Liquids, Water
(25°C)

Material	Density, g/cc (g/cc)	Viscosity, cp (cp)	Surface Tension (dyne/cm)	Vapor Pressure (mm Hg)
H_2O [a]	0.997	0.89	72.	23.8 [a]
UNH [b]	1.54	1.70	66.4	13.6 [d]
Uranine [c]	0.993	0.79 —	52.1	23.7 [d]
Air [a]	1.155×10^{-3}	1.83-02	—	—

(a) Handbook of Chemistry and Physics, 59th ed.

(b) Uranyl Nitrate Hexahydrate solution in nitric acid, 208.7 g U/l (0.877M), 8.4 M HNO_3

(c) 10 g/l uranine in water.

(d) Calculated

TI
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LIQUID SPILL DIMENSIONAL ANALYSIS

INDEPENDENT VARIABLES:

- μ & μ_a, VISCOSITY OF LIQUID AND AIR
- ρ & ρ_a, DENSITY OF LIQUID AND AIR
- g, ACCELERATION OF GRAVITY
- h, HEIGHT OF SPILL
  (OR V, IMPACT VELOCITY = $\sqrt{2gh}$)
- m_s, MASS OF SPILL
  (OR DIAMETER OF EQUIVALENT SPHERE = $\sqrt[3]{6m_s/\pi\rho}$)
- γ, LIQUID SURFACE TENSION

DEPENDENT VARIABLES:

- m_p, MASS OF DROPLETS AIRBORNE
- d_p, MASS MEDIAN DIAMETER
- σ_g, LOG MEAN STANDARD DEVIATION

DIMENSIONLESS GROUPS:

$W_e = \rho D V^2/\gamma$, WEBER NO.

$R_e = \rho D V/\mu$, REYNOLDS NO.

$F_r = V^2/gD$, FROUDE NO.

μ/μ_a, ρ/ρ_a

d_p/D, σ_g

$m_p/m_s = F$, FRACTION OF SPILL AIRBORNE

RELATIONSHIPS DESIRED:

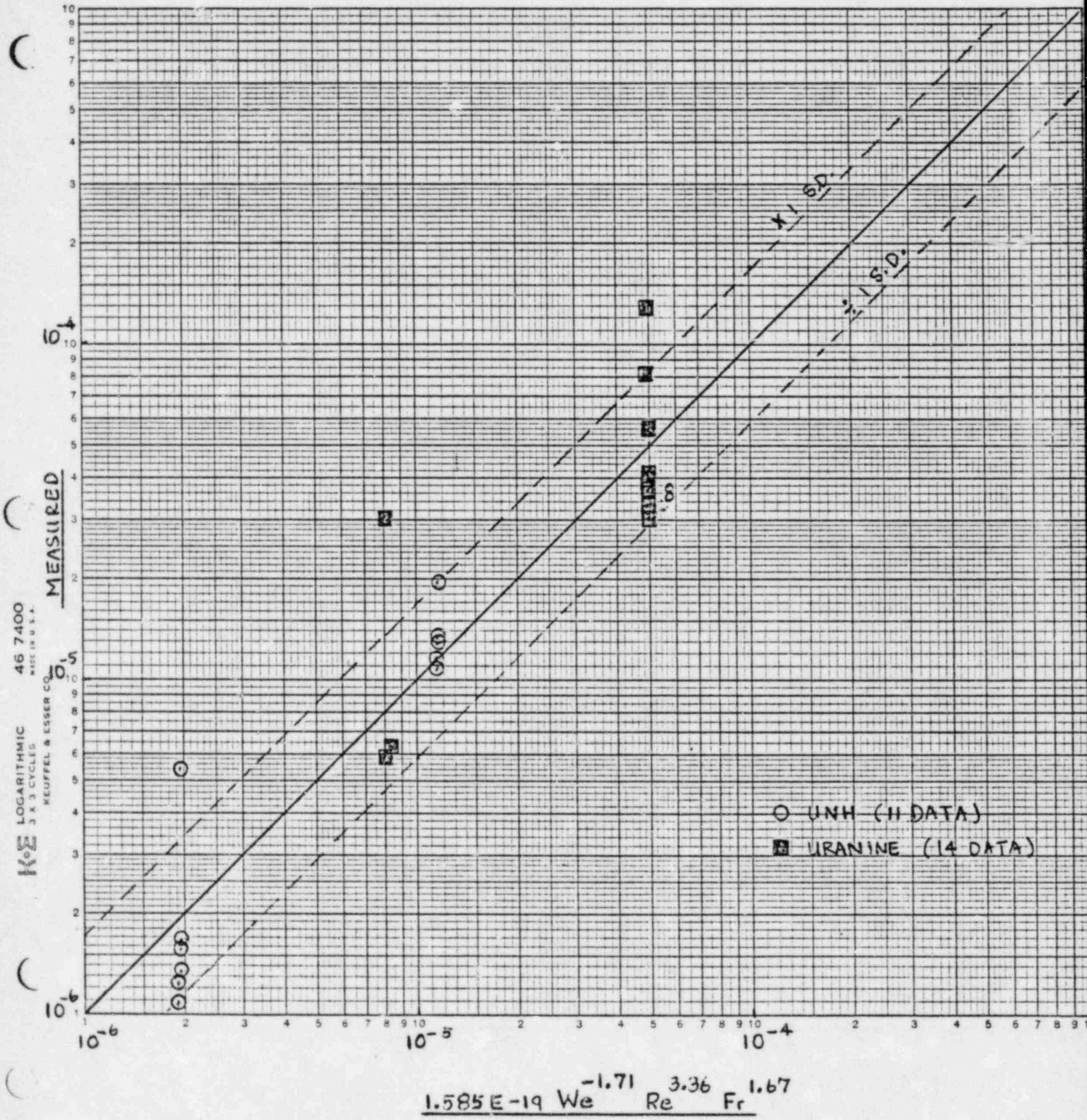
$$F = F\,(W_e,\ R_e,\ F_r,\ \mu/\mu_a,\ \rho/\rho_a)$$

$$d_p/D = d_p/D\,(W_e,\ R_e,\ F_r,\ \mu/\mu_a,\ \rho/\rho_a)$$

$$\sigma_g = \sigma_g\,(W_e,\ R_e,\ F_r,\ \mu/\mu_a,\ \rho/\rho_a)$$

FRACTION OF LIQUID SPILL AIRBORNE

MEASURED vs. PREDICTED VALUES



	Y	X_1	X_2	X_3	
	$\log_{10} F$	$\log_{10} We$	$\log_{10} Re$	$\log_{10} Fr$	
1	-5.97100	4.75100	5.69700	1.20700	
2	-5.91500	4.75100	5.69700	1.20700	
3	-5.68000	4.65000	5.59600	1.30800	
4	-5.81000	4.65000	5.59600	1.30800	
5	-5.26700	4.45000	5.39600	1.50900	
6	-5.77900	4.45000	5.39600	1.50900	
7	-4.96300	5.22800	5.93500	1.68400	UNH
8	-4.94300	5.22800	5.93500	1.68400	
9	-4.86800	5.12700	5.83400	1.78500	
10	-4.87700	4.92700	5.63400	1.98600	
11	-4.70500	4.92700	5.63400	1.98600	
12	-4.51500	4.66600	5.83900	1.20700	
13	-5.23200	4.56500	5.73900	1.30800	
14	-5.20400	4.36500	5.53800	1.50900	
15	-3.89300	5.14300	6.07900	1.68400	
16	-4.09300	5.14300	6.07900	1.68400	
17	-4.40800	5.04100	5.97700	1.78500	
18	-4.50100	5.04100	5.97700	1.78500	
19	-4.51000	5.04100	5.97700	1.78500	
20	-4.25000	5.04100	5.97700	1.78500	URANINE
21	-4.28900	5.04100	5.97700	1.78500	
22	-4.48400	5.04100	5.97700	1.78500	
23	-4.38600	5.04100	5.97700	1.78500	
24	-4.42900	5.04100	5.97700	1.78500	
25	-4.47600	4.84200	5.77600	1.98600	

THE REGRESSION EQUATION IS
Y = - 18.8 - 1.71 X1 + 3.36 X2
+ 1.67 X3

	COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	--	-18.762	1.448	-12.96
X1	C3	-1.714	0.439	-3.91
X2	C4	3.365	0.475	7.09
X3	C5	1.672	0.254	6.59

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 0.2350
WITH (25- 4) = 21 DEGREES OF FREEDOM

R-SQUARED = 87.2 PERCENT
R-SQUARED = 85.4 PERCENT, ADJUSTED FOR D.F.

$$R^2 = \frac{\Sigma (Y_i^2)_p}{\Sigma (Y_i^2)_m}$$

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	3	7.93386	2.64462
RESIDUAL	21	1.15982	0.05523
TOTAL	24	9.09368	

Drop Size Distribution Parameters

All Data

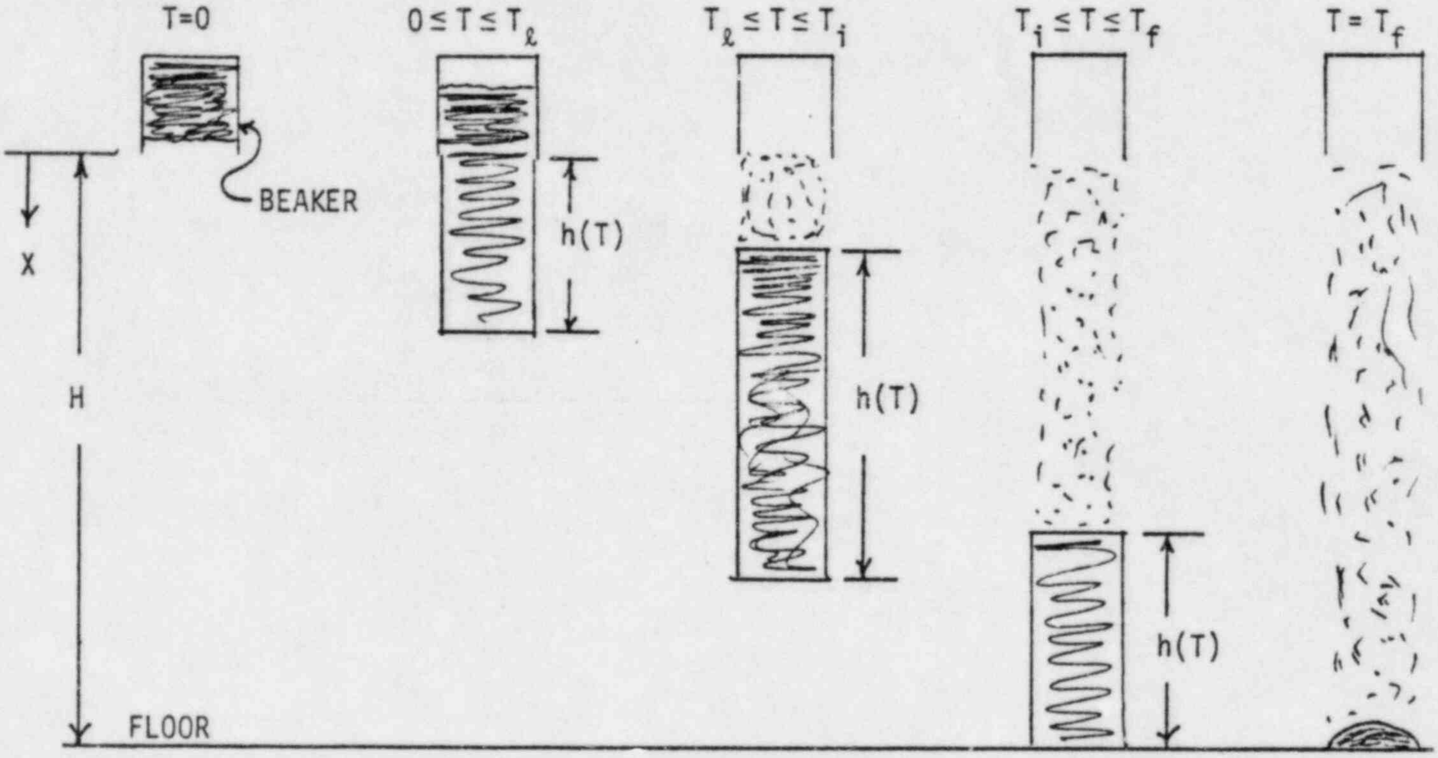
	d_p/D	σ_g
mean :	1.023-04	3.365
90% CI :	7.79-05 to 1.344-04	2.913 to 3.888

UNH

	d_p/D	σ_g
mean :	1.655-04	4.265
90% CI :	9.696-05 to 2.826-04	3.227 to 5.636

Uranine

	d_p/D	σ_g
mean :	7.010-05	2.794
90% CI :	6.100-05 to 8.056-05	2.532 to 3.083



SCENARIO ONE: BEAKER EMPTIES BEFORE POWDER IMPACTS FLOOR

H: HEIGHT OF SPILL (CM)

h(T): HEIGHT OF COLUMN OF SPILL (CM)

T: TIME (SEC)

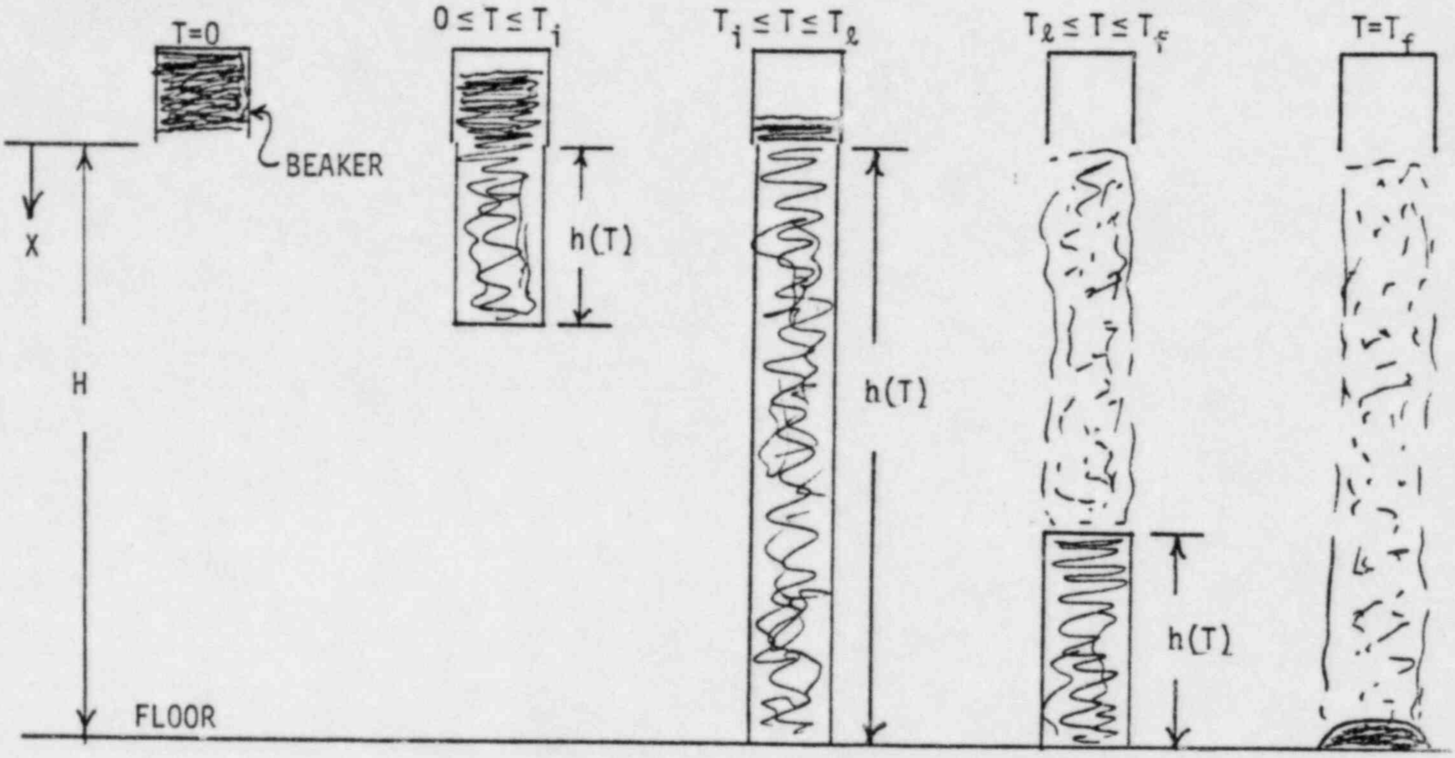
T_ℓ: TIME TO EMPTY BEAKER (SEC)

T_i: TIME WHEN POWDER FIRST IMPACTS FLOOR (SEC)

T_f: TIME TO COMPLETE SPILL (SEC) [ALL POWDER AT FLOOR LEVER]

X: DISTANCE FROM BEAKER (CM)

NOTE: $T_\ell \le T_i$



SCENARIO TWO: POWDER IMPACTS FLOOR BEFORE BEAKER EMPTIES

DEFINITION OF TERMS THE SAME AS SCENARIO ONE EXCEPT THAT $T_i \leq T_\ell$

ASSUMPTIONS

1) AIRBORNE RELEASE OF POWDER CORRELATES WITH THE VOLUME FRACTION OF THE FALLING SPILL COLUMN.
(REF: CHENG, L., "FORMATION OF AIRBORNE-RESPIRABLE DUST AT BELT CONVEYOR TRANSFER POINTS", AMERICAN INDUSTRIAL HYGIENE ASSOCIATION JOURNAL, DECEMBER 1973).

   A) VOLUME FRACTION, ϕ_C, IS DEFINED AS THE RATIO OF THE VOLUME OF UNDISPERSED MATERIAL TO THE VOLUME OCCUPIED BY THE DISPERSED MATERIAL

   B) REFERENCE CONSIDERED COAL FALLING FROM A CONVEYOR BELT, THEREFORE

$$\phi_C = \frac{\text{VOLUME OF COAL FALLING}}{\text{VOLUME OF FALLING COLUMN}} = \frac{\text{MASS OF COAL FALLING}}{\text{MASS OF SOLID COLUMN OF COAL}}$$

   C) REFERENCE DERIVED ϕ_C FOR A STEADY STATE SCENARIO

$$\phi_C = \frac{M}{AH\rho_C}$$

WHERE M = MASS OF COAL IN FALLING COLUMN

A = CROSS SECTIONAL AREA OF COLUMN

H = HEIGHT OF COLUMN

ρ_C = DENSITY OF COAL

2) WE HAVE A TRANSIENT SCENARIO, THEREFORE ϕ_C IS A FUNCTION OF TIME.

3) A CONSTANT CROSS SECTIONAL AREA FOR THE COLUMN OF FALLING POWDER AND ASSUME IT TO BE THE CROSS SECTIONAL AREA OF THE BEAKER THE POWDER IS SPILLED FROM.

4) DENSITY OF THE POWDER, ρ_P, IS THE BULK DENSITY, AND CONSTANT.

5) TAKE

$$\phi_C(T) = \frac{M(T)}{A\rho_P h(T)}$$

WHERE $M(T)$ = MASS OF POWDER IN FALLING SPILL COLUMN AT TIME T (GM)

$h(T)$ = HEIGHT OF FALLING COLUMN AT TIME T(CM)

A = CROSS SECTIONAL AREA OF BEAKER POWDER IS SPILLED FROM (CM^2)

ρ_P = BULK DENSITY OF POWDER ($\frac{GM}{CM^3}$)

6) VOLUME FRACTION FOR A TRANSIENT SCENARIO CAN BE WRITTEN IN TERMS OF A TIME INTEGRATED AVERAGE

$$\phi_C = \overline{\phi_C(T)} = \frac{1}{A\rho_P} \frac{1}{T_f} \int_0^{T_f} \left(\frac{M}{h}\right) d\tau$$

7) NEGLECT FRICTIONAL FORCES, i.e., ONLY THE GRAVITATIONAL FORCE ACCELERATES THE POWDER. THIS ASSUMPTION THUS DETERMINES THE VELOCITY AT ANY DISTANCE X FROM THE BEAKER.

$$V(X) = \sqrt{2GX}$$

WHERE G IS THE ACCELERATION OF GRAVITY.

8) THE RATE OF POWDER FLOWING FROM THE BEAKER ATTAINS A CONSTANT VALUE, $\dot{Q}_C$, IN TIME T_O. (VIEWGRAPH OF $\dot{Q}$)

A) PHYSICALLY, THIS IS APPROPRIATE SINCE IT TAKES TIME FOR THE POWDER TO GET STARTED FLOWING.

B) MATHEMATICALLY, IF THE POWDER HAS A FLOW RATE OF $\dot{Q}_C$ AT $T = 0$, THEN $\frac{M}{h} \to \infty$, AND THE INTEGRAL IN ϕ_C WOULD NOT BE FINITE.

M(T) AND h(T) FOR VARIOUS TIME INTERVALS (SCENARIO ONE)

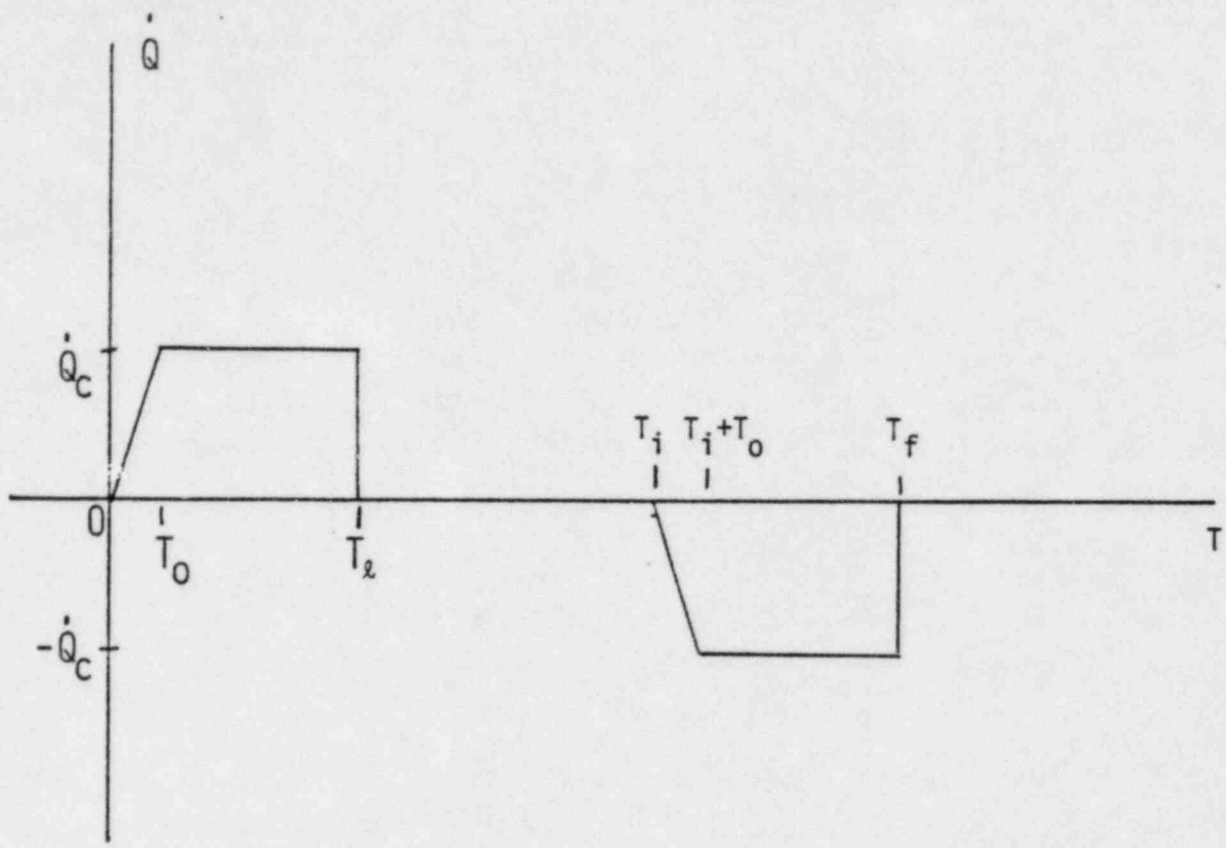
$0 < T < T_O$

$$M(T) = \int_0^T \dot{Q}_C \frac{\tau}{T_O} \, d\tau$$

$$h(T) = \frac{1}{2} G T^2$$

IF THE ASSUMPTION IS MADE THAT $\phi_C \approx 1$ FOR $T < T_O$, THEN T_O CAN BE EXPLICITLY DETERMINED.

$$T_O = \frac{\dot{Q}_C}{G A \rho_P}$$



RATE, $\dot{Q}$, AT WHICH POWDER ENTERS AND LEAVES SPILL COLUMN AS A FUNCTION OF TIME FOR SCENARIO ONE

$\dot{Q}_C$: CONSTANT RATE OF POWDER EXITING BEAKER $\left(\frac{GM}{SEC}\right)$

T_O: TIME TO REACH STEADY RATE $\dot{Q}_C$ (SEC)

OTHER TIMES DEFINED IN SCENARIO ONE

NOTE: FOR SCENARIO TWO THE POSITIVE AND NEGATIVE CURVES WILL OVERLAP IN TIME

$T_0 < T < T_\ell$

$$M(T) = \frac{1}{2}\dot{Q}_C T_0 + \int_{T_0}^{T} \dot{Q}_C \, d\tau$$

$$h(T) = \frac{1}{2} G T^2$$

$T_\ell < T < T_i$

$$M(T) = \frac{1}{2}\dot{Q}_C T_0 + \dot{Q}_C (T_\ell - T_0)$$

$$h(T) = \frac{1}{2} G T^2 - \frac{1}{2} G (T - T_\ell)^2$$

$T_i < T < T_i + T_0$

$$M(T) = \dot{Q}_C (T_\ell - \frac{T_0}{2}) - \int_{T_i}^{T} \frac{\dot{Q}_C}{T_0} (\tau - T_i) \, d\tau$$

$$h(T) = H - \frac{1}{2} G (T - T_\ell)^2$$

$T_i + T_0 < T_i < T_f$

$$M(T) = \dot{Q}_C (T_\ell - T_0) - \dot{Q}_C \left[T - (T_i + T_0)\right]$$

$$h(T) = H - \frac{1}{2} G (T - T_\ell)^2$$

DUE TO THE FORM OF THE CURVE FOR $\dot{Q}$ ASSUMED AND THAT ONLY GRAVITY ACCELERATES THE POWDER, THEN

T_i, T_ℓ, AND T_f CAN BE EXPLICITLY DETERMINED.

$$T_i = \sqrt{\frac{2H}{G}}$$

$$T_\ell = \frac{Q}{\dot{Q}_C} + \frac{T_O}{2}$$

$$T_f = T_\ell + T_i$$

WHERE Q = THE TOTAL MASS OF THE POWDER IN THE BEAKER (GM)

THE INTEGRAL IN ϕ_C CAN BE EVALUATED USING THE FUNCTIONS $M(T)$ AND $h(T)$ FOR THE VARIOUS TIME INTERVALS. THE TIME INTEGRATED AVERAGE VOLUME FRACTION BECOMES:

$$\phi_C = \frac{2\dot{Q}_C}{GA\rho_P(T_\ell + T_i)} \left\{ \ln\left(\frac{T_\ell}{T_O}\right) + \frac{1}{2}\left(\frac{T_O}{T_\ell}\right) \right.$$

$$+ \frac{1}{2}\left(1 - \frac{1}{2}\frac{T_O}{T_\ell}\right) \ln\left(\frac{2T_i - T_\ell}{T_\ell}\right) + \frac{1}{2}$$

$$+ \frac{1}{2T_i}\left(T_\ell - \frac{T_O}{2} - \frac{T_\ell^2}{2T_O}\right) \ln\left[\frac{T_\ell(2T_i + T_O - T_\ell)}{(T_\ell - T_O)(2T_i - T_\ell)}\right]$$

$$\left. + \left(\frac{T_\ell - T_i}{T_O}\right) \ln\left(\frac{2T_i + T_O - T_\ell}{2T_i - T_\ell}\right) + \ln\left(\frac{2T_i}{2T_i + T_O - T_\ell}\right) \right\}$$

ONLY CASE ONE SCENARIO EVALUATED, SINCE FOR RANGE OF PARAMETER VALUES USED, THIS SCENARIO WAS APPROPRIATE FOR ALL BUT ONE COMBINATION.

RANGE OF VARIABLES

ρ_P = 0.63 GM/CM^3 (TiO_2)

1.5 GM/CM^3 (DUO)

H = 300 CM
200 CM
100 CM

Q = 1000 GM
500 GM
100 GM

$\dot{Q}_C$ = 2000 GM/SEC
3000 GM/SEC
4000 GM/SEC

THE RANGE FOR $\dot{Q}_C$ WAS OBTAINED BY ESTIMATING THE DIFFERENCE IN TIME FROM FIRST IMPACT OF POWDER ON THE FLOOR TO THE FINAL IMPACT OF POWDER IN THOSE EXPERIMENTS WHICH WERE FILMED. THE TIME DIFFERENCES WERE ON THE ORDER OF 1/4 TO 1/2 SECONDS.

ADDITIONAL EXPERIMENTS ARE BEING CONDUCTED WHICH WILL FILM THE BEAKER EMPTYING TO GET A BETTER ESTIMATE OF THIS PARAMETER.

COMPARISON OF TiO_2 AND DUO

1) T_O, TIME TO ATTAIN $\dot{Q}_C$, IS LESS FOR DUO THAN FOR TiO_2, SINCE $T_O \sim \frac{1}{\rho_P}$.

   ADDITIONAL EXPERIMENTS WILL PROVIDE DATA TO DETERMINE IF FLOW RATES DIFFER FOR TiO_2 AND DUO.

2) RANGE OF VOLUME FRACTION FOR RANGE OF PARAMETERS.

   TiO_2: $.19 < \phi_C < .47$

   DUO : $.11 < \phi_C < .28$

   LOWER VALUE IS FOR $H = 300$ CM AND $\dot{Q}_C = 2000$ GM/SEC
   UPPER VALUE IS FOR $H = 100$ CM AND $\dot{Q}_C = 4000$ GM/SEC

3) SMALLER VALUES OF ϕ_C ARE CALCULATED FOR SMALLER $\dot{Q}_C$.

   NOTE: PERCENT AIRBORNE $\sim \frac{1}{\phi_C}$.

   THIS IS PHYSICALLY REALISTIC.

4) FOR EACH POWDER (i.e., FOR CONSTANT ρ_P) ϕ_C IS MOST SENSITIVE TO $\dot{Q}_C$, THEN TO H, AND FINALLY TO Q.

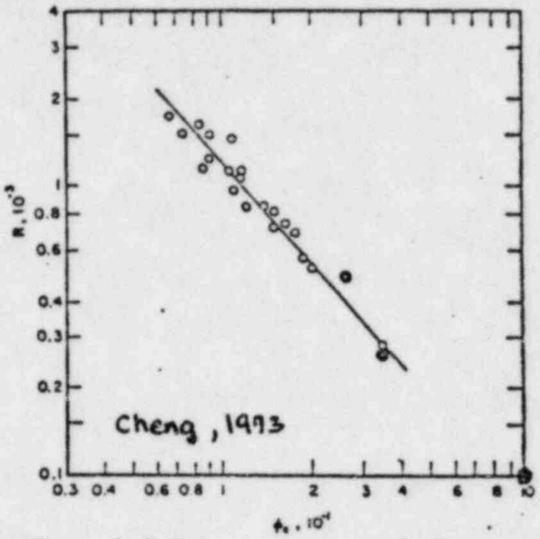
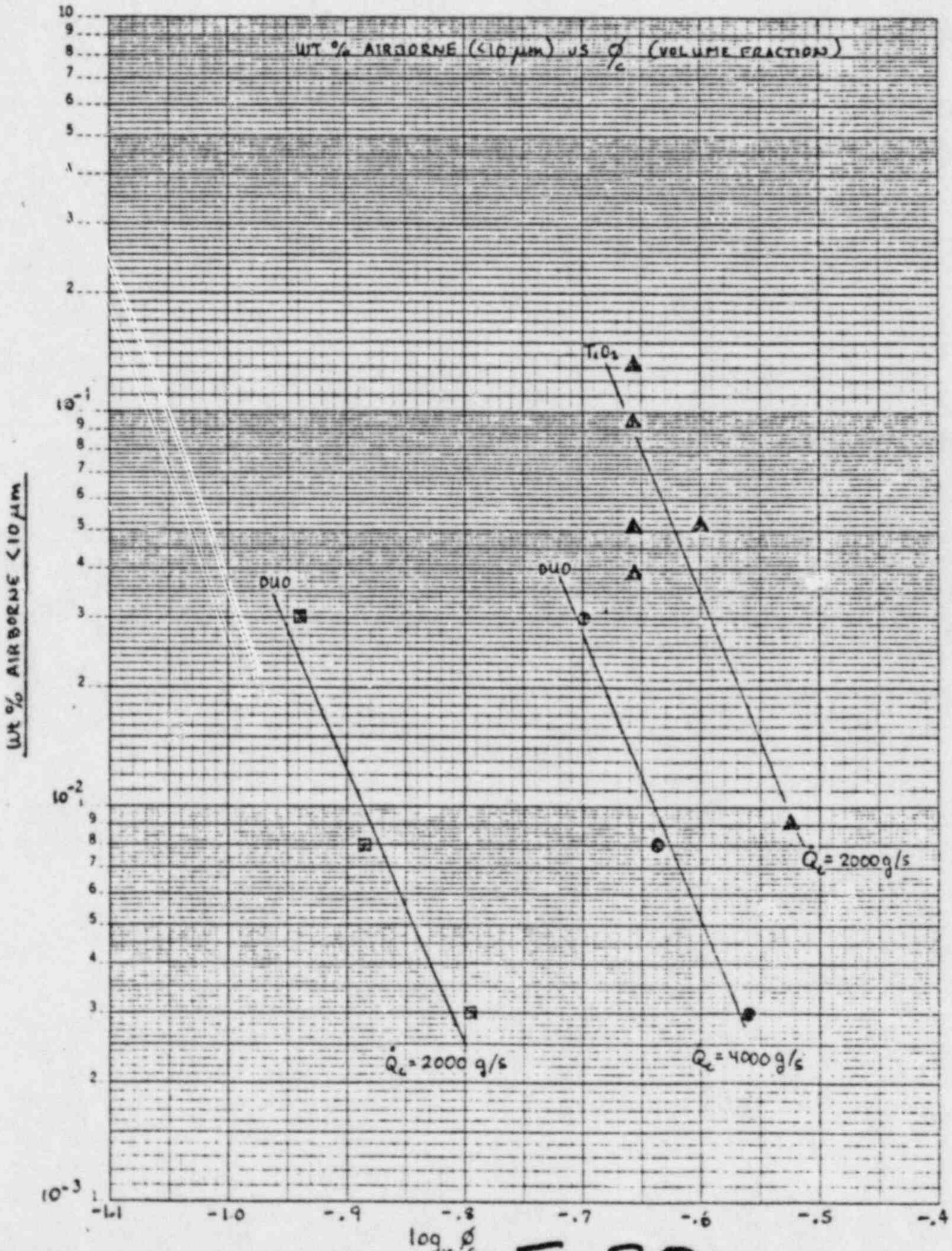


Figure 3. Relation between specific formation of airborne respirable dust and volume fractions of a dropping coal.



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ADDITIONAL ANALYSES NEEDED

1) EVALUATE SCENARIO TWO.

2) EXTRAPOLATE SCENARIO TWO TO STEADY STATE SPILL ANALYZED IN PAPER BY CHENG.

3) REFINE ASSUMPTION OF LINEAR INCREASE TO $\dot{Q}_C$; POSSIBLY AN EXPONENTIAL RISE IS MORE REALISTIC.

4) INVESTIGATE USE OF ONLY PART OF THE TIME HISTORY OF $\frac{M}{h}$ FOR EVALUATING TIME AVERAGE OF ϕ_C:

   A) INITIALLY $\phi_C = 1$

   B) ϕ_C DECREASES AND IN SOME CASES PASSES THROUGH A MINIMUM VALUE AT $T = T_i$

   C) FOR A 300 CM HEIGHT OF SPILL THE FIRST 100 CM TAKES .45 SEC; THE LAST 200 CM TAKES .33 SEC. THEREFORE THE INTEGRAL IN ϕ_C HAS MORE CONTRIBUTIONS FROM THE EARLIER TIME HISTORY OF $\frac{M}{h}$.

5) INCLUDE FRICTIONAL FORCES IN SOME AVERAGE SENSE.

LOS ALAMOS PRESENTATION

- FY 83 WORK PRIORITIES
- "REVISED" USER GUIDANCE
- PREVIEW OF LLNL COMPARTMENT FIRE TESTS

Purpose of User Guidance

- Provide a "User oriented" way to prescribe fires
- Prevents user from prescribing unrealistic fire scenarios
- Provides input to FIRAC for:
  - mass release ($\dot{m}$)
  - Heat release ($\dot{Q}$)
  - Particulate release ($\dot{m}_p$)
  - Step Times (τ)
  - Local Heat Fluxes

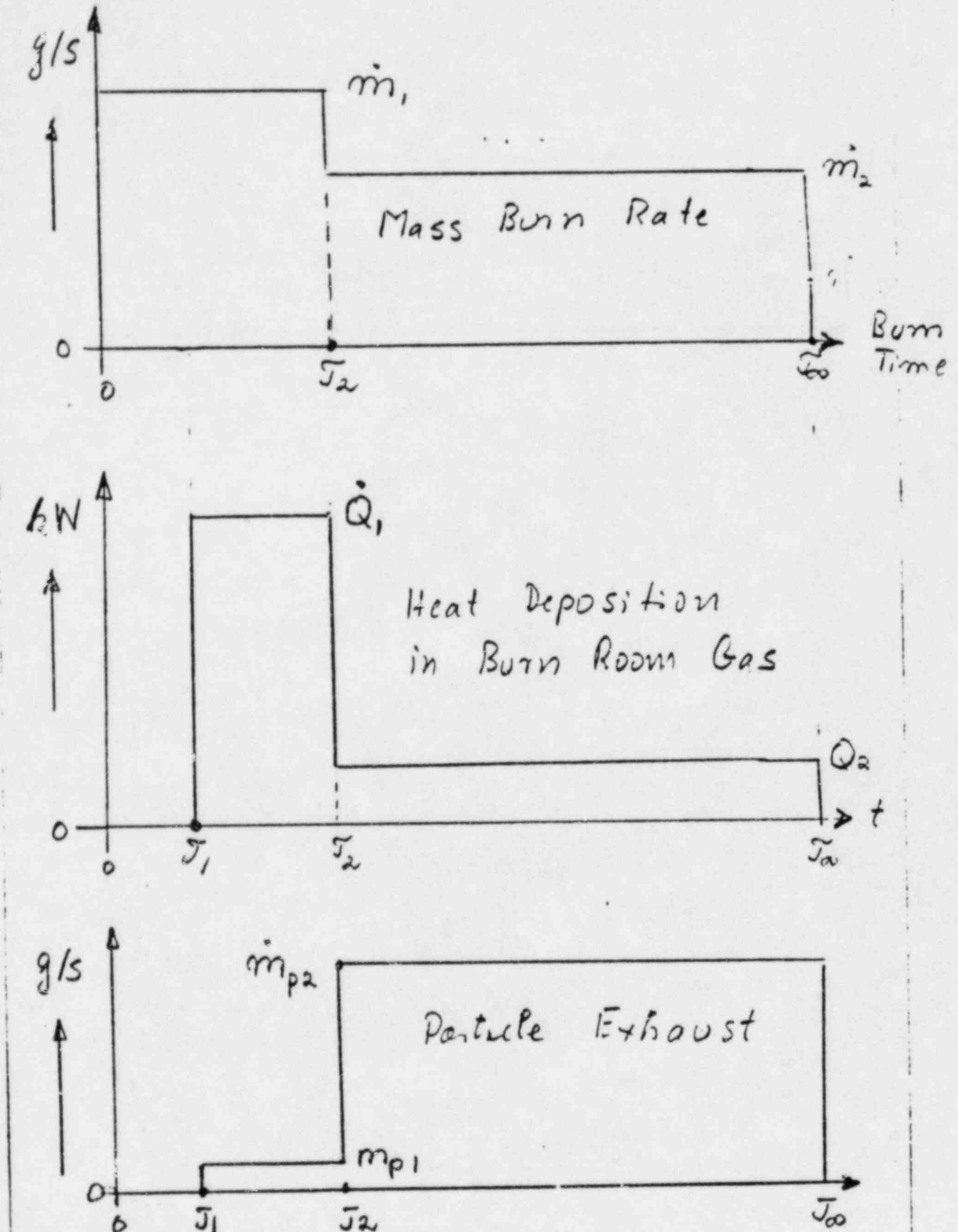


Fig 1. Level One... Fire Source Terms

How has user Guidance been revised?

- ~5 pgs. to 76 pgs.
- sample problems
- comparison to experiments
- computerized input.

CONTENTS

Special Features

- Allows user to specify & mix nine different types of fires
- Provides default values
- Maximizes flexibility of analysis by using FIRAC, rather than compartment fire models to calculate burn room transients
- Uses heat & mass release rate limiting factors
- Fire source terms restricted to constant exhaust flow rate but could be modified to provide system interaction

Special Features

- Documentation includes 7 sample problems that illustrate the calculations
- Preliminary comparison with experimentation is provided when possible

Input Description

- Architecture:
  - burn room floor area
  - burn room height
  - volumetric exhaust rate
- Fire Scenarios
  - available burn area
  - top or bottom elevation of burn area (horizontal/vertical)
  - weight of combustibles
  - fire type

Input Description

Fire Type:

Fuel Package	Type No.
A. Spray Fires	
. clean burning	1
. moderately smoky	2
. very smoky	3
B. Pool Fires	
. clean burning	4
. moderately smoky	5
. very smoky	6
C. Solid Surface Fires	
. noncharring plastic	7
. charring plastic	8
. cellulosic	9

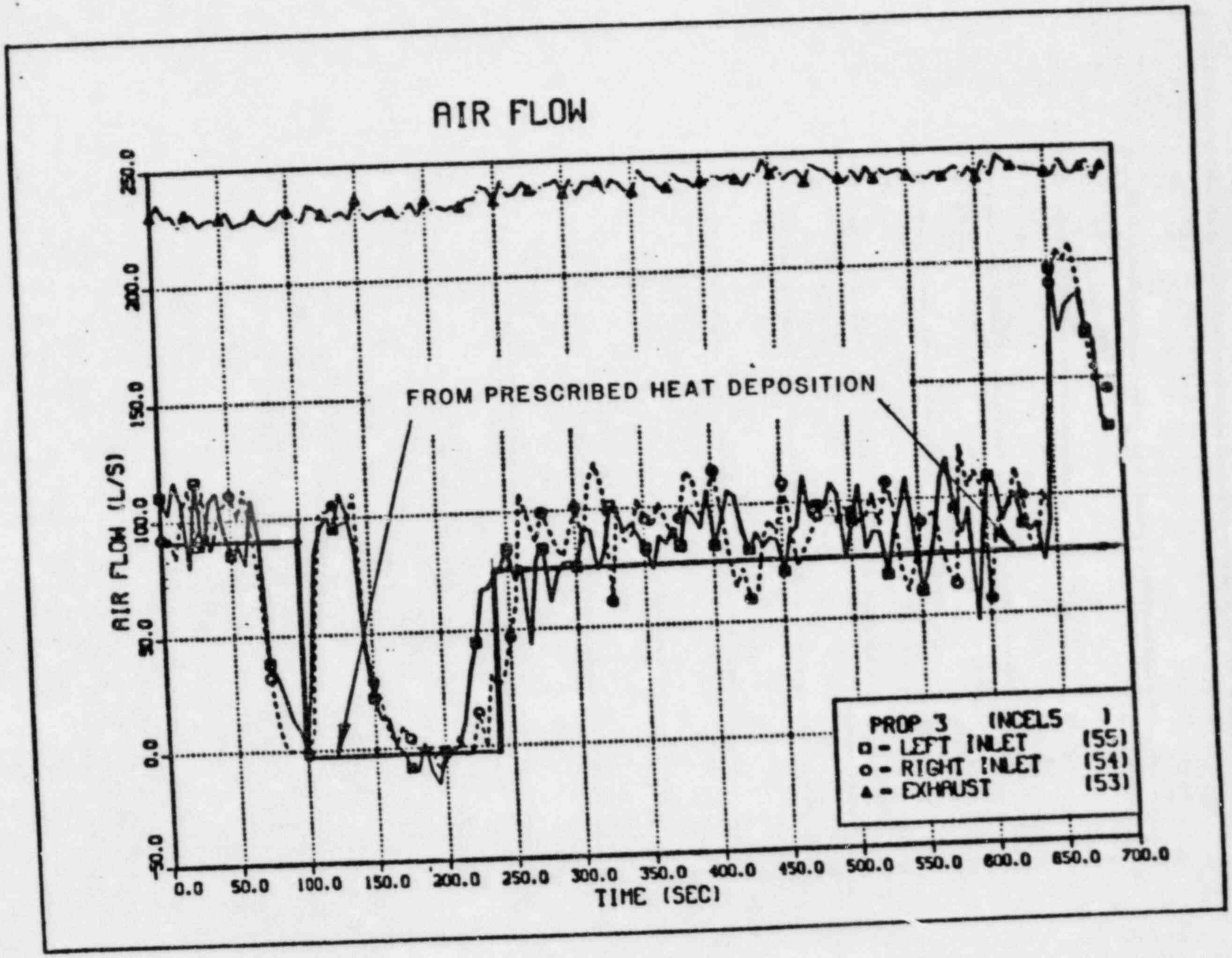
Limiting Factors

Parameter	Limiting Factor
• initial mass burning rate	Air Entrainment by fire plume
• Final air intake	Entropy maximation
• Final air intake	wall heat loss
• initial fire product density	Adiabatic fire plume
• initial fire product density	heat convection efficiency
• final fire product density	constant nitrogen concentration

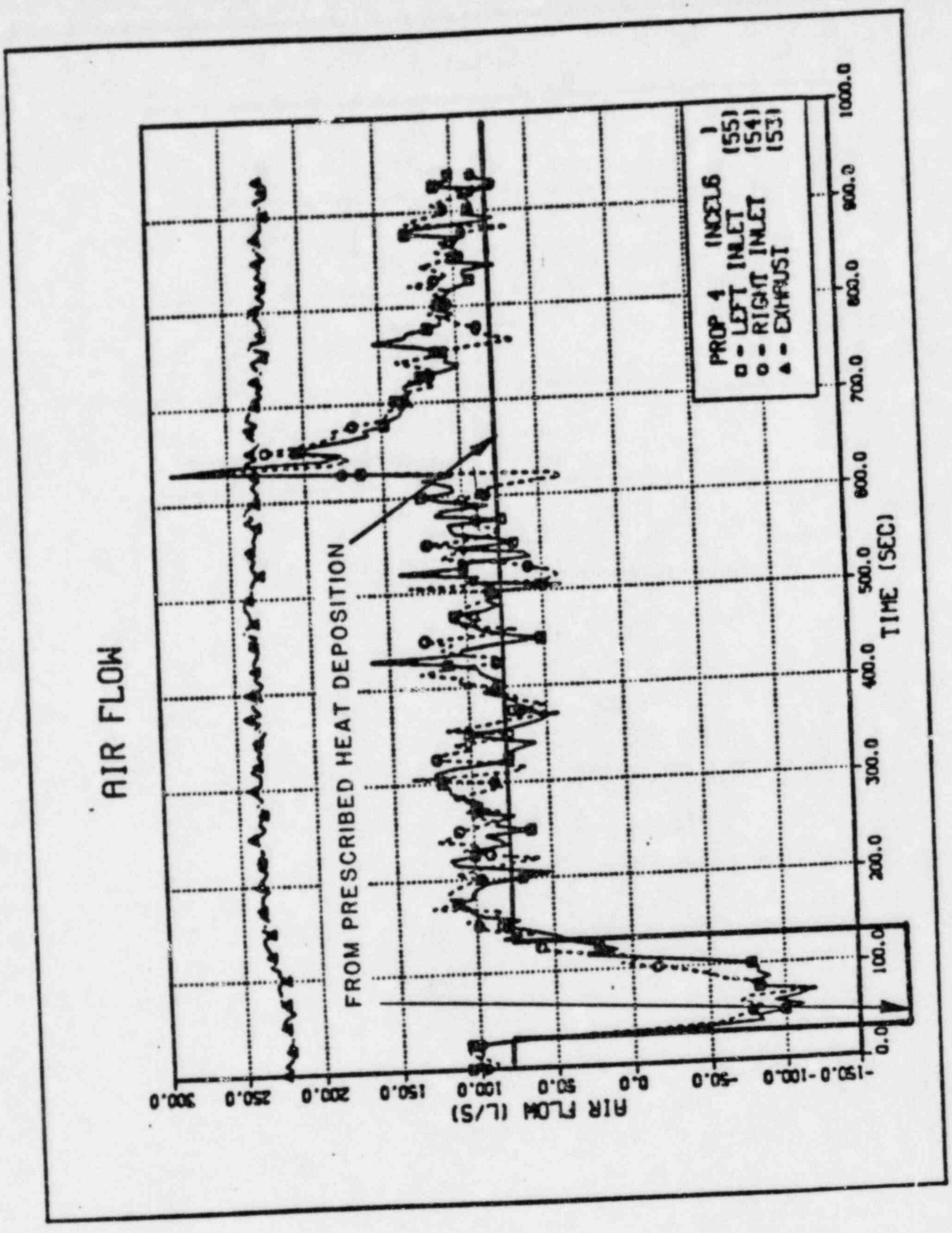
How can we check source term prescriptions?

Experimentation:

- Temperature in burn room
- "back calculate" volumetric intake flux



AIR FLOW
FROM PRESCRIBED HEAT DEPOSITION
AIR FLOW (L/S)
TIME (SEC)
PROP 3 (NCELS 1)
□ - LEFT INLET (55)
○ - RIGHT INLET (54)
▲ - EXHAUST (53)



AIR FLOW
FROM PRESCRIBED HEAT DEPOSITION
PROP 4 (NCELL6 1
□ - LEFT INLET (55)
○ - RIGHT INLET (54)
▲ - EXHAUST (53)
AIR FLOW (L/S)
TIME (SEC)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1000.0

FIRE CODE OPTIONS FOR

FUEL CYCLE FACILITY ACCIDENT ANALYSIS HANDBOOK

OPTION 1: FIRIN1 + FIRAC

OPTION 2: LOS ALAMOS GUIDELINES + FIRAC

OPTION 3: MODIFIED HARVARD FIRE CODE + FIRAC

OPTION 4: PNL NEAR FIELD MODEL + LOS ALAMOS COMPARTMENT MODEL + FIRAC

CRITERIA FOR

ASSESSMENT OF FIRE COMPARTMENT MODELS

1. COMPARISON TO LLNL TEST RESULTS

   parameter priority

2. TIME/ COST TO INTEGRATE WITH FIRAC

   COMPATIBILITY WITH FIRAC

3 INPUT REQUIREMENTS

4 ACCEPTANCE BY FIRE RESEARCH COMMUNITY