2/20/85
MW

HEAT LOSS ANALYSIS FOR

MARK III CONTAINMENT GEOMETRIES

BY

ERDEM URAL

ROBERT ZALOSH

FRANCO TAMANINI

FACTORY MUTUAL RESEARCH CORP.

HCOG/NRC MEETING, FEBRUARY 20, 1985

BETHESDA, MARYLAND

CONTENTS

BACKGROUND

- CONVECTIVE AND RADIATIVE HEAT TRANSFERS DO NOT FOLLOW FROUDE MODELING REQUIREMENTS EXACTLY (I.E. SQUARE ROOT VARIATION OF FLUXES WITH SCALE).

- IN REDUCED-SCALE EXPERIMENTS, HEAT TRANSFER BY...
  ...CONVECTION IS GENERALLY HIGHER THAN NEEDED.
  ...RADIATION IS HIGHER/LOWER FOR OPTICALLY THICK/THIN MEDIA.

- THIS FACTOR ALONE WOULD LEAD TO GAS TEMPERATURES IN A REDUCED-SCALE MODEL WHICH ARE LOWER THAN CORRESPONDING TEMPERATURES AT FULL SCALE, <u>IF ALL HEAT SINKS ARE ACCURATELY MODELED IN THE EXPERIMENT.</u>

- EXPECTATION THAT ABSENCE OF HEAT SINK DUE TO EQUIPMENT IN 1/4 - SCALE FACILITY WOULD OFFSET HIGHER HEAT TRANSFER.

- NEED TO QUANTIFY EXTENT OF COMPENSATING EFFECTS.

OBJECTIVE

- DETERMINE, BY ANALYSIS, THE RELATIONSHIP BETWEEN GAS TEMPERATURES PRODUCED IN THE 1/4 SCALE FACILITY AND THOSE EXPECTED IN MARK III UNITS.

- ANALYSIS NOT INTENDED TO PROVIDE ACCURATE ESTIMATE OF ABSOLUTE TEMPERATURE LEVELS.

ANALYTICAL APPROACH

- ZONE MODELING OF DOMINANT COMPONENTS OF CONTAINMENT FLOW.

- GLOBAL CONSERVATION OF MASS/ENERGY FOR SELECTED SUBSYSTEMS: FLAMES, INNER WALL, OUTER WALL, EQUIPMENT, BACKGROUND GAS, ETC.

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- CALCULATED RESULTS PRESENTED IN TERMS OF CONTAINMENT - AVERAGED TEMPERATURES AND DISTRIBUTION OF TOTAL RELEASED ENERGY AMONG VARIOUS SUBSYSTEMS.

- ASSESSMENT OF EFFECT OF DIFFERENT EQUIPMENT DISTRIBUTION/CHARACTERISTICS.

CASES CONSIDERED

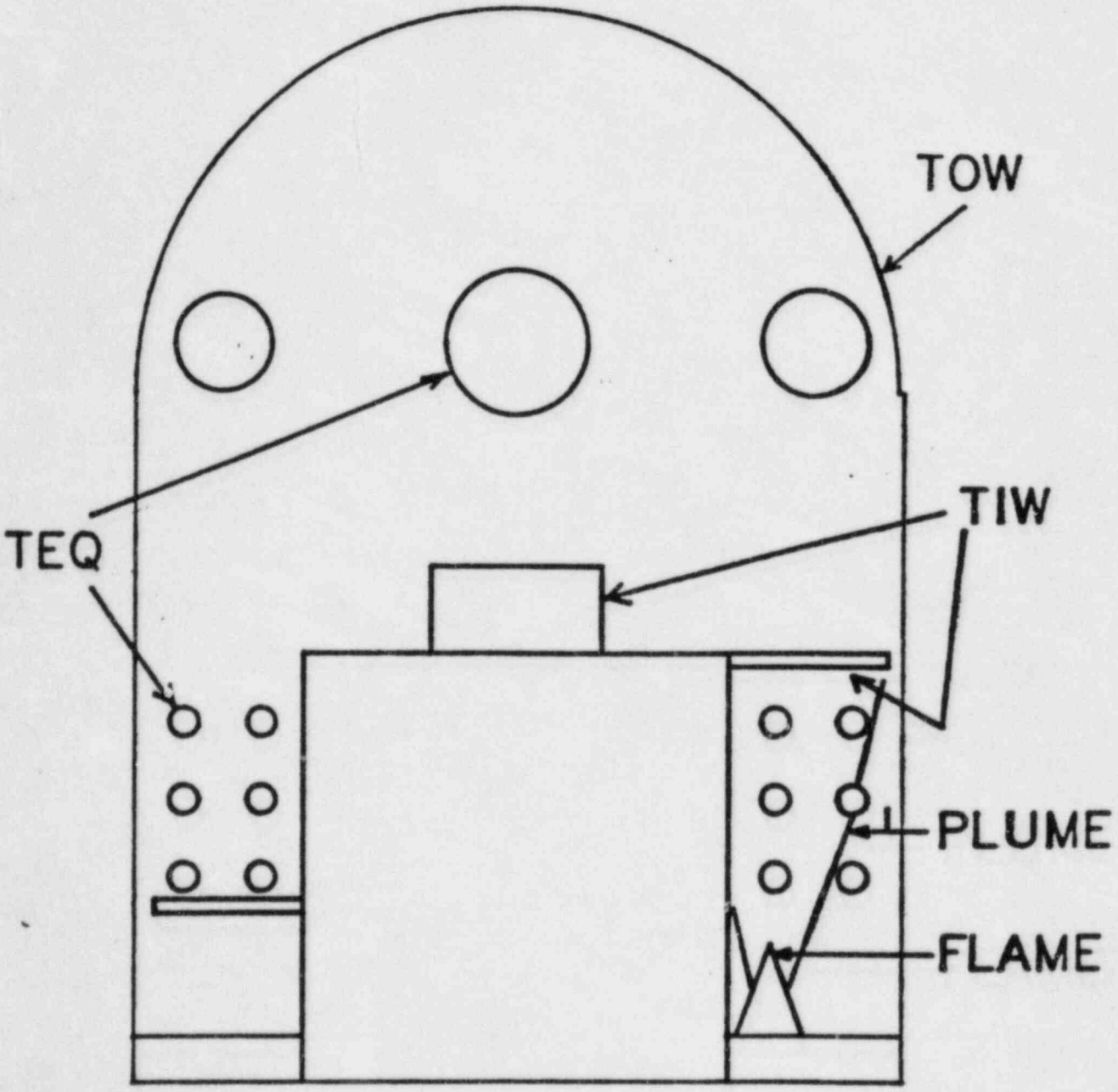
- 1/4 - SCALE FACILITY:
  BASELINE CASE, ESTIMATE OF OVERALL ENERGY BUDGET.

- 1/4 - SCALE FACILITY "SCALED" TO FULL SIZE:
  TO DETERMINE EFFECTS ASSOCIATED WITH IMPERFECT MODELING OF HEAT FLUXES.

- MARK III UNIT WITH CONCRETE CONTAINMENT:
  TO EXAMINE THE EFFECT OF ACTUAL EQUIPMENT LOADINGS.

- STEEL SHELL:
  TO EVALUATE THE HEAT LOSS FROM FREE - STANDING CONTAINMENTS VERSUS THAT FROM A CONCRETE SHELL.

MODEL DESCRIPTION



GAS TEMPERATURE/VELOCITY COMPUTATION

* FLAME/PLUME TEMPERATURES/ VELOCITY

  - BASED ON PREVIOUS MEASUREMENTS OF AXIAL AND RADIAL TEMPERATURE/VELOCITY DISTRIBUTIONS IN HYDROCARBON FIRE PLUMES.

* BACKGROUND GAS

  - TEMPERATURE CALCULATED BY MASS AND ENERGY BALANCES FOR PRESCRIBED ADDITION AND CALCULATED LOSSES.

  - VELOCITIES ASSUMED TO BE LOW (QUIESCENT GAS).

HEAT LOSSES

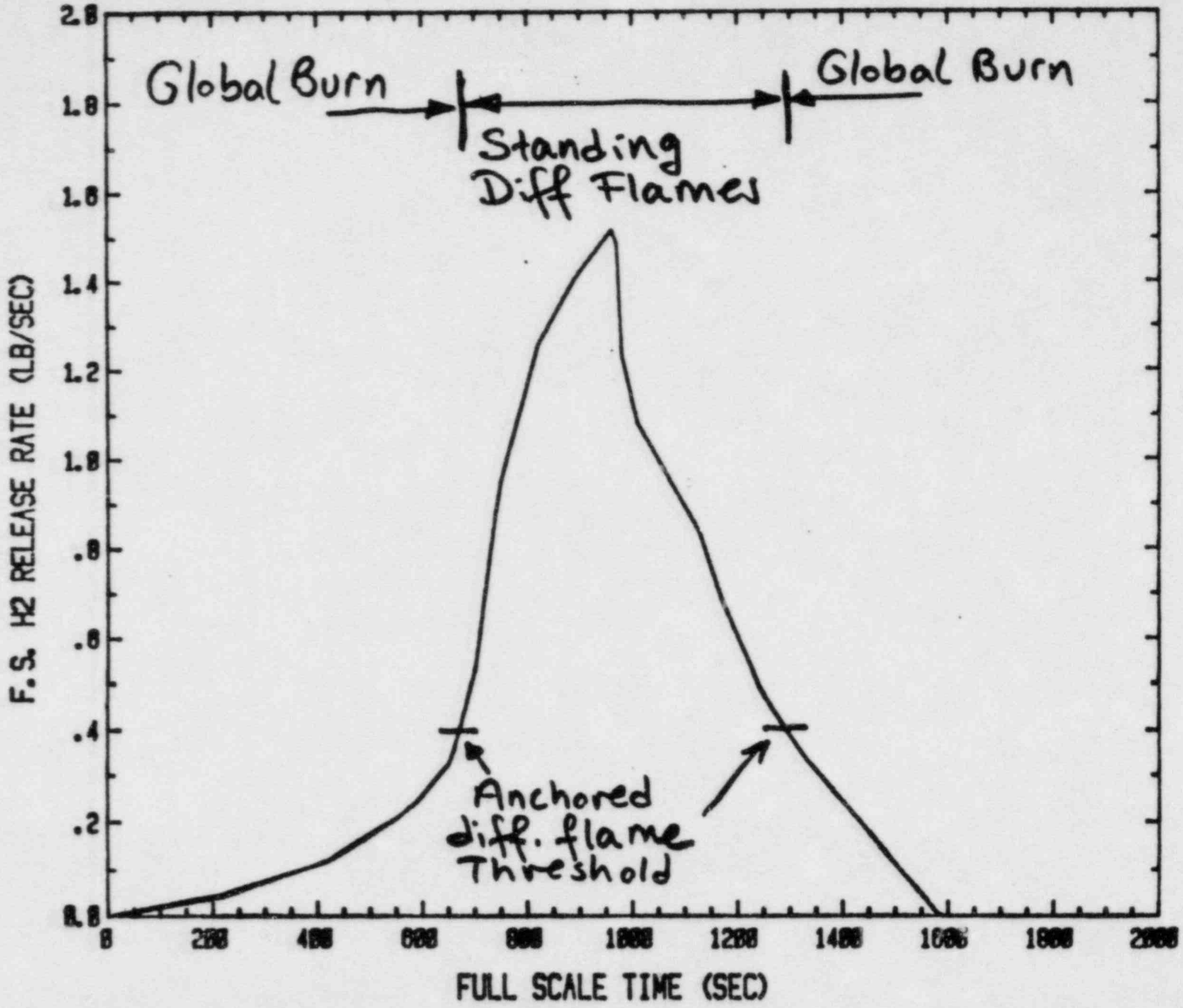
	FROM FLAMES	FROM BACKGROUND
TO OUTER WALL	RADIATION	RADIATION CONVECTION CONDENSATION
TO INNER WALL	RADIATION CONVECTION	RADIATION CONVECTION
TO EQUIPMENT	CONVECTION (IN AREAS INTERCEPTED BY PLUMES ONLY)	RADIATION CONVECTION

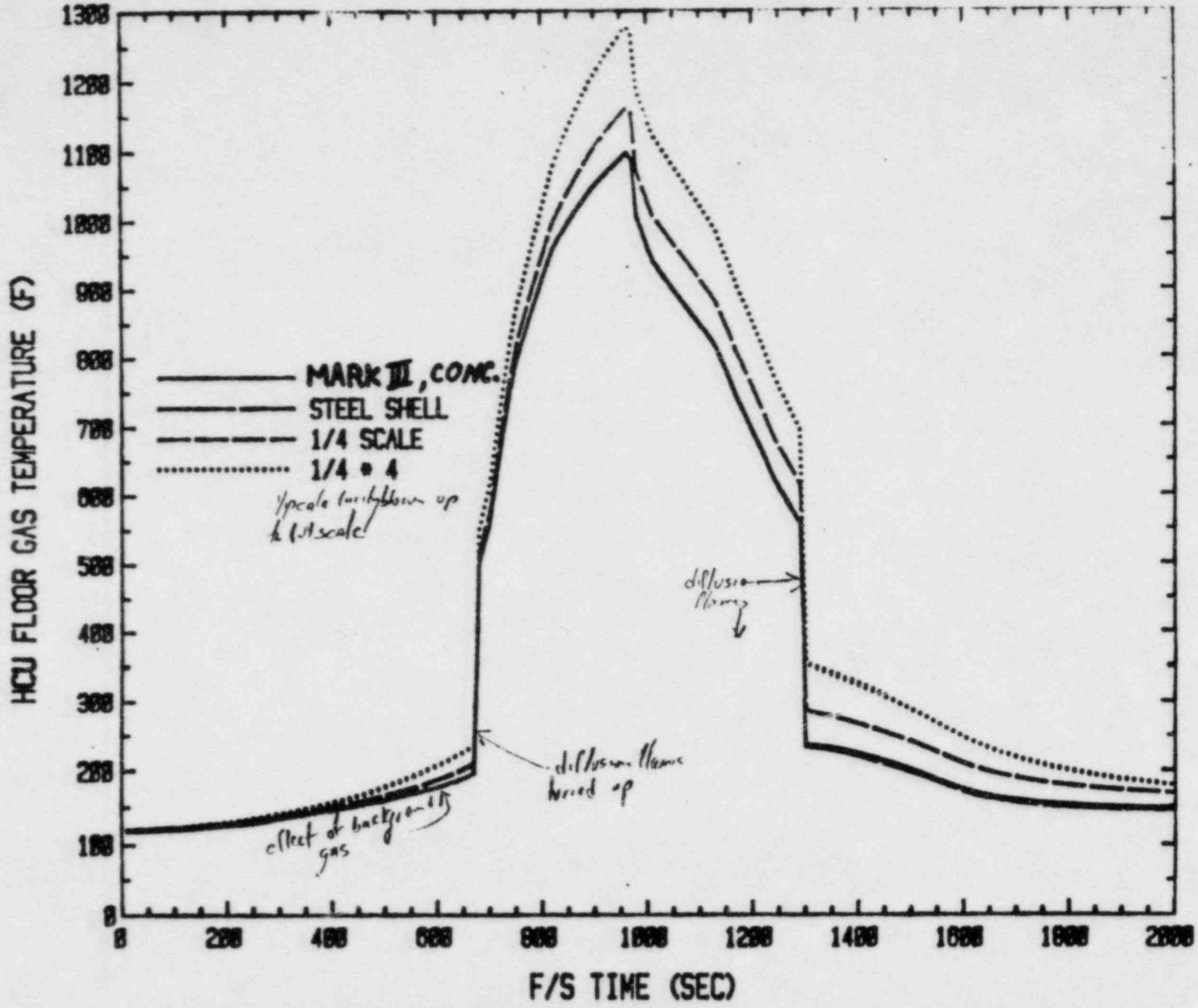
HEAT SINK MODELING

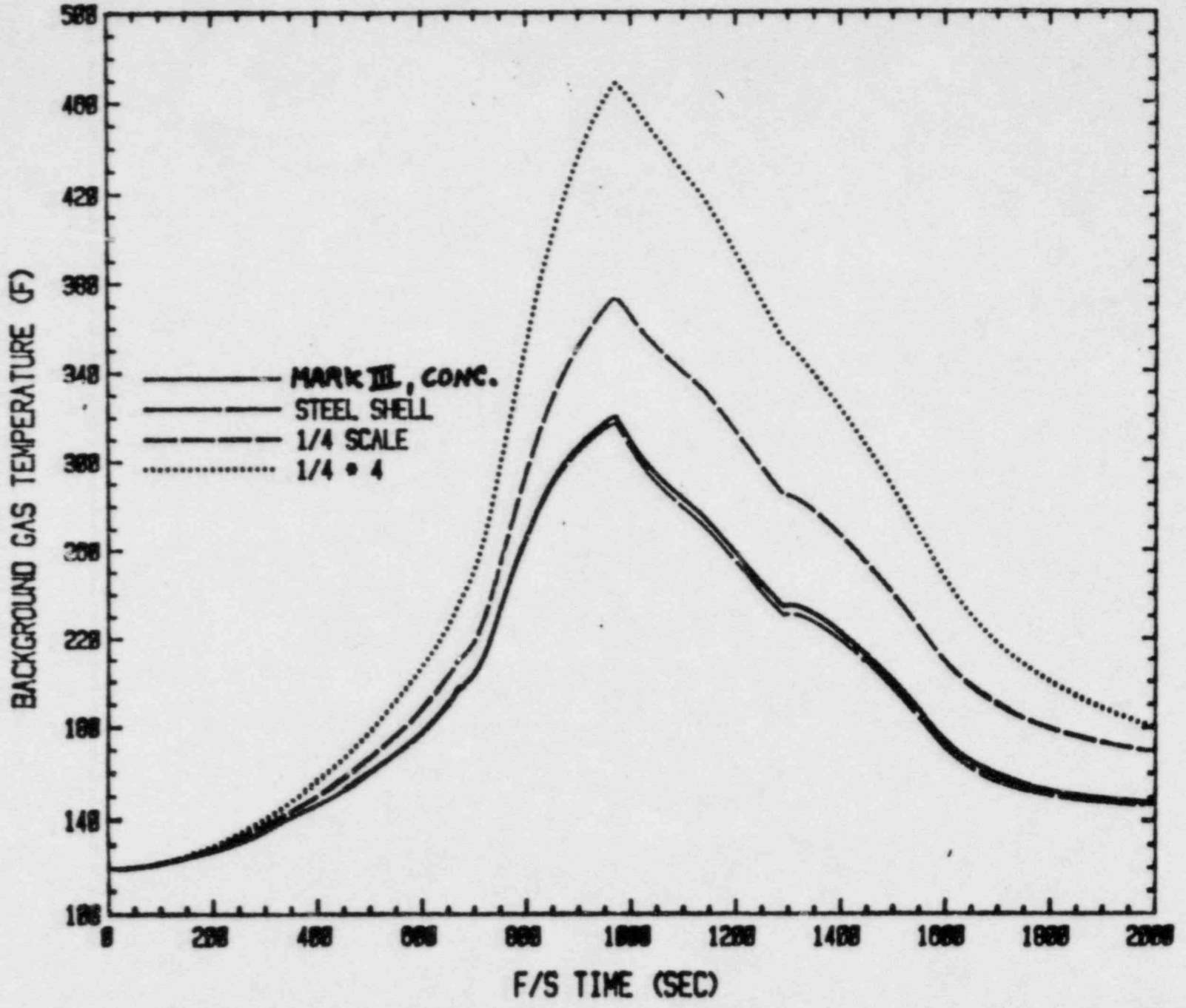
- INNER WALL/FLOORS
  - SEMI - INFINITE SOLID

- OUTER WALL
  - 1/4 SCALE
    - SEMI-INFINITE SOLID
  - MARK III UNIT
    - SEMI-INFINITE COMPOSITE (LINER ON CONCRETE)
  - STEEL SHELL PLANT
    - THERMALLY THIN SHELL

- EQUIPMENT/GRATING ETC.
  - DISTRIBUTED UNIFORMLY IN ANNULUS ABOVE HCU FLOOR AND IN UPPER DOME
  - THERMALLY THIN


Global Burn
Standing Diff Flames
Global Burn
Anchored diff. flame Threshold
F.S. H2 RELEASE RATE (LB/SEC)
FULL SCALE TIME (SEC)
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0.0
0
200
400
600
800
1000
1200
1400
1600
1800
2000

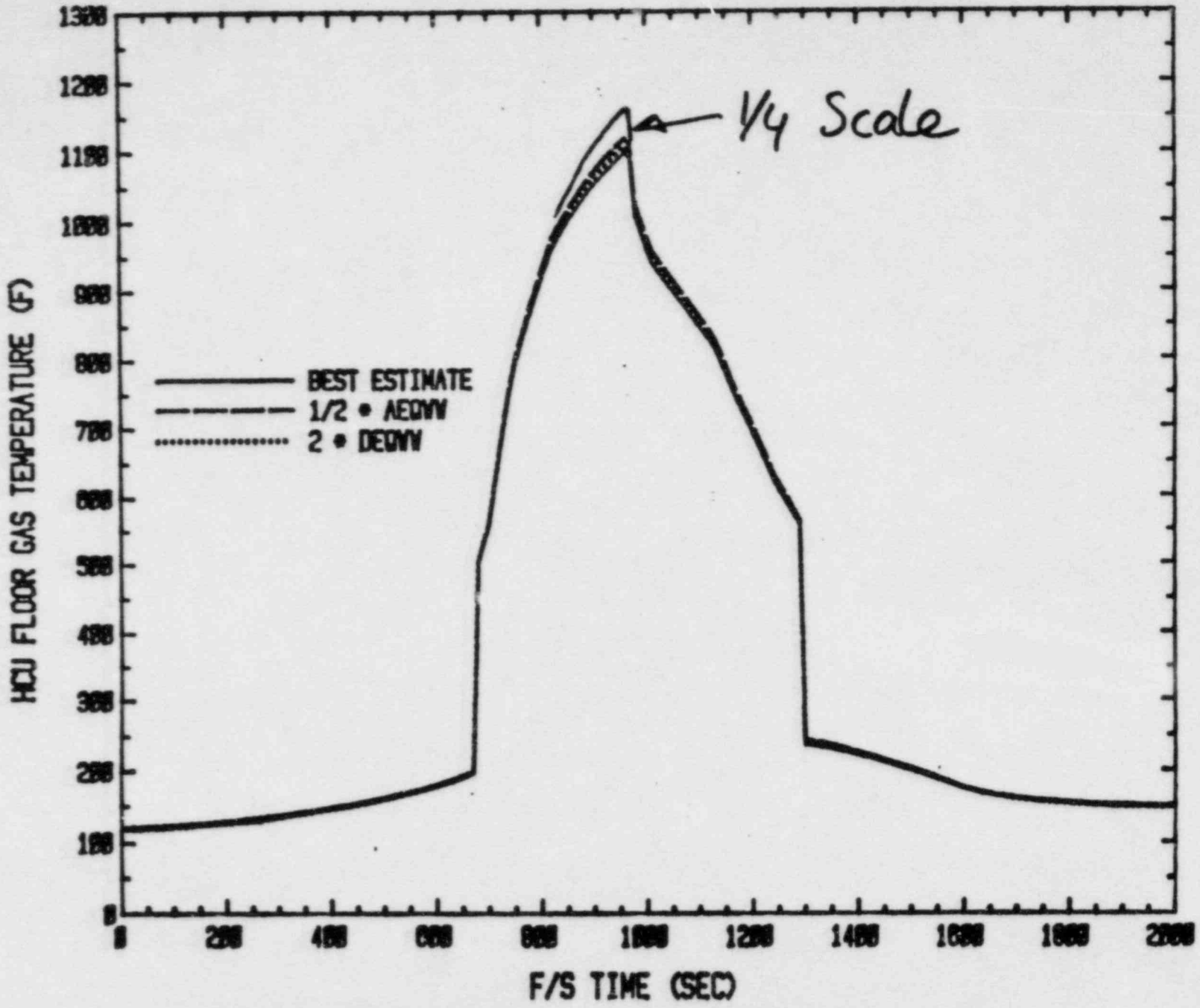

HCU FLOOR GAS TEMPERATURE (F)
F/S TIME (SEC)
MARK III, CONC.
STEEL SHELL
1/4 SCALE
1/4 • 4
1/4 scale burnthrough up to full scale
diffusion flame
diffusion flame burned up
effect of background gas
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
0
200
400
600
800
1000
1200
1400
1600
1800
2000


BACKGROUND GAS TEMPERATURE (F)
F/S TIME (SEC)
MARK III, CONC.
STEEL SHELL
1/4 SCALE
1/4 • 4

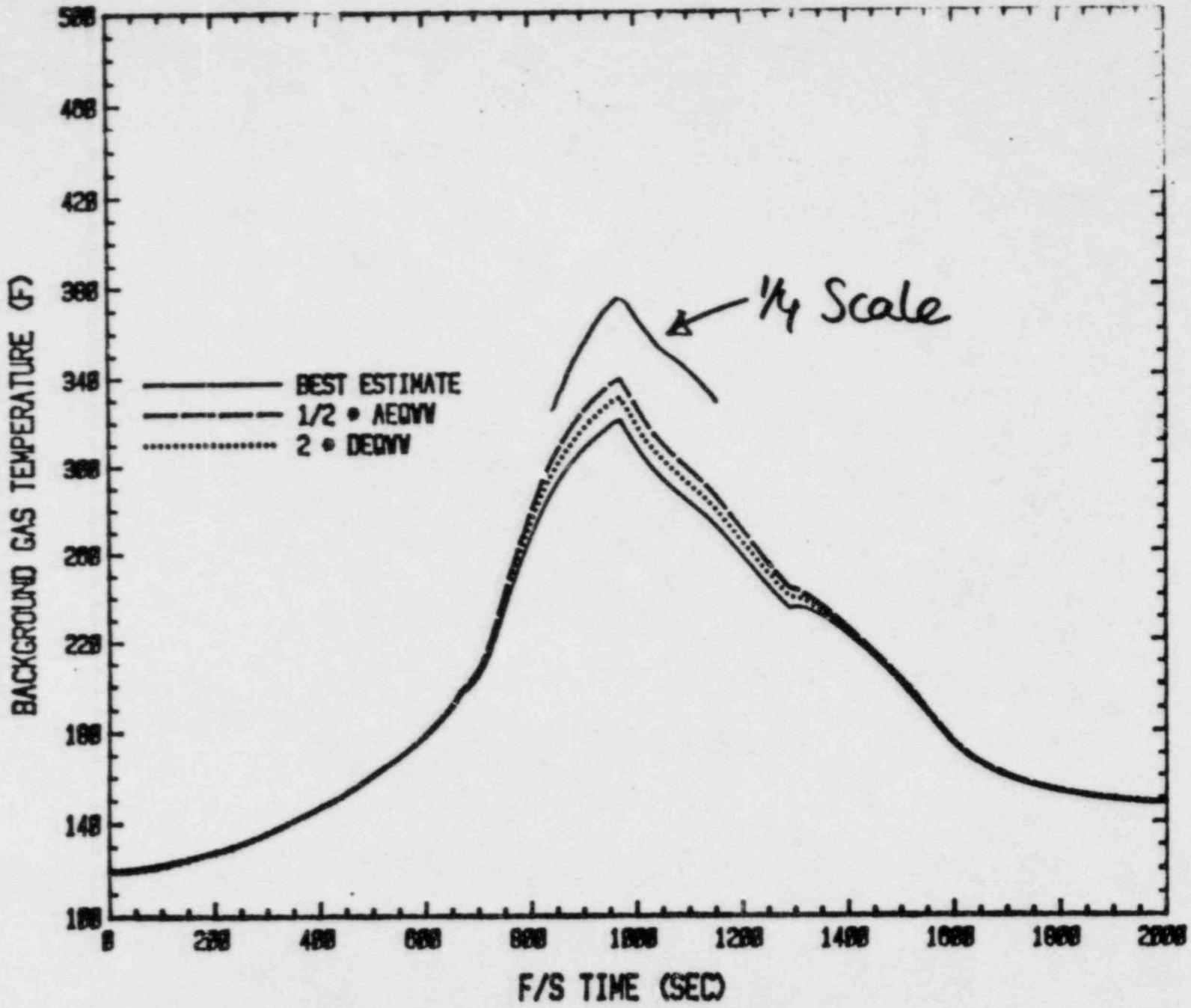
SENSITIVITY STUDY:

CASE 1 REDUCE THE EQUIPMENT IN THE ANNULUS BY 50% AND ADD THIS DIFFERENCE TO THE DOME EQUIPMENT.

CASE 2 INCREASE THE CHARACTERISTIC DIMENSION OF THE EQUIPMENT IN THE ANNULUS BY A FACTOR OF 2.



SENSITIVITY STUDY - MARK III, CONCRETE



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* Calculations made for a MARK III Unit and 1/4 scale Facility.

* The gas temperatures calculated for the MARK III Unit are lower than those for the 1/4 scale Facility.

* Replacement of the MARK III Unit outer wall with an 1½" thick steel shell did not significantly influence the calculated gas temperatures.

CONCLUSION

BASED ON THIS EVALUATION GAS TEMPERATURES PRODUCED IN THE 1/4 SCALE TEST FACILITY CAN BE EXPECTED TO BE GREATER THAN THOSE IN MARK III PLANTS

12-115

Enclosure 1 [illegible] Several Open Items that [illegible]

Page No.

ATTENDANCE

February 2 1982 Meeting PSE&G/NRC

Marc Wigdor	NRC/ASLB
Carl Stahle	NRC/LB#4
K.I. PARCZEWSKI	NRC/NRR/CHEB
Hukam Garg	NRR/DE/EQB
C G TINKLER	NRR/DSI
A. Notafrancesco	NRR/DSI/CSB
//	
L. KINTNER	NRR/LB#4
J. Bongarra	NRR/CHEB
F. NISTICO	NRR/RSB
S Hobbs	MP&L
R. Evans	Enercon Services Inc
J. Hosler	EPRI
F. Tamfarini	FMRC
G S Green	Illinois Power Co.
Erdem Ural	FMRC
Erwin J. Zoch	Gulf States Utilities Co.
MIKE MANSKI	MP&L
Gary W. Smith	MP&L
Alan Wang	ACRS
Dennis B. Hacking	Enercon Services Inc.
EMIN CARTHEN	CEI
E. ED. BITTLE	CEI
John D G Lee	Enercon Services Inc
Harry H. Glasspiegel	Shaw, Pittman, Potts & Trowbridge

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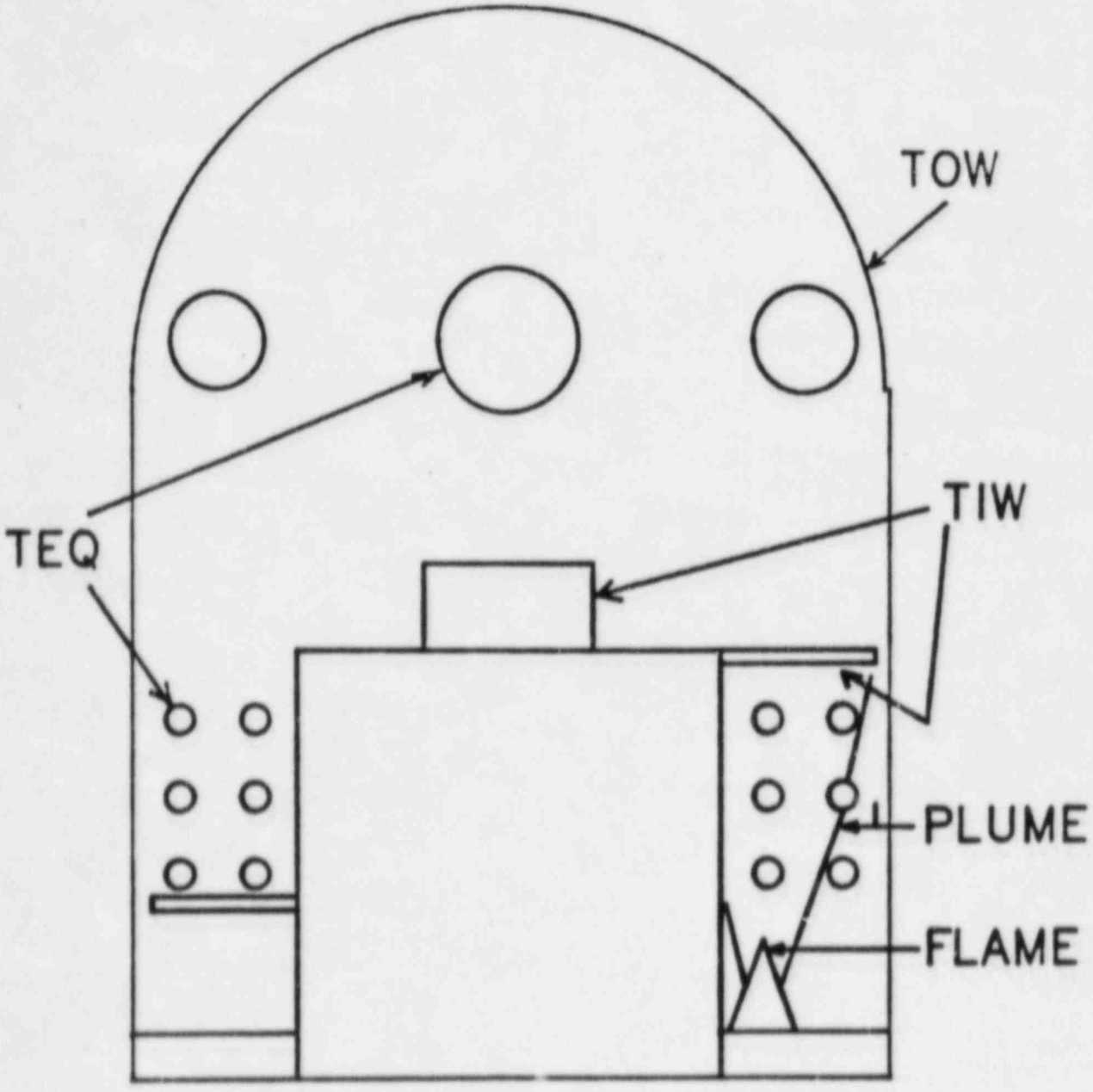

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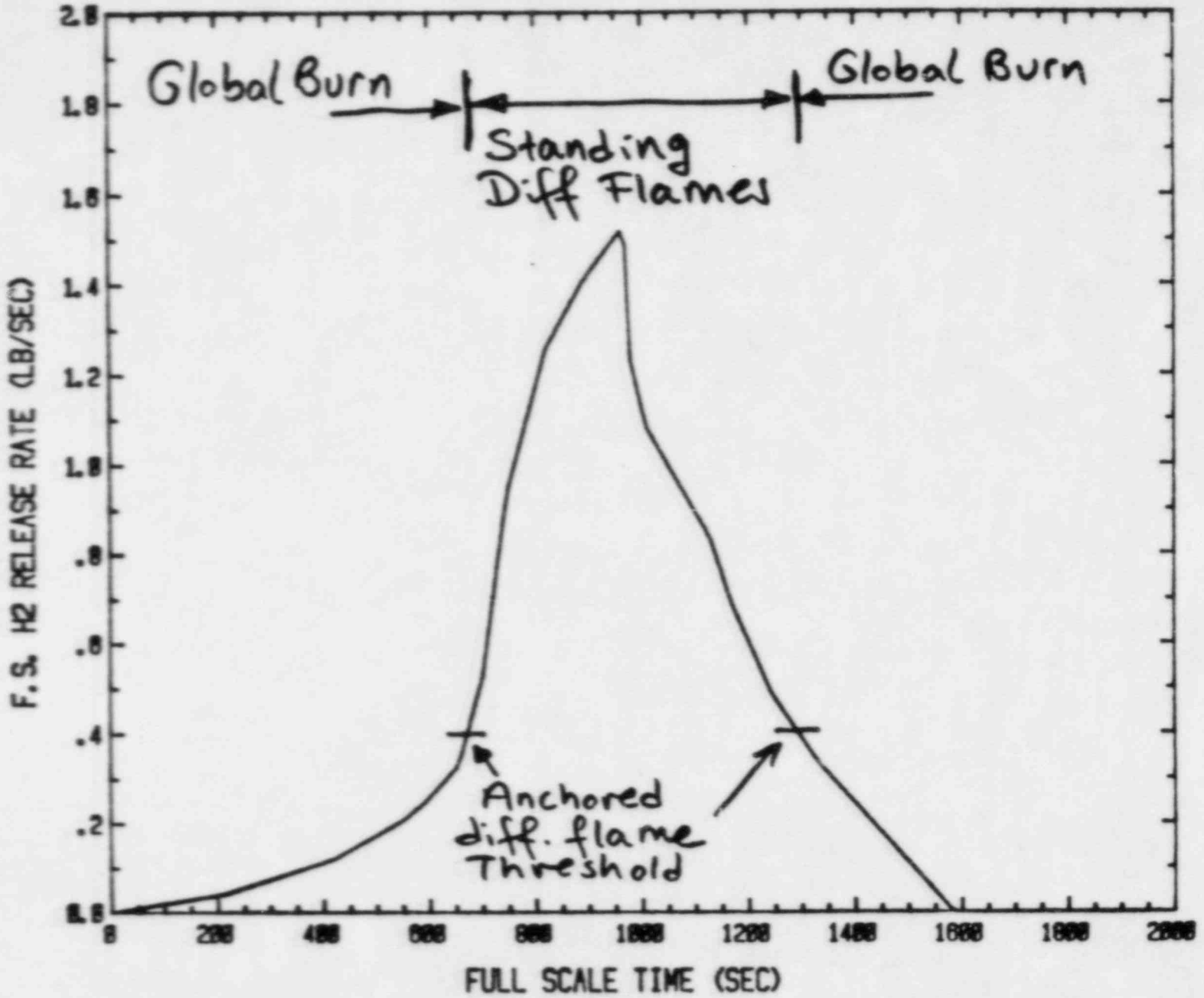
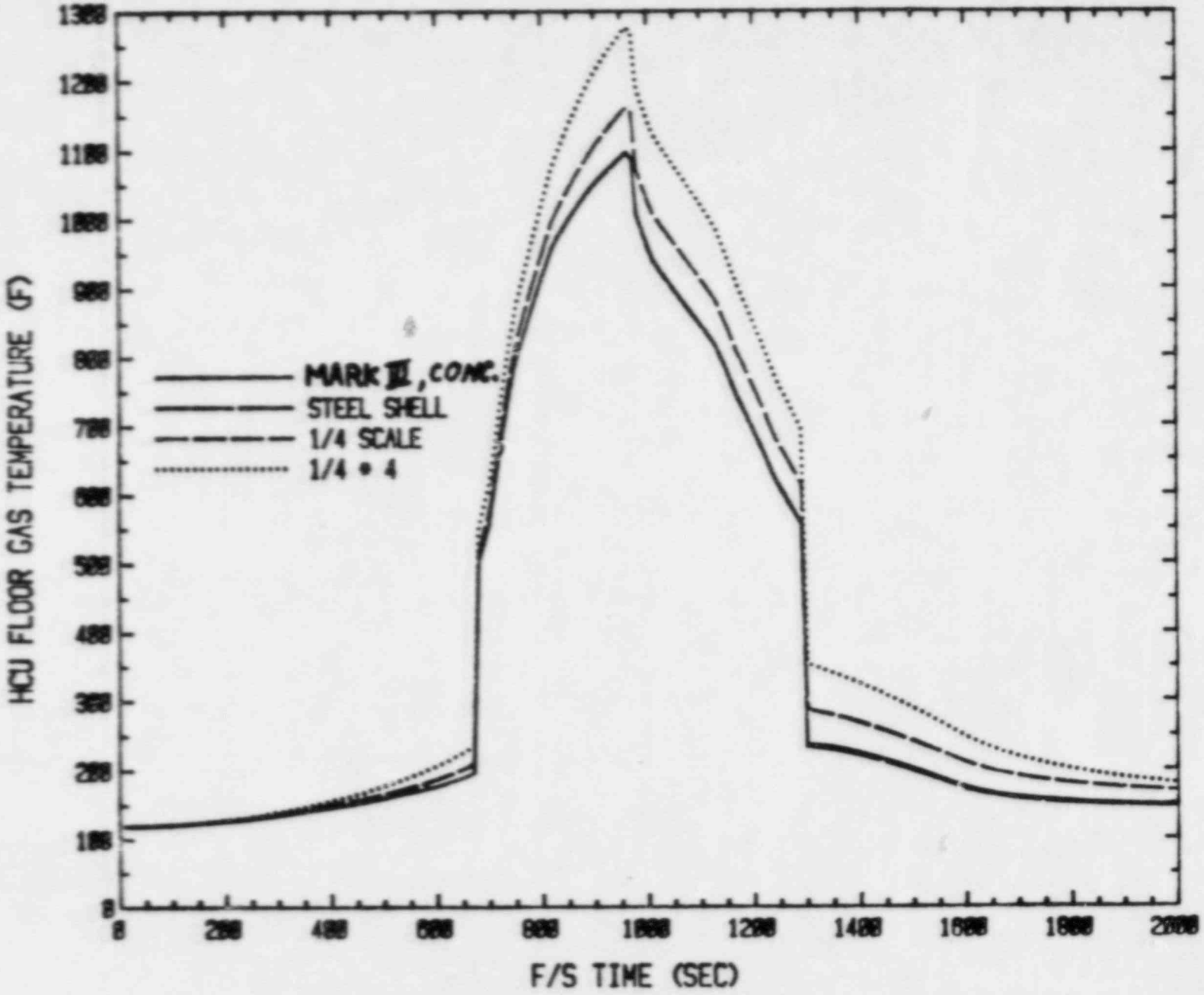
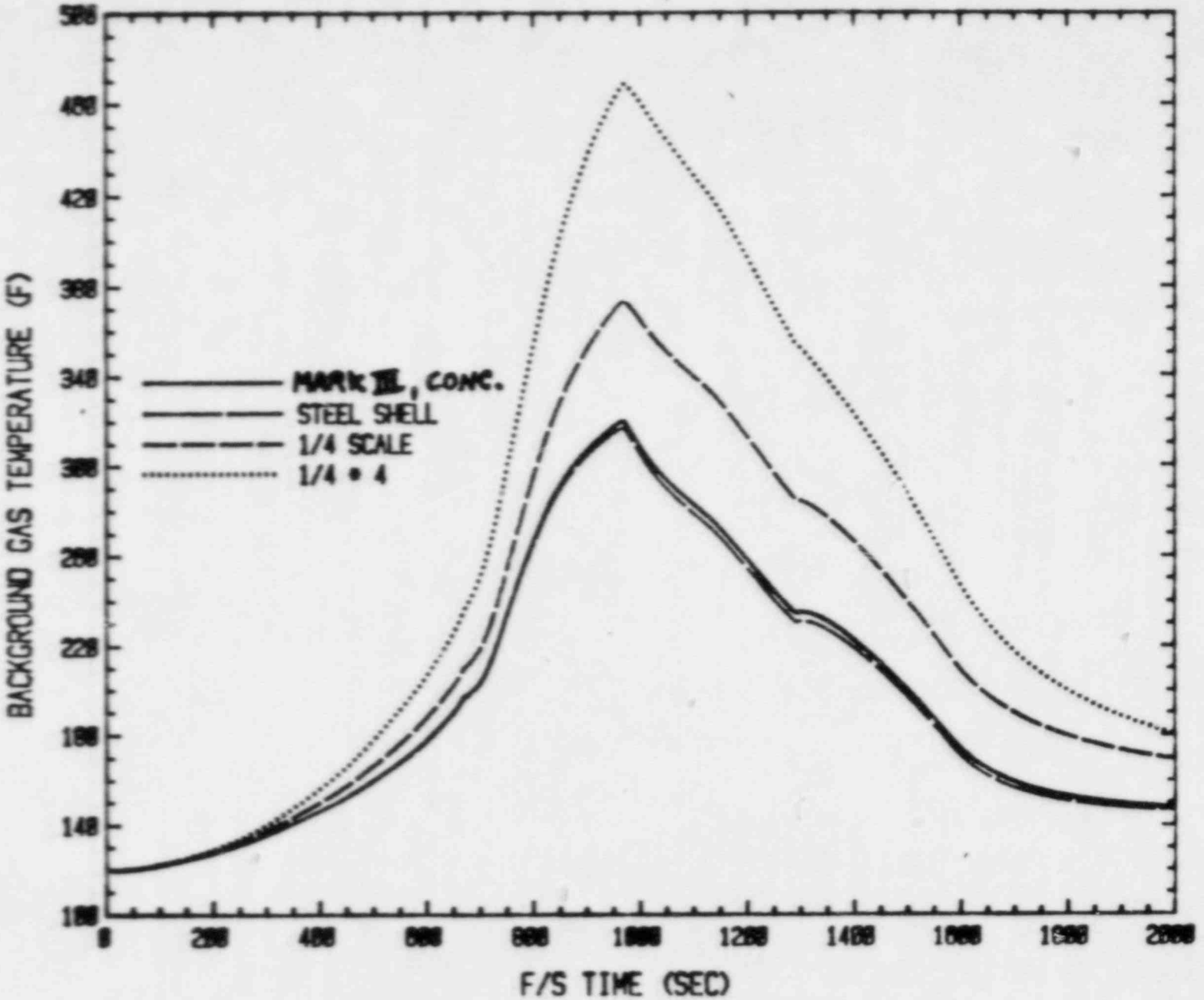


H_2 RELEASE HISTORY



DRY GAS TEMP AT WALL FLOOR



BACKGROUND GAS TEMPERATURE

SENSITIVITY STUDY:

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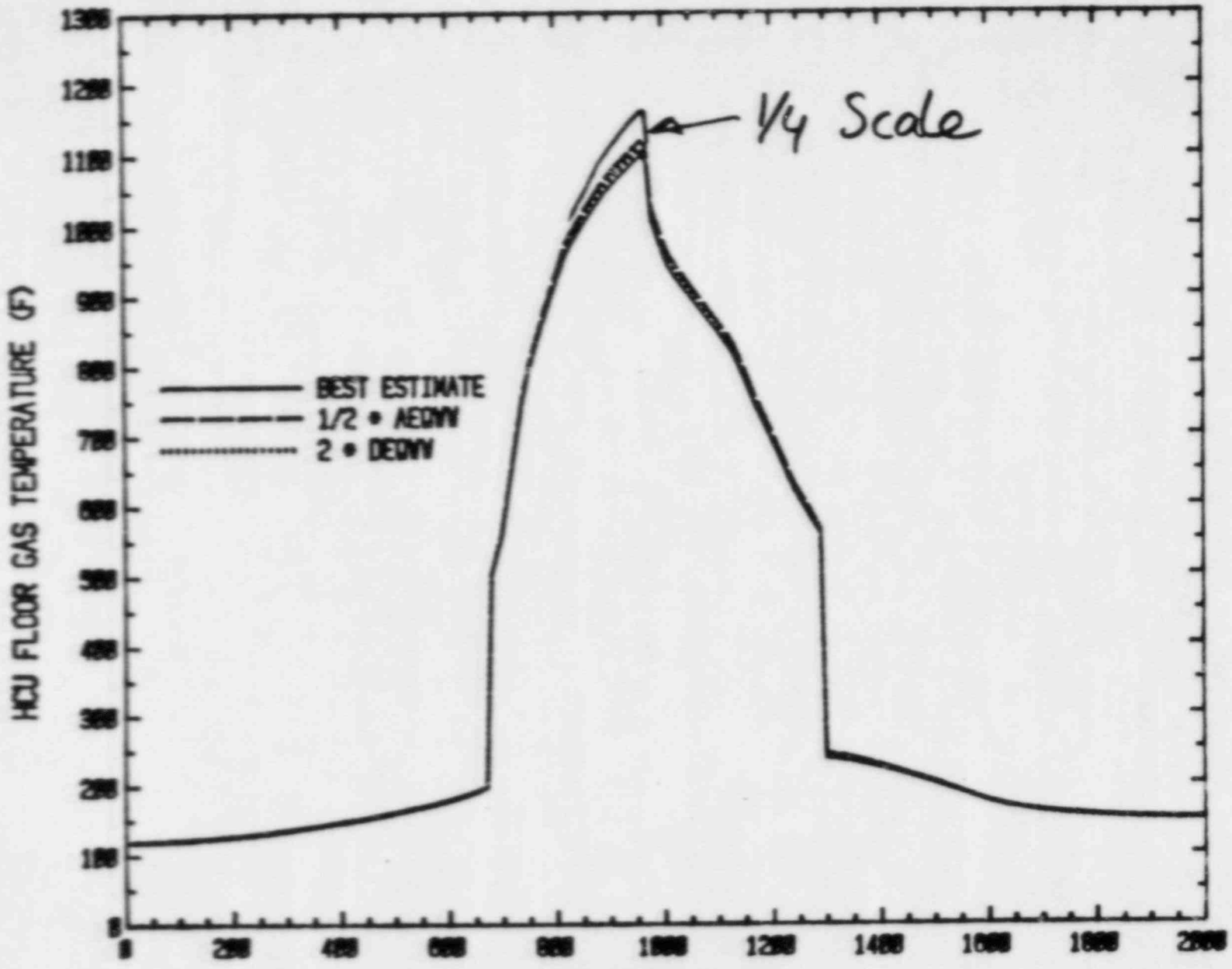
Case 2 Increase the characteristic dimension of the equipment in the annulus by a factor of 2.



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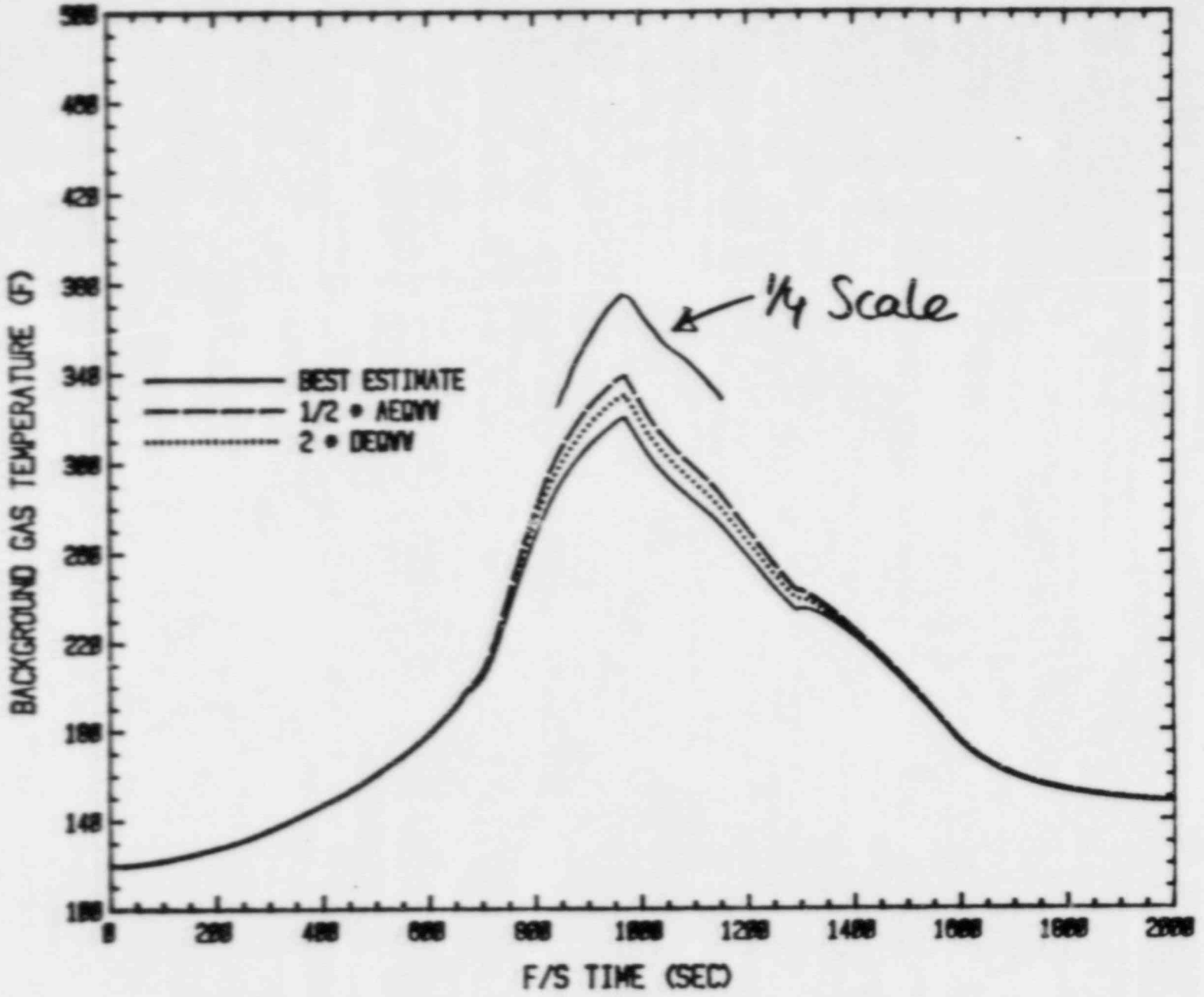

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ASSESSMENT OF EFFECTS OF FLOW BLOCKAGE (DUE TO EQUIPMENT, PIPING, ETC.) ON HYDROGEN COMBUSTION PHENOMENA IN A MARK III CONTAINMENT

HCOG/NRC MEETING
BETHESDA, MARYLAND
FEBRUARY 20,1985

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EQUIPMENT/PIPING BLOCKAGE

IN MARK III UNITS

- TWO MARK III CONTAINMENTS (GRAND GULF & RIVER BEND) SURVEYED TO ASSESS FLOW BLOCKAGES DUE TO EQUIPMENT/PIPING

- SURVEYS INVOLVED REVIEW OF PLANT DRAWINGS, INTERROGATION OF COMPUTERIZED DATA BASE DEFINING PLANT PIPING/ EQUIPMENT ARRANGEMENTS AND ACTUAL PLANTS WALKDOWNS.

- RESULTS OF SURVEYS
  - FLOW BLOCKAGE (TO VERTICAL FLOW IN CHIMNEYS) FROM 30 - 60% EXISTS IN PLANTS

  - AMONG THE 45°, 135°, AND 315° CHIMNEYS THE AVERAGE MAXIMUM BLOCKAGE LEVEL TO VERTICAL FLOW IS ~ 50%

  - THE 225° (EQ. HATCH) CHIMNEY HAS BLOCKAGE OF ~ 35%

POTENTIAL EFFECTS OF EQUIPT./PIPING

FLOW BLOCKAGE ON HYDROGEN COMBUSTION PHENOMENA

1. COULD LIMIT OVERALL FLOW CIRCULATION IN CONTAINMENT SUCH THAT OXYGEN IN THE UPPER CONTAINMENT COULD NOT BE SUPPLIED AT A SUFFICIENT RATE TO SUSTAIN STANDING FLAMES ON POOL SURFACE. IN ADDITION, COULD REDUCE GLOBAL CIRCULATION VELOCITIES AND THEREFORE CONVECTION HEAT TRANSFER RATES.

2. COULD AFFECT THE FRACTION OF SPRAY DROPLETS WHICH PENETRATE TO THE WETWELL WHICH MAY INFLUENCE SPRAY EFFECTIVENESS IN LIMITING CONTAINMENT GAS TEMPERATURES.

3. COULD PRODUCE EDDY FLOWS NEAR EQUIPMENT AFFECTING CONVECTIVE HEAT TRANSFER RATES.

4. COULD LOCALLY INCREASE BULK FLOW VELOCITY INCREASING CONVECTIVE HEAT TRANSFER RATES.

ASSESSMENT OF EFFECTS OF EQUIPT./PIPING

BLOCKAGE ON HYDROGEN COMBUSTION PHENOMENA

1 EFFECTS ON GLOBAL CIRCULATION

- BLOCKAGE WILL NOT SIGNIFICANTLY AFFECT OXYGEN SUPPLY TO WETWELL

  - 1/20TH SCALE TESTING WITH GRAND GULF & RIVER BEND (CHIMNEYS ~ 67% BLOCKED) SHOWS NO QUALITATIVE CHANGE IN COMBUSTION PHENOMENA I.E. FLAMES BURN ON POOL UNTIL OXYGEN % REACHES ~ 6 - 7%

- BLOCKAGE WILL REDUCE GLOBAL FLOW CIRCULATION VELOCITIES: REDUCE CONVECTIVE HEAT TRANSFER RATES

- BLOCKAGE MAY REDUCE AIR ENTRAINMENT IN FLAMES INCREASING PLUME GAS TEMPERATURES

2. EFFECTS ON SPRAY EFFECTIVENESS

- PRIMARY GAS COOLING EFFECT IS COOLING UPPER CONTAIMENT GAS AND SUPPLYING THIS GAS VIA THE 225° (~OPEN) CHIMNEY TO THE POOL SURFACE

- INCREASING BLOCKAGE IN OTHER CHIMNEYS NOT EXPECTED TO SIGNIFICANTLY AFFECT GAS TEMPS

3. EFFECT OF BLOCKAGE INDUCED EDDY FLOWS

- HCOG PROGRAM OBJECTIVE IS TO PROVIDE AN ENGINEERING ESTIMATE OF THE THERMAL ENVIRONMENT (BASED ON BULK FLOW CONDITIONS) TO ALLOW A DETERMINATION OF EQUIPMENT SURVIVABILITY FOR "BEYOND DESIGN BASIS" DEGRADED CORE CONDITIONS.

- EXAMINATION OF SUCH DETAILED LOCAL EFFECTS ON CONVECTIVE HEAT TRANSFER RATES IS NOT CONSISTENT WITH THIS OBJECTIVE

4. EFFECT ON LOCAL BULK FLOW VELOCITIES

- LOCAL REDUCTIONS IN AREA RESULTING FROM EQUIPT./PIPING BLOCKAGE WILL INCREASE LOCAL BULK FLOW VELOCITIES ABOVE THOSE MEASURED IN TEST AND WILL RESULT IN HIGHER CONVECTIVE HEAT TRANSFER RATES.

HCOG APPROACH FOR RESOLVING ISSUE:

* HCOG COMMITS TO EVALUATE THE EFFECTS OF EQUIPT./PIPING BLOCKAGE ON LOCAL BULK FLOW VELOCITIES AS PART OF THEIR EVALUATION OF THE LOCAL THERMAL ENVIRONMENT FOR EACH EQUIPMENT TYPE.

* TO CONFIRM HCOG'S CONTENTION THAT SUCH BLOCKAGE WILL NOT SIGNIFICANTLY AFFECT THE THERMAL ENVIRONMENT PRODUCED BY HYDROGEN COMBUSTION, A SCOPING TEST WILL BE PERFORMED WITH A UNIFORM LEVEL OF ADDITIONAL FLOW BLOCKAGE (50%) OVERLAYING THE GRATING AT THE NEXT LEVEL ABOVE THE HCU FLOOR IN ALL AREAS EXCEPT THE 225° CHIMNEY. A BLOCKAGE FRACTION OF 35% WILL BE INCLUDED IN THIS CHIMNEY.

  - THE LEVEL ABOVE THE HCU FLOOR WAS CHOSEN FOR BLOCKAGE ADDITION TO ALLOW ASSESSMENT OF POSSIBLE EFFECTS ON OVERALL CIRCULATION AND SPRAY PENETRATION WHILE MINIMIZING SHIELDING EFFECTS ON THE DETAILED ARRAY OF INSTRUMENTATION LOCATED NEAR THE HCU FLOOR.

STATUS OF
OPEN ISSUES
IDENTIFIED DURING
JANUARY 23 HCOG-NRC MEETING

- o Define hydrogen release histories which can be produced by recoverable accidents
  - Definition of recoverable accidents
  - Accident sequences which should be considered
  - Resolve questions on BWR Core Heatup Code

Status:

- HOCG agreed to complete sensitivity study assuming recoverable core with 50% of active core zircaloy inventory liquified.
- HCOG-NRC agreed on two base cases and appropriate sensitivity studies
- HCOG-NRC agreed on acceptability of BWR Core Heatup Code pending final review of sensitivity results

- o Definition of diffusion flame thermal environment
  - Resolution of questions on 1/4 scale facility design
  - Finalize 1/4 scale test matrix

Status:

- Information presented to NRC staff on resolution of open technical issues
- Revised test matrix proposed

STATUS OF
OPEN ISSUES
IDENTIFIED DURING
JANUARY 23, HCOG-NRC MEETING
(CONT)

- o Demonstrate equipment survivability
  - Acceptability of methodology validation
  - NTS data evaluation

Status:

- HCOG-NRC agreed on general approach for methodology validation
- HCOG submitting additional details on the complex calorimeter
- HCOG-NRC agreed on scope of NTS data evaluation

- o Definition of drywell thermal environment
  - Resolution of questions on deflagration analysis
  - Assessment of possible inverted diffusion flames

Status:

- All technical questions open with NRC identified

- o Development of combustible gas control emergency procedure guideline

Status:

- HCOG committed to provide draft EPG to NRC for early review

HCOG APPROACH IN ESTABLISHING DEGRADED CORE ACCIDENTS FOR EVALUATION

- Accidents to be considered limited to recoverable degraded core accidents

- Area of greatest interest are accidents which can be assured to be recoverable

- Investigate sensitivity of hydrogen release history predictions to definition of recoverable

- Assure consideration of recoverable accidents which result in hydrogen production equivalent to oxidizing 75% of the active cladding

HCOG APPROACH ON HYDROGEN RELEASE HISTORIES

- Most probable HGE is loss of all inventory makeup, core heatup, hydrogen production, recovery of ECCS

- HCOG will also evaluate one scenario which results in a limiting diffusion flame thermal environment

- HCOG will define hydrogen release history which results in total hydrogen equivalent to oxidizing 75% of the active cladding

- Proposed release histories for use in 1/4 scale test program
  - Release History "A" - 300 GPM reflood with 30% of active zircaloy inventory melted
  - Release History "B" - 5000 GPM reflood
  - Release History "C" - .1 lbm/sec

AGREEMENTS WITH NRC
NEEDED TO PROCEED WITH TESTING

- o BWR Core Heatup Code is adequate for predicting hydrogen release histories which might result in diffusion flames

- o Three histories to be used in 1/4 scale test program are acceptable
  - 5000 GPM ECCS reflood
  - 300 GPM reflood
  - .1 lbm/sec

- o Goals for 1/4 scale program
  - Define diffusion flame thermal environment
  - Validate CLASIX-3 analysis

- o Adequacy of 1/4 scale facility
  - Models Mark III plants
  - Blockage fraction in facility is acceptable
  - Heat loss in facility is conservative compared with heat loss at full scale
  - Facility instrumentation is acceptable
  - Complex calorimeter is acceptable for validating heat transfer methods
  - Scoping test matrix is acceptable
  - Production test matrix is acceptable
  - Proposed approach for validating CLASIX-3 is acceptable

PROSPOSED SCHEDULE
FOR HCOG PROGRAM PLAN

* HCOG SUBMIT PROPOSED REVISIONS TO ACCEPTANCE CRITERIA - 2/15/84 (COMPLETE)

* FINAL MEETING ON TASK 9 - 2/20/85

* REVISE ENTIRE PROGRAM PLAN, MAKE ANY ADDITIONAL REQUIRED MODIFICATIONS TO TASK 9, SUBMIT ALL REVISIONS - 3/1/85

* START SCOPING TESTING - 3/18/85

* WRITTEN NRC APPROVAL OF TASKS 1,7,9, AND 12 ACCEPTANCE CRITERIA AND IDENTIFIED AGREEMENTS NEEDED BY MARCH 22, 1985

* NRC ISSUE SAFETY EVALUATION REPORT - 4/9/85

* APPLICANTS SUBMIT SCHEDULE FOR COMPLYING WITH FINAL HYDROGEN CONTROL RULE - 6/25/85

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POTENTIAL EFFECTS OF EQUIPT./PIPING

FLOW BLOCKAGE ON HYDROGEN COMBUSTION PHENOMENA

1. COULD LIMIT OVERALL FLOW CIRCULATION IN CONTAINMENT SUCH THAT OXYGEN IN THE UPPER CONTAINMENT COULD NOT BE SUPPLIED AT A SUFFICIENT RATE TO SUSTAIN STANDING FLAMES ON POOL SURFACE. IN ADDITION, COULD REDUCE GLOBAL CIRCULATION VELOCITIES AND THEREFORE CONVECTION HEAT TRANSFER RATES.

2. COULD AFFECT THE FRACTION OF SPRAY DROPLETS WHICH PENETRATE TO THE WETWELL WHICH MAY INFLUENCE SPRAY EFFECTIVENESS IN LIMITING CONTAINMENT GAS TEMPERATURES.

3. COULD PRODUCE EDDY FLOWS NEAR EQUIPMENT AFFECTING CONVECTIVE HEAT TRANSFER RATES.

4. COULD LOCALLY INCREASE BULK FLOW VELOCITY INCREASING CONVECTIVE HEAT TRANSFER RATES.

ASSESSMENT OF EFFECTS OF EQUIPT./PIPING

BLOCKAGE ON HYDROGEN COMBUSTION PHENOMENA

1 EFFECTS ON GLOBAL CIRCULATION

- BLOCKAGE WILL NOT SIGNIFICANTLY AFFECT OXYGEN SUPPLY TO WETWELL

    - 1/20TH SCALE TESTING WITH GRAND GULF & RIVER BEND (CHIMNEYS ~ 67% BLOCKED) SHOWS NO QUALITATIVE CHANGE IN COMBUSTION PHENOMENA I.E. FLAMES BURN ON POOL UNTIL OXYGEN % REACHES ~ 6 - 7%

- BLOCKAGE WILL REDUCE GLOBAL FLOW CIRCULATION VELOCITIES: REDUCE CONVECTIVE HEAT TRANSFER RATES

- BLOCKAGE MAY REDUCE AIR ENTRAINMENT IN FLAMES INCREASING PLUME GAS TEMPERATURES

2. EFFECTS ON SPRAY EFFECTIVENESS

- PRIMARY GAS COOLING EFFECT IS COOLING UPPER CONTAIMENT GAS AND SUPPLYING THIS GAS VIA THE 225° (~OPEN) CHIMNEY TO THE POOL SURFACE

- INCREASING BLOCKAGE IN OTHER CHIMNEYS NOT EXPECTED TO SIGNIFICANTLY AFFECT GAS TEMPS

3. EFFECT OF BLOCKAGE INDUCED EDDY FLOWS

- HCOG PROGRAM OBJECTIVE IS TO PROVIDE AN ENGINEERING ESTIMATE OF THE THERMAL ENVIRONMENT (BASED ON BULK FLOW CONDITIONS) TO ALLOW A DETERMINATION OF EQUIPMENT SURVIVABILITY FOR "BEYOND DESIGN BASIS" DEGRADED CORE CONDITIONS.

- EXAMINATION OF SUCH DETAILED LOCAL EFFECTS ON CONVECTIVE HEAT TRANSFER RATES IS NOT CONSISTENT WITH THIS OBJECTIVE

4. EFFECT ON LOCAL BULK FLOW VELOCITIES

- LOCAL REDUCTIONS IN AREA RESULTING FROM EQUIPT./PIPING BLOCKAGE WILL INCREASE LOCAL BULK FLOW VELOCITIES ABOVE THOSE MEASURED IN TEST AND WILL RESULT IN HIGHER CONVECTIVE HEAT TRANSFER RATES.

HCOG APPROACH FOR RESOLVING ISSUE:

* HCOG COMMITS TO EVALUATE THE EFFECTS OF EQUIPT./PIPING BLOCKAGE ON LOCAL BULK FLOW VELOCITIES AS PART OF THEIR EVALUATION OF THE LOCAL THERMAL ENVIRONMENT FOR EACH EQUIPMENT TYPE.

* TO CONFIRM HCOG'S CONTENTION THAT SUCH BLOCKAGE WILL NOT SIGNIFICANTLY AFFECT THE THERMAL ENVIRONMENT PRODUCED BY HYDROGEN COMBUSTION, A SCOPING TEST WILL BE PERFORMED WITH A UNIFORM LEVEL OF ADDITIONAL FLOW BLOCKAGE (50%) OVERLAYING THE GRATING AT THE NEXT LEVEL ABOVE THE HCU FLOOR IN ALL AREAS EXCEPT THE 225° CHIMNEY. A BLOCKAGE FRACTION OF 35% WILL BE INCLUDED IN THIS CHIMNEY.

  - THE LEVEL ABOVE THE HCU FLOOR WAS CHOSEN FOR BLOCKAGE ADDITION TO ALLOW ASSESSMENT OF POSSIBLE EFFECTS ON OVERALL CIRCULATION AND SPRAY PENETRATION WHILE MINIMIZING SHIELDING EFFECTS ON THE DETAILED ARRAY OF INSTRUMENTATION LOCATED NEAR THE HCU FLOOR.

February 19, 1985
ATTENDEES

2/20/85

MEETING WITH HYDROGEN CONTROL OWNERS GROUP

NAME	AFFILIATION
Erwin J. Zoch	Gulf States Utilities Co.
John F. Hosler	EPRI
Steve Green	Illinois Power Co.
MIKE MANSKI	MP&L
John L. Gr[illegible]	[illegible]
Bob Evans	Energy Sciences Inc
S H Nebbs	MP&L
Fulvio Nistico	NRC/ENFA
Mark Wigder	NRC/RSB
K. I. Parczewski	NRC/NRR/CHEB
R. G. LaGrange	NRC/NRR/EQB
C. G. Tinkler	NRC/NRR/[illegible]
Emin Ortalano	CEI
[illegible]	[illegible]

TASK 9 - DIFFUSION FLAME THERMAL ENVIRONMENT

Requirements — 10 CFR 50.44 (c)(3)(vi)

A hydrogen control system shall be provided and justified by a program of experiment and analysis.

Task Description

The hydrogen combustion testing completed under Task 6 demonstrated that steady diffusion flames could exist at the suppression pool surface. This task involves completing a test program to define the thermal environment in the wetwell and upper containment produced by this type of combustion.

TASK 9 - DIFFUSION FLAME THERMAL ENVIRONMENT

MAJOR SUBTASKS

9.2 Design Test Facility

- Facility designed to simulate Mark III containment features (i.e. suppression pool, sprays or unit coolers, spargers)
- Floor geometry variable to simulate all four Mark III plants
- Heavily instrumented to provide data on thermal environment

9.7 Draft Test Matrix

- A matrix of tests to be completed in the facility was developed
- Covers range of hydrogen release locations
- Evaluates key parameters which might affect thermal environment

9.12 Complete Shakedown Testing

- Tests to check operation of facility systems
- Tests to verify instrument operability and responses
- Tests to evaluate integrated system performance

9.14 Prepare Final Test Facility Design Report

- Document final facility configuration
- Identify key facility characteristics

TASK 9 - DIFFUSION FLAME THERMAL ENVIRONMENT

MAJOR SUBTASKS (CONT)

9.17 Complete Scoping Tests

- o Test series to evaluate effects of varying important parameters
- o Potential impact on production tests
- o Utilize same hydrogen history as production tests

9.19 Production Test Matrix Acceptable

- o Review scoping test results
- o Determine if assumptions used in developing production test matrix are valid

9.23 Complete Production Tests

- o Execute tests in production test matrix
- o Record required data
- o Make necessary changes in test configuration

9.28 Prepare Final Test Report

- o Document test results
- o Discuss effect of important parameters on test results
- o Discuss reliability of data

TASK 9 - DIFFUSION FLAME THERMAL ENVIRONMENT

Status

- o Subtasks 9.1 - 9.3, 9.7 - 9.8 and 9.11 complete
- o Subtasks 9.5, 9.9, 9.10 and 9.12 in progress

Remaining Work

- o HCOG preparing responses to NRC questions on 1/4 scale facility design
- o Final facility design report remains to be submitted
- o Execute balance of shakedown and scoping tests
- o Determine if production test matrix is adequate
- o Schedule meeting to review scoping test results
- o Schedule meeting to review production test progress
- o Complete Production tests
- o Reduce Data
- o Schedule meeting to discuss production test data
- o Submit final test Report

TASK 9 - DIFFUSION FLAME THERMAL ENVIRONMENT

Acceptance Criteria

- o Obtain data to define thermal environment produced by steady diffusion flames
- o Scaling for test facility shall be conservative
- o Scaled test facility shall represent Mark III plants
  - capability to simulate each containment geometry
  - simulate major blockages
  - simulate containment cooling system including sprays and unit coolers
  - heat transfer characteristics shall be conservative compared to full scale parameters
  - simulate variable hydrogen and steam injection to facility
- o Testing in scaled facilities shall be consistent with accident progression based on operator actions in EPG
- o Parameters which could affect full scale thermal environment shall be evaluated in scaled test facility
- o A limiting thermal environment produced by diffusion flames shall be established for each area in wetwell and upper containment
- o Hydrogen distribution shall be measured throughout facility to resolve mixing
- o Data shall be obtained to validate analytical methods

[illegible] Meeting

Minutes:

Task 7 Diffusion Island Thermal [illegible]

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STATUS OF OPEN ISSUES IDENTIFIED DURING JANUARY 23 HCOG-NRC MEETING

o Define hydrogen release histories which can be produced by recoverable accidents

- Definition of recoverable accidents
- Accident sequences which should be considered
- Resolve questions on BWR Core Heatup Code

Status:

- HCOG agreed to complete sensitivity study assuming recoverable core with 50% of active core zircaloy inventory liquified.
- HCOG-NRC agreed on two base cases and appropriate sensitivity studies
- HCOG-NRC agreed on acceptability of BWR Core Heatup Code pending final review of sensitivity results

o Definition of diffusion flame thermal environment

- Resolution of questions on 1/4 scale facility design
- Finalize 1/4 scale test matrix

Status:

- Information presented to NRC staff on resolution of open technical issues
- Revised test matrix proposed

STATUS OF
OPEN ISSUES
IDENTIFIED DURING
JANUARY 23, HCOG-NRC MEETING
(CONT)

- o Demonstrate equipment survivability
  - Acceptability of methodology validation
  - NTS data evaluation

Status:

- HCOG-NRC agreed on general approach for methodology validation
- HCOG submitting additional details on the complex calorimeter
- HCOG-NRC agreed on scope of NTS data evaluation

- o Definition of drywell thermal environment
  - Resolution of questions on deflagration analysis
  - Assessment of possible inverted diffusion flames

Status:

- All technical questions open with NRC identified

- o Development of combustible gas control emergency procedure guideline

Status:

- HCOG committed to provide draft EPG to NRC for early review

HCOG APPROACH IN ESTABLISHING DEGRADED CORE ACCIDENTS FOR EVALUATION

- Accidents to be considered limited to recoverable degraded core accidents

- Area of greatest interest are accidents which can be assured to be recoverable

- Investigate sensitivity of hydrogen release history predictions to definition of recoverable

- Assure consideration of recoverable accidents which result in hydrogen production equivalent to oxidizing 75% of the active cladding

HCOG APPROACH ON HYDROGEN RELEASE HISTORIES

- Most probable HGE is loss of all inventory makeup, core heatup, hydrogen production, recovery of ECCS

- HCOG will also evaluate one scenario which results in a limiting diffusion flame thermal environment

- HCOG will define hydrogen release history which results in total hydrogen equivalent to oxidizing 75% of the active cladding

- Proposed release histories for use in 1/4 scale test program
  - Release History "A" - 300 GPM reflood with 30% of active zircaloy inventory melted
  - Release History "B" - 5000 GPM reflood
  - Release History "C" - .1 lbm/sec

AGREEMENTS WITH NRC
NEEDED TO PROCEED WITH TESTING

- [illegible] Core Heatup Code is adequate for predicting hydrogen release histories which might result in diffusion flames

- Three histories to be used in 1/4 scale test program are acceptable
  - [illegible]0 GPM ECCS reflood
  - [illegible] GPM reflood
  - .[illegible] lbm/sec

- Goals for 1/4 scale program
  - Define diffusion flame thermal environment
  - Validate CLASIX-3 analysis

- Adequacy of 1/4 scale facility
  - Models Mark III plants
  - Blockage fraction in facility is acceptable
  - Heat loss in facility is conservative compared with heat loss at full scale
  - Facility instrumentation is acceptable
  - Complex calorimeter is acceptable for validating heat transfer methods
  - Scoping test matrix is acceptable
  - Production test matrix is acceptable
  - Proposed approach for validating CLASIX-3 is acceptable

PROSPOSED SCHEDULE
FOR HCOG PROGRAM PLAN

* HCOG SUBMIT PROPOSED REVISIONS TO ACCEPTANCE CRITERIA - 2/15/84 (COMPLETE)

* FINAL MEETING ON TASK 9 - 2/20/85

* REVISE ENTIRE PROGRAM PLAN, MAKE ANY ADDITIONAL REQUIRED MODIFICATIONS TO TASK 9, SUBMIT ALL REVISIONS - 3/1/85

* START SCOPING TESTING - 3/18/85

* WRITTEN NRC APPROVAL OF TASKS 1,7,9, AND 12 ACCEPTANCE CRITERIA AND IDENTIFIED AGREEMENTS NEEDED BY MARCH 22, 1985

* NRC ISSUE SAFETY EVALUATION REPORT - 4/9/85

* APPLICANTS SUBMIT SCHEDULE FOR COMPLYING WITH FINAL HYDROGEN CONTROL RULE - 6/25/85