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Meeting Notebook(w/out att)
EPEaston(w/att)

MEMORANDUM FOR: The Files

FROM: Nancy L. Osgood, SGTB, SGTR, NMSS

SUBJECT: Meeting Summary Concerning BR-100 Spent Fuel Rail Cask

Attendees

NRC	B&W Fuel Co.	EG&G Idaho
Nancy Osgood	Bernie Copsey	Ken Henry
Carl Withee	Brian Butler	
Marissa Garcia	George Vames	DOE HQ
Bernie White	Dan Young	Alan Berusch
George Gardes	Ed McGuinn	Bill Lake
Daniel Huang	Paul Childress	
Li Yang		Weston
Henry W. Lee		Maraj Rahimi

Introduction

A meeting was held at the request of B&W Fuel Company at Rockville, Maryland, on December 12, 1990, to discuss the BR-100 spent fuel cask. The BR-100 is being designed by B&W Fuel Company for the Department of Energy for spent fuel shipment by rail under the Nuclear Waste Policy Act.

Discussion

The discussion followed the attached meeting handout.

Results of thermal analyses and thermal testing were reported. The current conceptual design of the impact limiters was discussed. Testing of the impact limiters will be discussed at a future meeting.

An application is expected to be submitted to the NRC spring 1992.

Nancy L. Osgood
Transportation Branch
Division of Safeguards and
Transportation, NMSS

Attachment: Meeting Handout

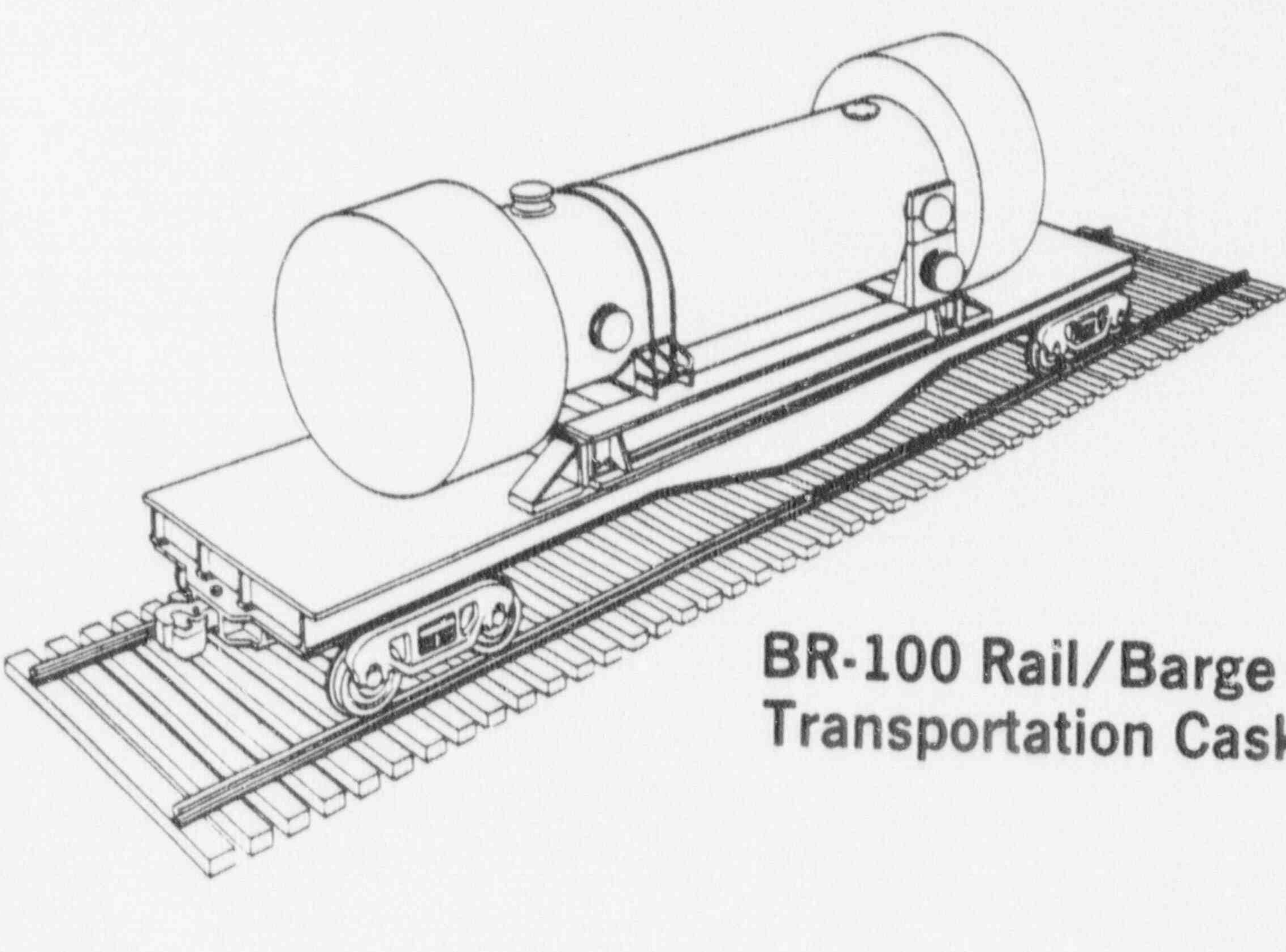
OFC :SGTB NLO	:SGTB CRC
NAME:NLOsgood	:CRChappell
DATE:12/13/90	:12/13/90

OFFICIAL RECORD COPY

NT03

NRC Docket 71-9230

B&W Fuel Company
Presentation to the
NRC Transportation Branch
December 12, 1990



BR-100 Rail/Barge Transportation Cask

B&W FUEL COMPANY TEAM

GEORGE VAMES	PROJECT MANAGER
PAUL CHILDRESS	TECHNICAL CONSULTANT
DAN YOUNG	PROJECT ENGINEER
BERNIE COPSEY	THERMAL ANALYST
BRIAN BUTLER	IMPACT LIMITER DESIGNER
EDWARD MCGUINN	IMPACT LIMITER DESIGNER

B&W FUEL
COMPANY

NRC MEETING AGENDA
DECEMBER 12, 1990

INTRODUCTION	G.J. VAMES / P.C. CHILDRESS
IMPACT LIMITER DEVELOPMENT	E.J. McGUINN / B.D. BUTLER
DESIGN CRITERIA LIMITER DESIGN DESCRIPTION MATERIAL PROPERTIES DEVELOPMENT TESTING VERIFICATION TEST PLANS	
THERMAL EVALUATION:	A.B. COPSEY
DESIGN CRITERIA THERMAL ANALYSIS STRATEGY THERMAL TESTING	
WRAP-UP and QUESTIONS	G.J. VAMES

B&W FUEL COMPANY

CASK THERMAL DESIGN

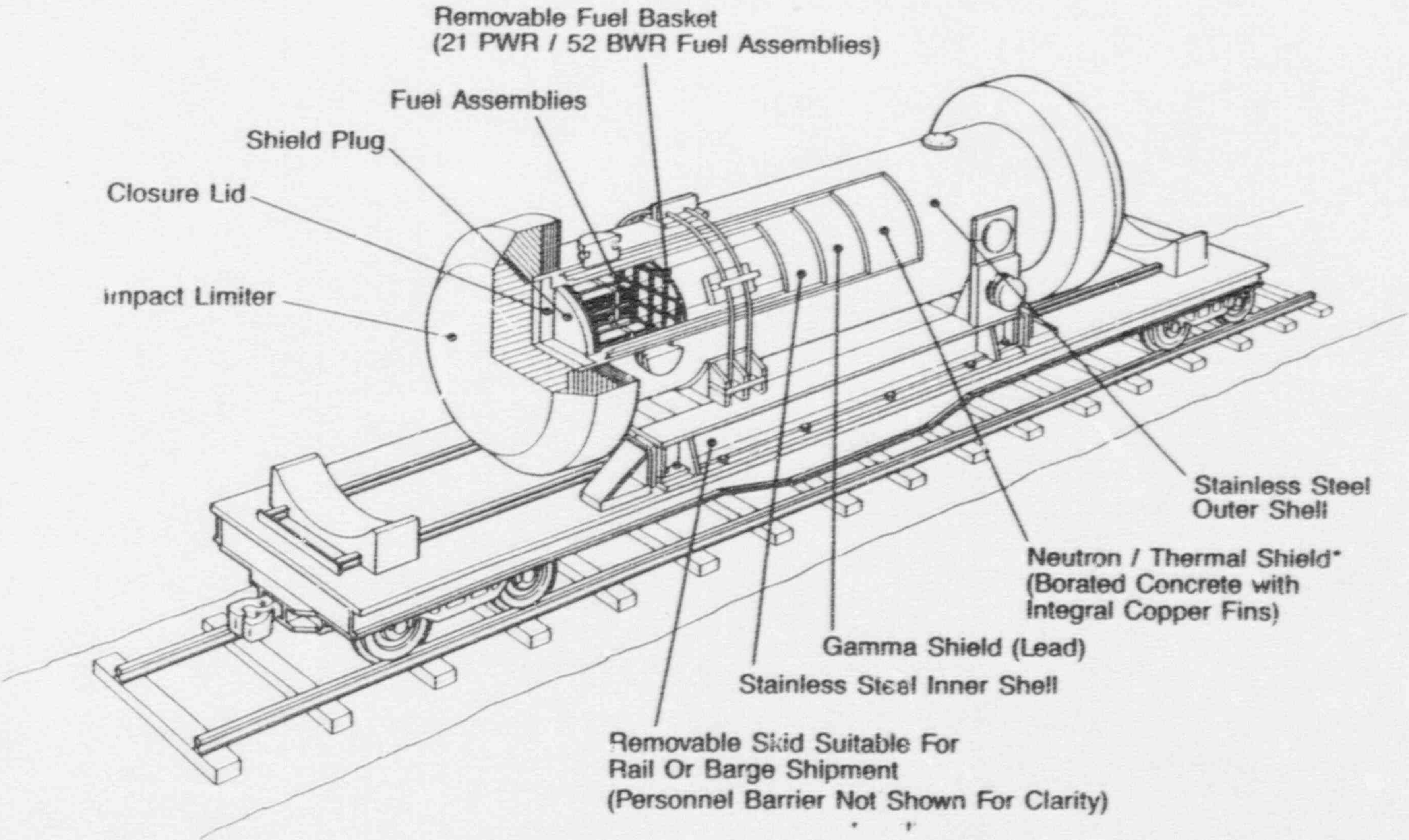
- O ANALYSES
  - FUEL BASKET ANALYSIS
  - NORMAL/ACCIDENT SCENARIOS
  - "THERMAL SWITCH" CASK WALL
- O THERMAL TESTING RESULTS

IMPACT LIMITER

- O DESIGN
  - USE OF KEVLAR
  - "QUICK DISCONNECT" ATTACHMENT

- O TEST PROGRAM
  - 1/4 SCALE VERIFICATION
  - MATERIAL TESTS

BABCOCK & WILCOX BR-100
100 TON RAIL / BARGE CASK



*Patented by ROBATEL SA

Department of Energy
Contract No. DE-AC07-88ID 12701

MEETING OBJECTIVE

- PRESENTATION IS PREVIEW OF SARP MATERIAL

- WANT STAFF OPINION OF ADEQUACY OF MATERIAL

BR-100 CASK

Impact Limiter Development Program

B&W FUEL COMPANY

BR-100 IMPACT LIMITERS

- DESIGN CRITERIA
- DESIGN DESCRIPTION
- KEY MATERIAL PROPERTIES
- DEVELOPMENT TESTING
- VERIFICATION TEST PLANS

B&W FUEL COMPANY

BR-100 IMPACT LIMITERS

- IMPACT LIMITER DESIGN CRITERIA

  - LIMIT 'G' FORCES ON THE CASK BODY

    - ACCIDENT EVENT
      - LATERAL 80 G'S
      - AXIAL 60 G'S

    - NORMAL OPERATION
      - LATERAL 20 G'S
      - AXIAL 20 G'S

  - PROVIDE A LEVEL OF THERMAL PROTECTION FOR THE SEALS

  - RADIATION SHIELDING

  - NO IMPACT ON TRUNNIONS OR ATTACHMENT HARDWARE

  - MAINTAIN ATTACHMENT TO CASK BODY

B&W FUEL COMPANY

BR-100 IMPACT LIMITERS

- DESIGN CRITERIA -- ENVIRONMENTAL
  - OPERATIONAL ENVIRONMENT
    - TEMPERATURE RANGE
      - CASK SURFACE MAX. 250 F
MIN. -20 F
      - AMBIENT MAX. 100 F
MIN. -20 F
  - OUTER ENVIRONMENT BARRIER
  - SEALED SYSTEM / MOISTURE BARRIER
  - CHEMICAL EXPOSURE (DURING FABRICATION)

B&W FUEL COMPANY

BR-100 IMPACT LIMITERS

- DESIGN CRITERIA -- OPERATIONAL

  - OPERATION LIFE OF 25 YEARS

  - MINIMIZE WEIGHT

  - EASE OF HANDLING / REMOTE OPERATION

  - QUICK ATTACHMENT & REMOVAL FROM CASK

  - OPERATIONAL CONSIDERATIONS

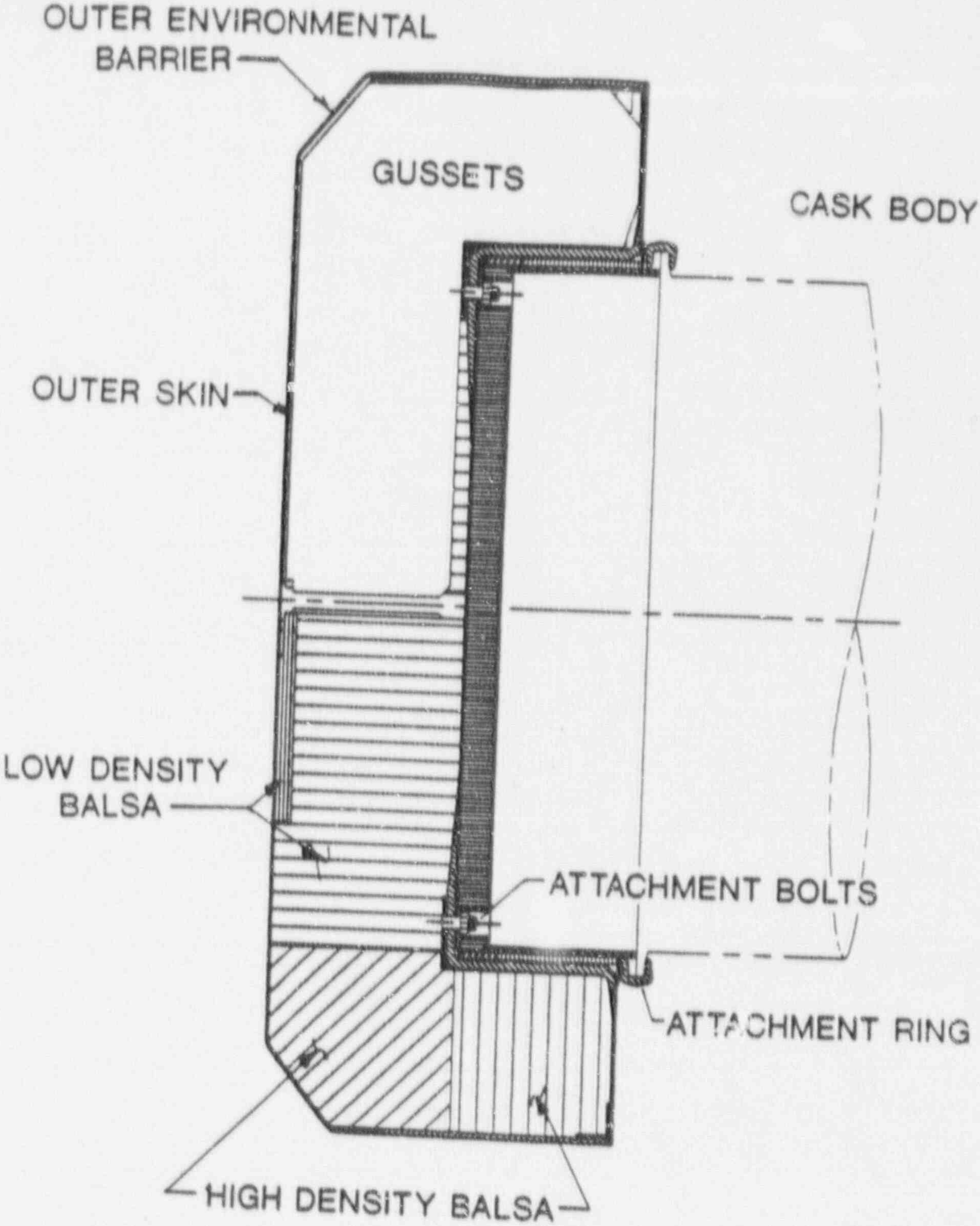
B&W FUEL COMPANY

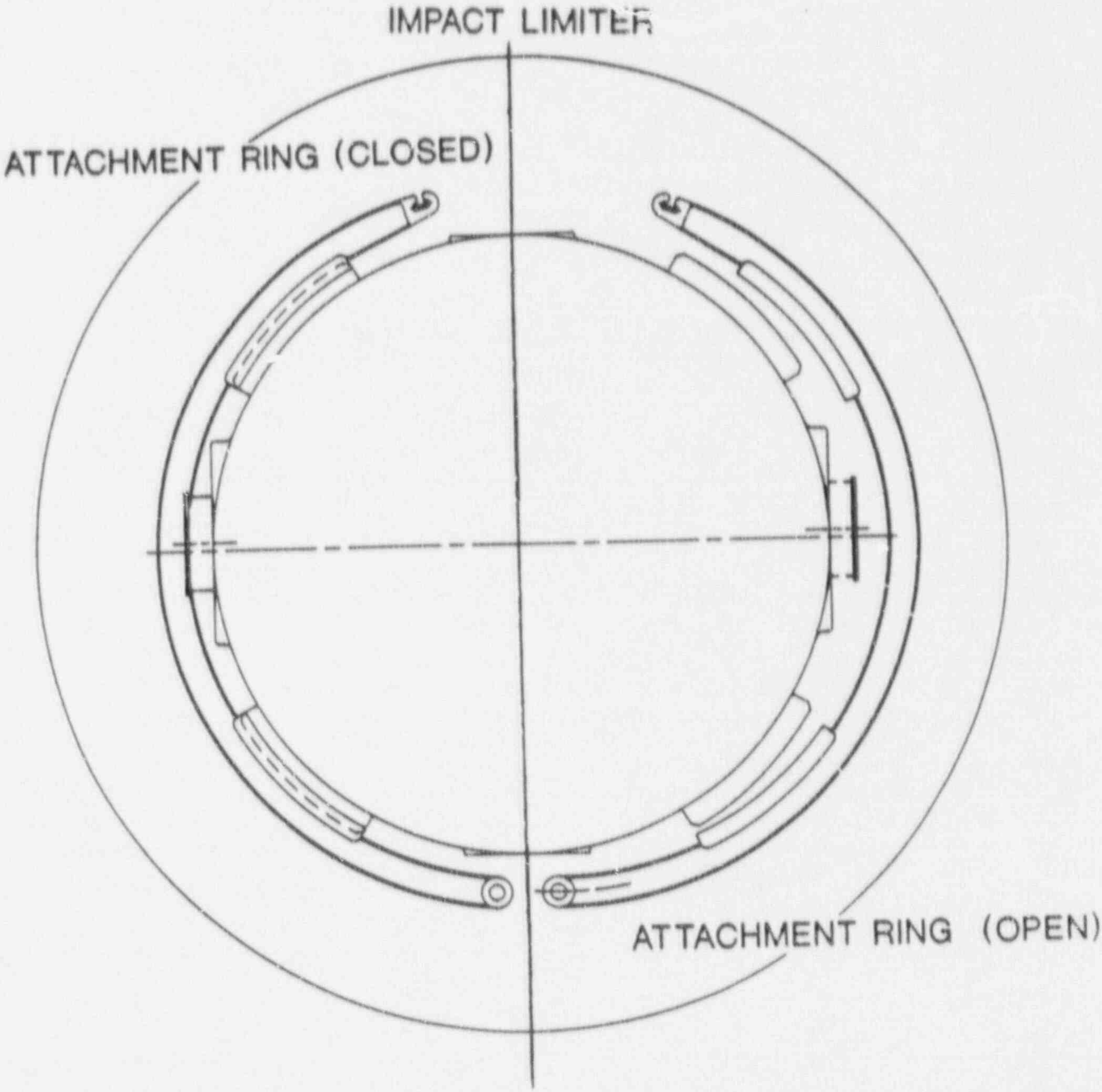
BR-100 IMPACT LIMITERS

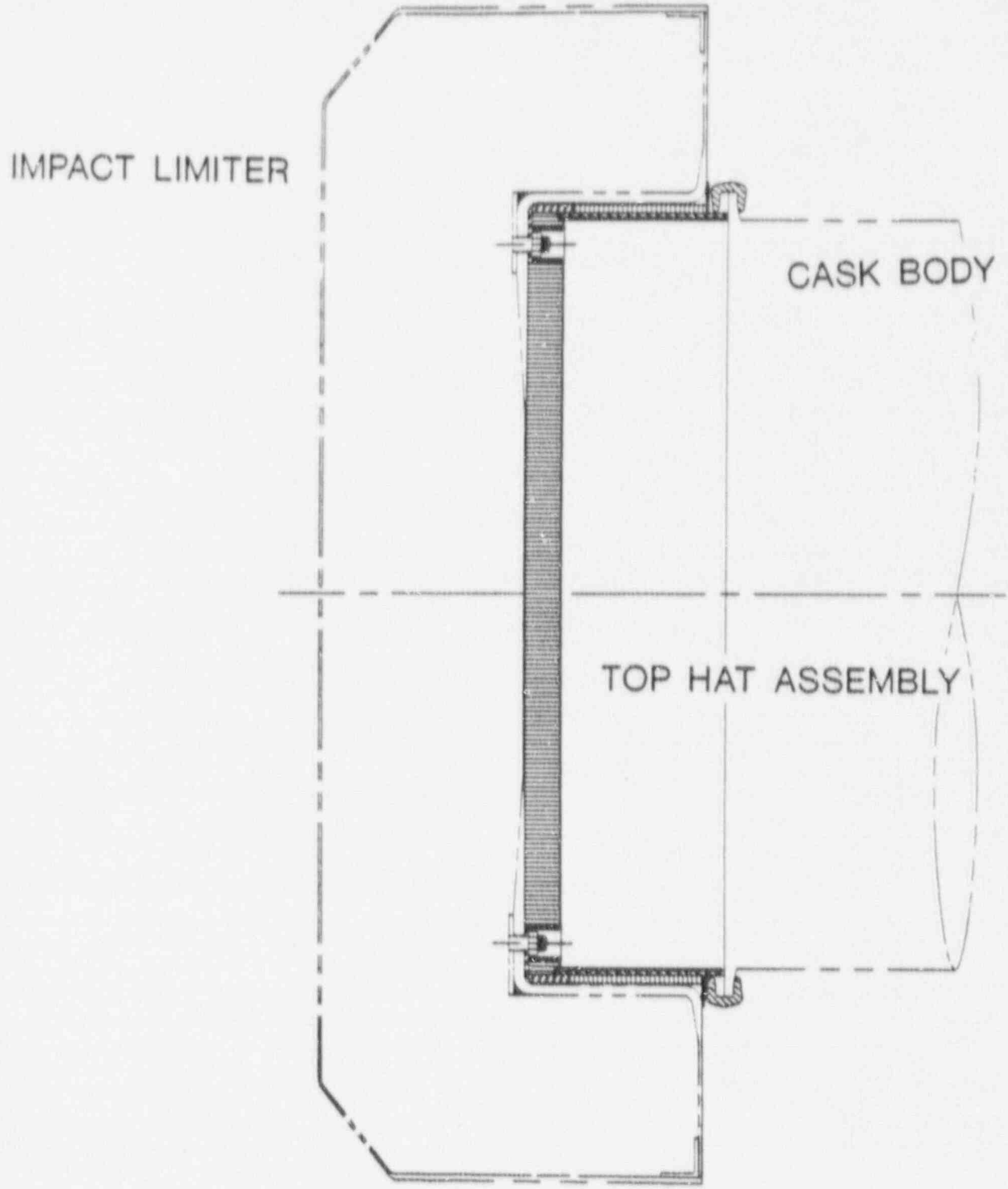
IMPACT LIMITER DESIGN DESCRIPTION

- DIMENSIONS
- MATERIALS OF CONSTRUCTION
  - KEVLAR/EPOXY COMPOSITE
  - LOW AND HIGH DENSITY BALSA
  - REDWOOD
- LIMITER DESIGN FEATURES
- ATTACHMENT DESIGN

B&W FUEL COMPANY


OUTER ENVIRONMENTAL
BARRIER
GUSSETS
CASK BODY
OUTER SKIN
LOW DENSITY
BALSA
ATTACHMENT BOLTS
ATTACHMENT RING
HIGH DENSITY BALSA


IMPACT LIMITER
ATTACHMENT RING (CLOSED)
ATTACHMENT RING (OPEN)


IMPACT LIMITER
CASK BODY
TOP HAT ASSEMBLY

BR-100 IMPACT LIMITER

MATERIAL PROPERTIES AND TESTING

- O ENERGY ABSORBER - BALSA

- O ENCASEMENT - KEVLAR/EPOXY COMPOSITE

BR-100 IMPACT LIMITER

ENERGY ABSORBING MATERIAL

BR-100 USES 7-10 AND 18-20 LB/FT^3 BALSA.

BALSA:

- CRUSH STRENGTH IS A FUNCTION OF:
  - DENSITY
  - TEMPERATURE
  - MOISTURE CONTENT
  - DEFORMATION (STRAIN) RATE

BR-100 IMPACT LIMITER

APPROACH TO GET MAX AND MIN CRUSH STRENGTH FOR HIGH DENSITY BALSA:

- O USE JPL AND BALTEK TEST DATA TO GET f(T, % H_2O) FOR 5-10 LB/FT^3 BALSA.
- O CRUSH TEST HIGH DENSITY BALSA AT ROOM TEMPERATURE AND 7-10 % H_2O.
- O APPLY RELATIONSHIP IN f(T, %H_2O) TO HIGH DENSITY CRUSH TEST DATA.
- O PERFORM HIGH STRAIN RATE CRUSH TESTS

RESULT:

HIGH DENSITY BALSA CRUSH STRENGTH AS A FUNCTION OF TEMPERATURE, %H_2O DEFORMATION RATE.

BR-100 IMPACT LIMITER

ENCASEMENT MATERIAL

- BR-100 USES KEVLAR FIBERS IN A TOUGHENED EPOXY RESIN MATRIX.

- PREPREG KEVLAR/EPOXY IS PROCURED AS COMMERCIAL GRADE AND DEDICATED AS SAFETY RELATED.

BR-100 IMPACT LIMITER

COMPOSITE MATERIAL TESTS

- CHARACTERIZATION TESTS: PERFORMED ON FIRST MATERIAL PROCURED TO GET MECHANICAL AND PHYSICAL PROPERTIES OF PREPREG AND COMPOSITE.

- QUALIFICATION TESTS: QUALIFIES MATERIAL FOR BR-100 SERVICE.

- CERTIFICATION TESTS: PERFORMED ON SUBSEQUENTLY PROCURED MATERIAL TO CERTIFY AS SAFETY-RELATED.

BR-100 IMPACT LIMITER

CHARACTERIZATION AND CERTIFICATION TESTS

- O MECHANICAL PROPERTIES (PERFORMED ON CURED COMPOSITE, TESTED AT ROOM TEMPERATURE).

  - TENSILE STRENGTH AND MODULUS - FIBER DEPENDENT

  - INTERLAMINAR SHEAR STRENGTH - RESIN DEPENDENT

  - COMPRESSIVE STRENGTH - DEPENDENT ON FIBER, RESIN AND INTERFACE

- O PHYSICAL PROPERTIES (PERFORMED ON PREPREG)

  RESIN CONTENT

  VOLATILE CONTENT

  RESIN PERCENT FLOW

BR-100 IMPACT LIMITER

QUALIFICATION TESTS

- O MECHANICAL PROPERTIES (PERFORMED ON FULLY CURED COMPOSITE).
  - TENSILE STRENGTH AND MODULUS (AT $-20^{\circ}F$ AND $300^{\circ}F$)
  - INTERLAMINAR SHEAR (AT $-20^{\circ}F$ AND $300^{\circ}F$)
  - COMPRESSION STRENGTH (AT $-20^{\circ}F$ AND $300^{\circ}F$)

- O ENVIRONMENTAL BEHAVIOR
  - THERMAL CYCLED PLUS MECHANICALS
  - ACCELERATED AGING PLUS MECHANICALS

CONCLUSION

- O BALSA MIN AND MAX CRUSH STRENGTH WILL BE DETERMINED USING JPL, BALTEK AND B&W TEST DATA.

- O KEVLAR/EPOXY COMPOSITE WILL BE CHARACTERIZED AND QUALIFIED BY A SERIES OF MECHANICAL, PHYSICAL AND ENVIRONMENTAL TESTS.

BR-100 IMPACT LIMITERS

DEVELOPMENT TESTING

- DESIGN ANALYSIS
  - ILAN COMPUTER CODE
- "DESIGN BY TEST" APPROACH
- TESTING PROGRAMS
  - SCOPING TESTS
  - ENGINEERING TESTS
    - COMPONENT TESTING (DESIGN DEVELOPMENT)
    - STATIC FORCE-DISPLACEMENT TESTS
    - MATERIAL TESTING
  - VERIFICATION TESTING (LICENSING)

B&W FUEL COMPANY

BR-100 IMPACT LIMITERS

- SCALE MODEL IMPACT LIMITER DESIGN *Later meeting*

- VERIFICATION TEST MODEL
  - QUARTER SCALE LIMITER CONFIGURATION
  - LIMITER-TO-CASK ATTACHMENT CONFIGURATION
  - SCALING CONSIDERATIONS *Later meeting*

B&W FUEL
COMPANY

BR-100 IMPACT LIMITERS

- ENGINEERING TESTS

  - STATIC FORCE-DISPLACEMENT TESTS

    - SIDE LOADING
    - LOW ANGLE OBLIQUE (SLAPDOWN)
    - OBLIQUE (CG OVER CORNER)

  - DATA PACKAGE

    - FORCE-DISPLACEMENT CURVE AT VARIOUS ANGLES

B&W FUEL COMPANY

BR-100 IMPACT LIMITERS

- VERIFICATION TESTING

  - 30 FOOT DROP TESTS

    - SLAPDOWN @ TEMP. 240 F

    - BOTTOM END IMPACT @ AMBIENT TEMP.

    - OBLIQUE @ TEMP. -20 F

  - PUNCTURE TESTS

    - CASK BODY / SIDE DROP

    - CLOSURE LID / CENTER

    - CLOSURE LID / COVER PLATE

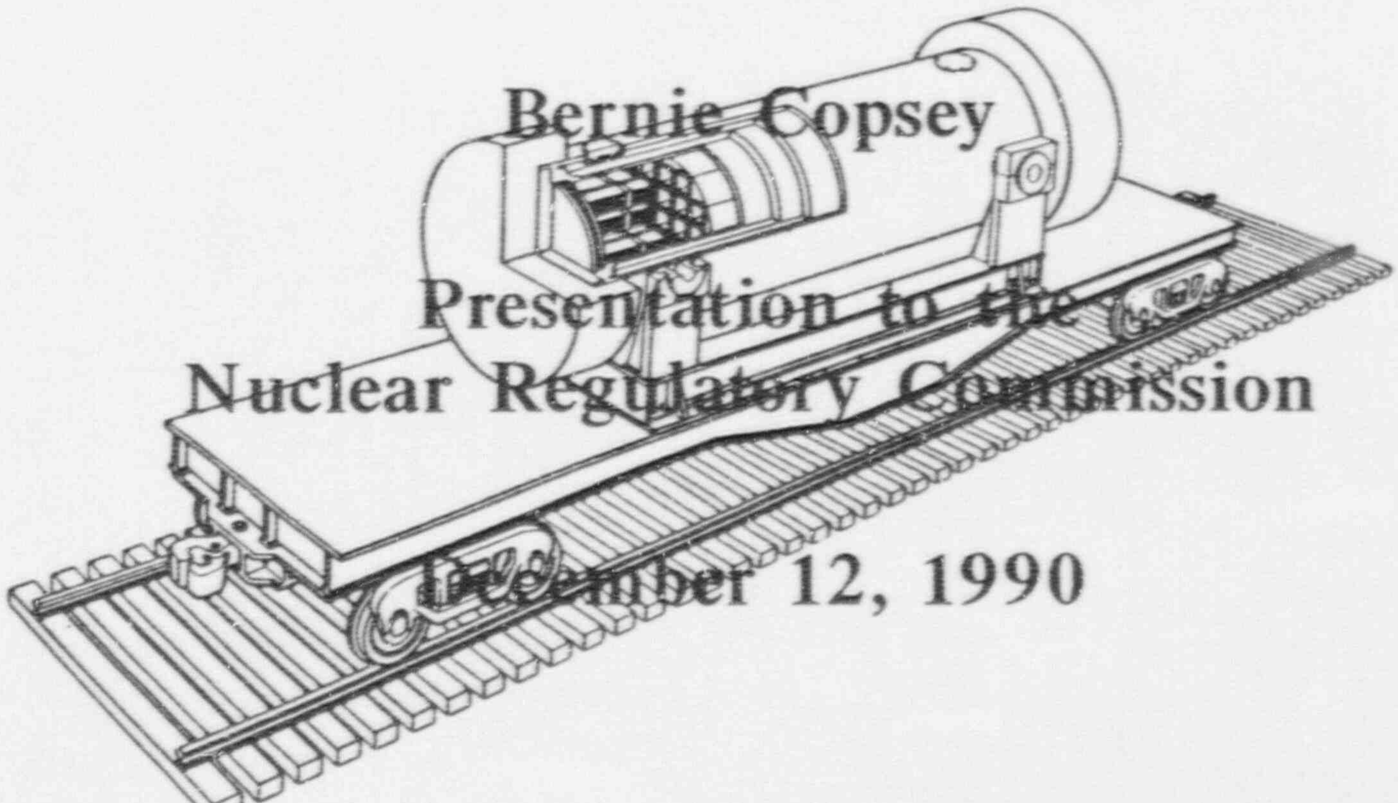
B&W FUEL COMPANY

BR-100 IMPACT LIMITERS

- VERIFICATION TESTS
  - DATA PACKAGE -- REGULATORY HYPOTHETICAL ACCIDENT TESTS
    - DEFORMATIONS
    - TEMPERATURE OF CASK SURFACE
    - CASK BODY ACCELERATION

B&W FUEL COMPANY

BR-100 CASK
Thermal Analyses



Bernie Copsey

Presentation to the
Nuclear Regulatory Commission

December 12, 1990

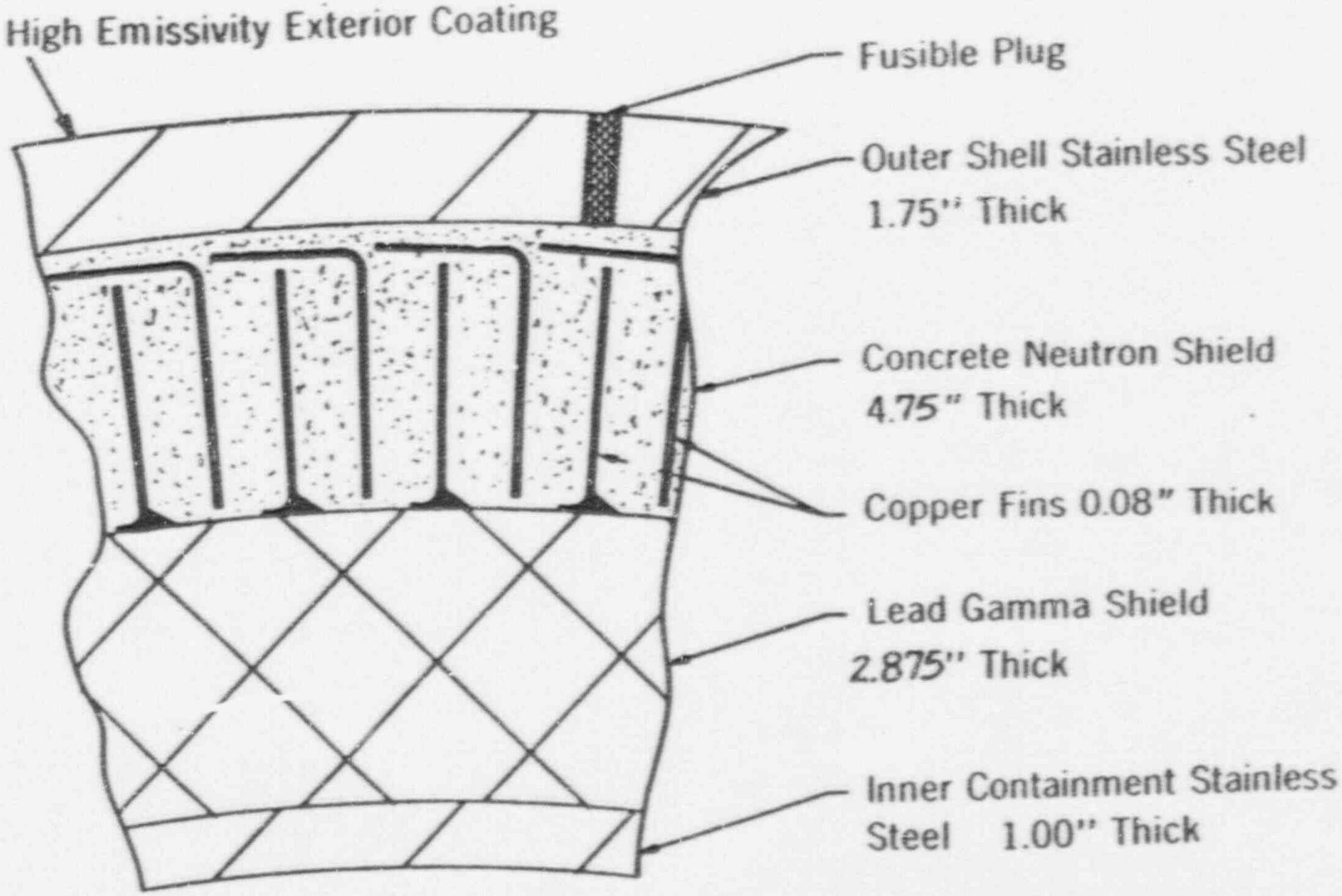
B&W Fuel Company

BR-100 Thermal Analyses

- Model Description
- Thermal Enhancements in the Design
- Normal Operation
  - Basket cross-section
  - Cask longitudinal section
- Hypothetical Accident Analyses
  - Thermal testing
  - Basket cross-section
  - Cask longitudinal section
- Conclusion

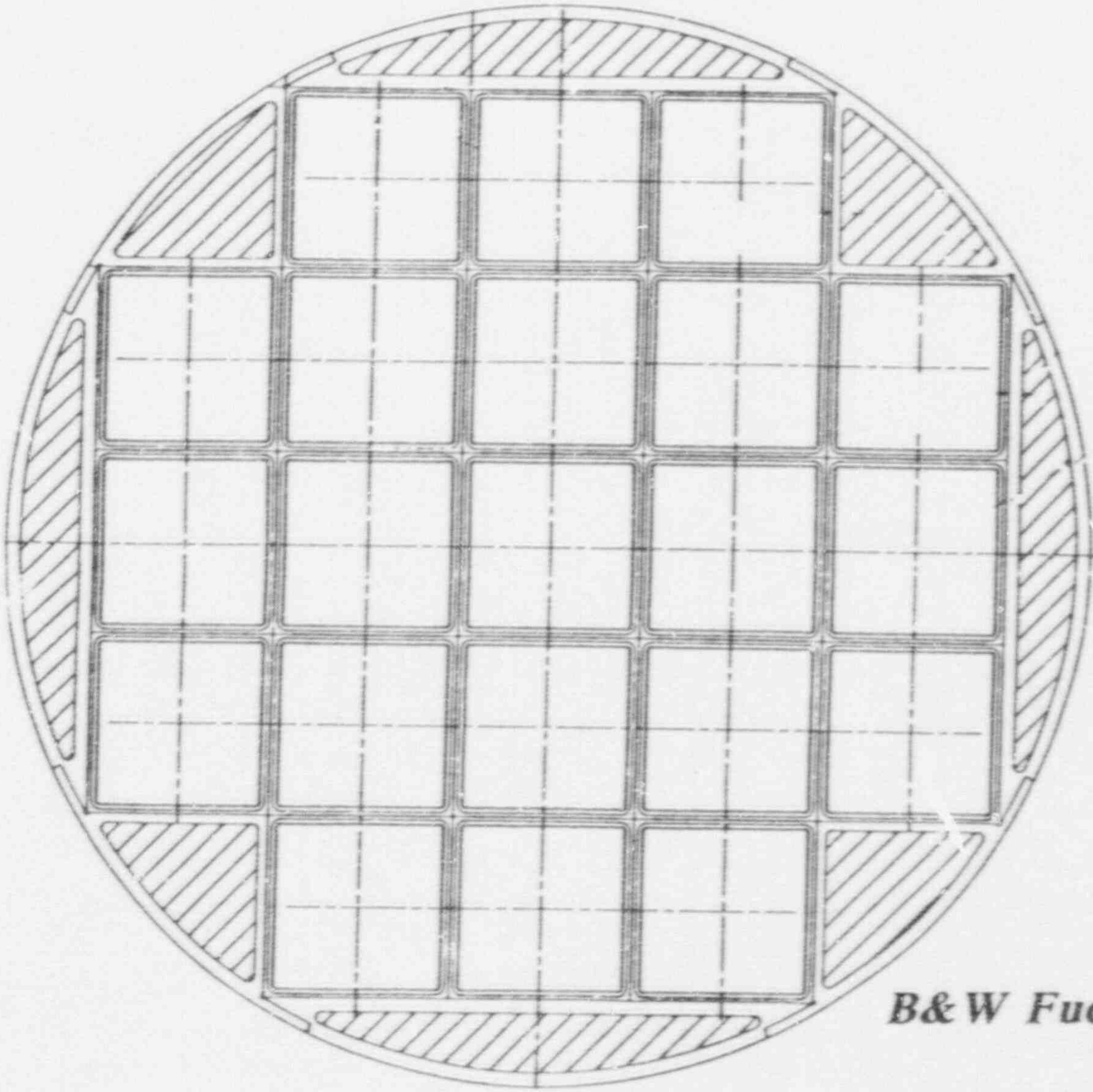
B&W Fuel Company

BR-100 Multi-layer Cask Wall



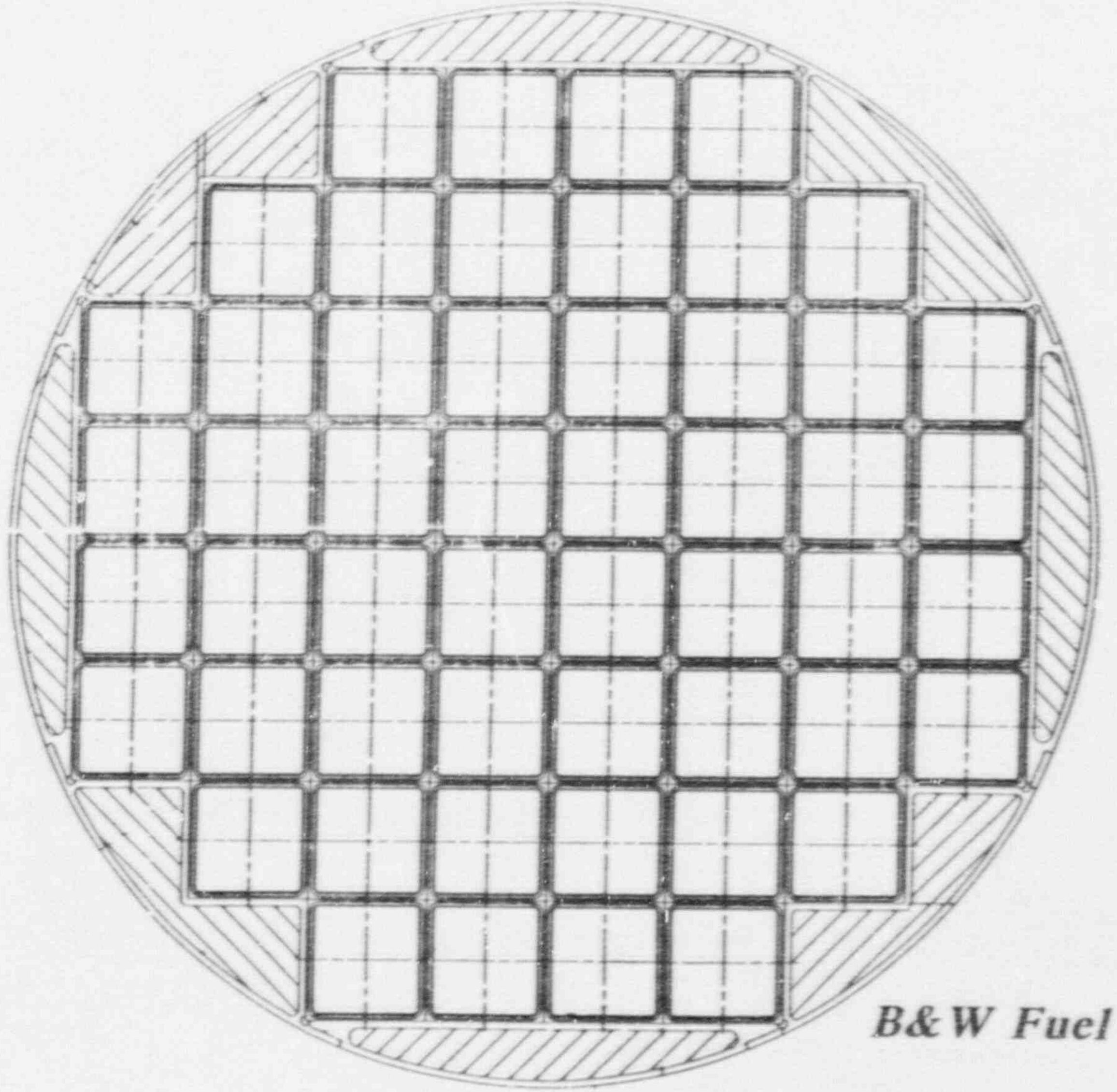
B&W Fuel Company

BR-100 Cask Basket
PWR Configuration



B&W Fuel Company

BR-100 Cask Basket
BWR Configuration



B&W Fuel Company

BR-100 Thermal Enhancements in the Design

- White paint exterior coating
- Robatel concrete-copper fin thermal/neutron shield
- Helium fill gas
- Copper/stainless steel laminate in basket

B&W Fuel Company

Thermal Analyses Assumptions

- Maximum temperatures occur near the axial midpoint
- Cask wall heat transfer is primarily one-dimensional
- Basket heat transfer is two-dimensional
- Cladding temperature calculated using Wooten-Epstein equation
- Cask inner wall-to-former gap is 100 mils

Cask Exterior Paint

- Clean white paint
  - Solar band $\alpha = 0.16$
  - Infrared band $\epsilon = 0.89$
- Dirty white paint
  - Solar band $\alpha = 0.30$
  - Infrared band $\epsilon = 0.89$
- There is little data on the effect of: dirt, scratches, nicks, corrosion, weathering

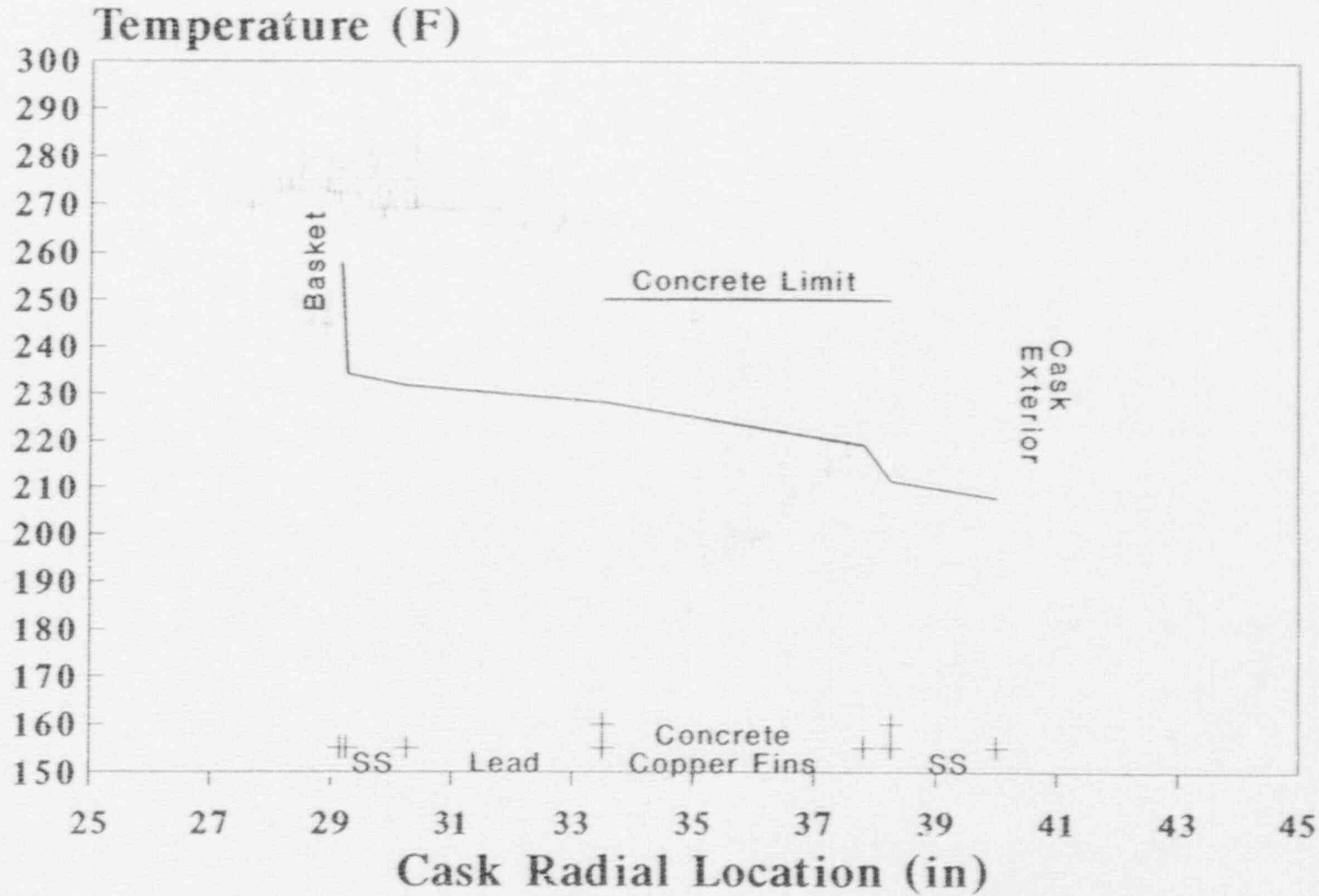
Personnel Barrier

- All of the thermal analyses assumed no personnel barrier
- The current personnel barrier will shade the cask and allow adequate ventilation
- Sensitivity studies indicate the personnel barrier will improve thermal performance
- The maximum personnel barrier temperature is less than 170 F

Temperature Design Limits For Normal Operation

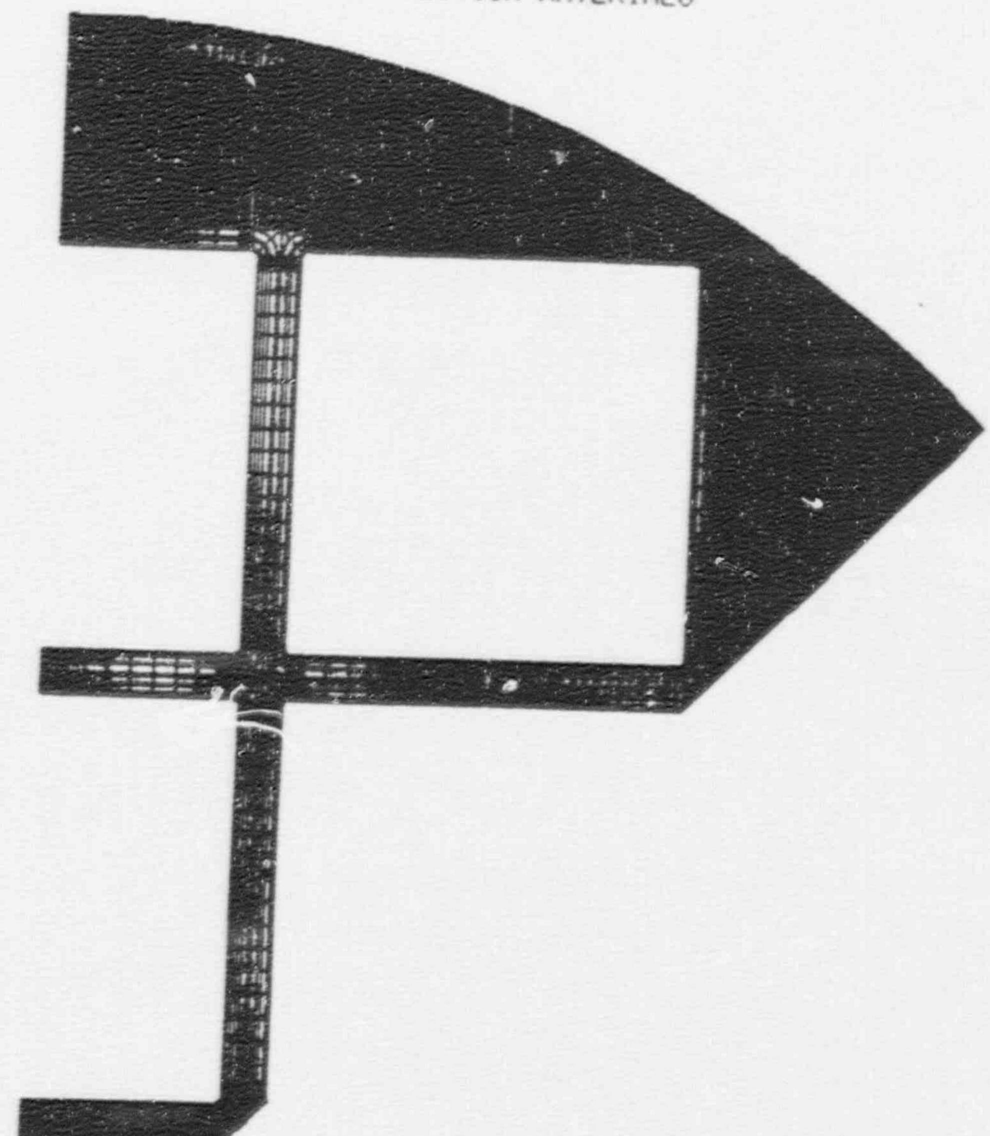
• Personnel Barrier	180 F
• Concrete	250
• Kevlar/Epoxy	250
• Closure Lid Seal	300
• Lead	621
• Fuel Cladding	680

PWR Cask Temperature Distribution

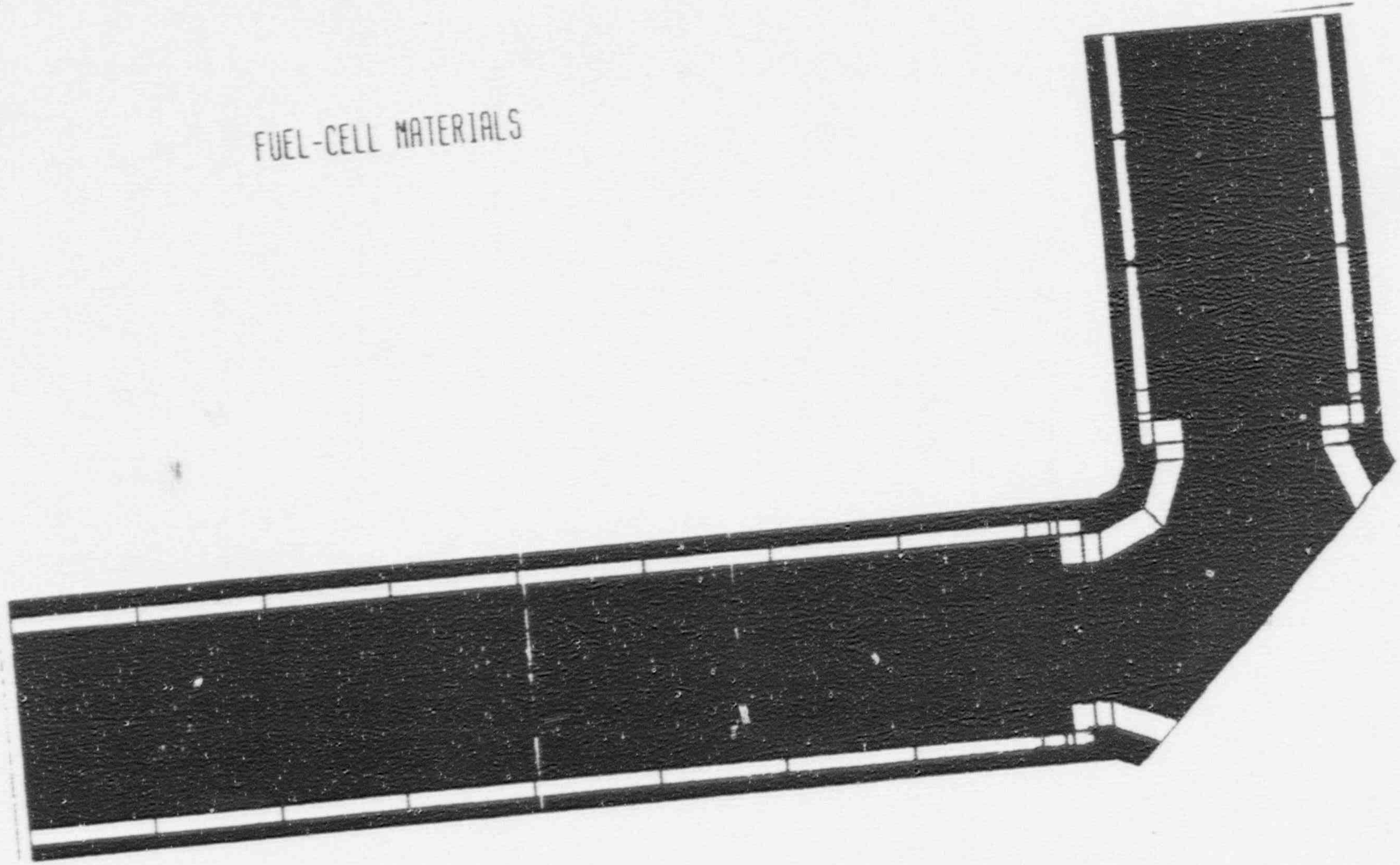


B&W Fuel Company

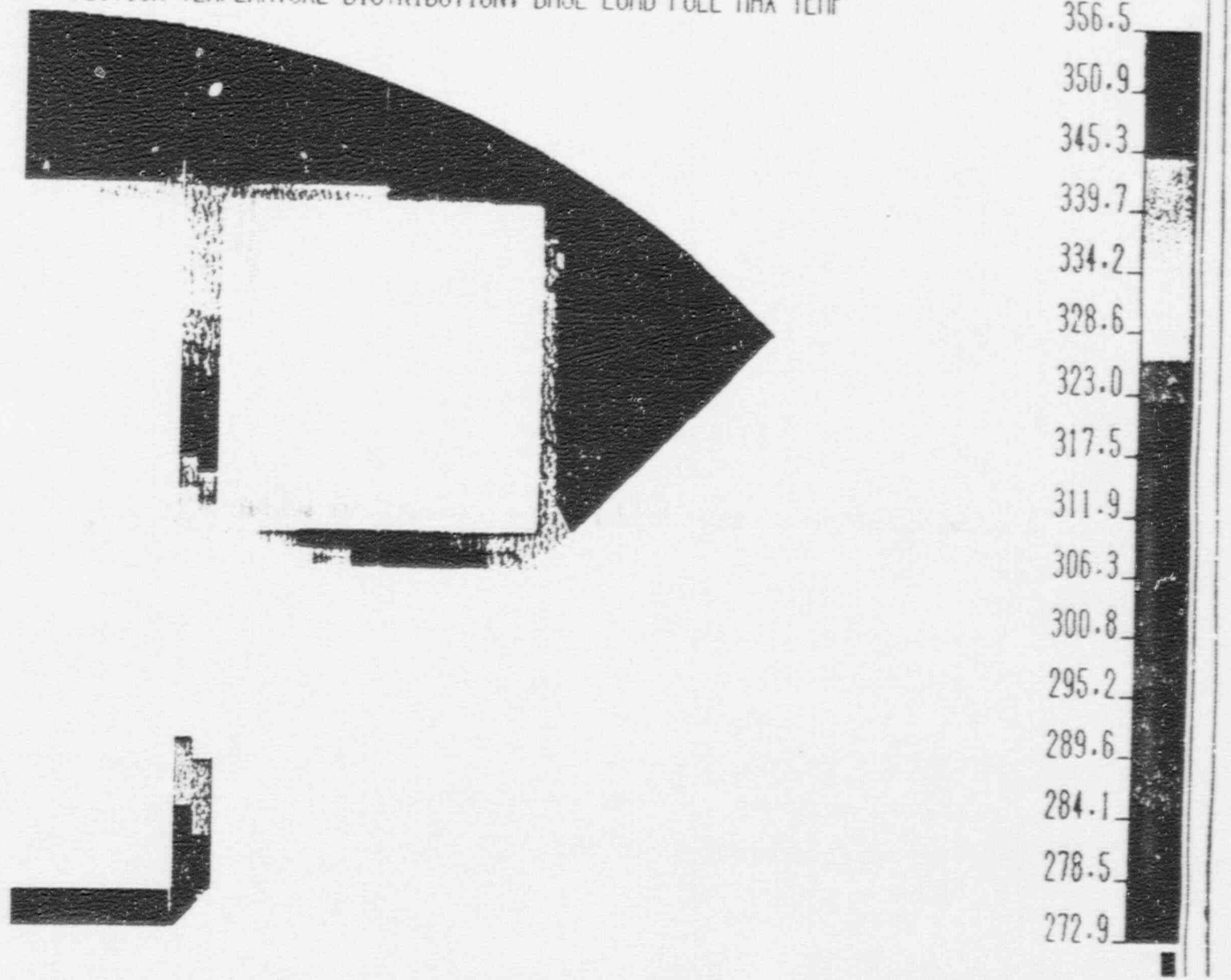
BASKET CROSS-SECTION MATERIALS



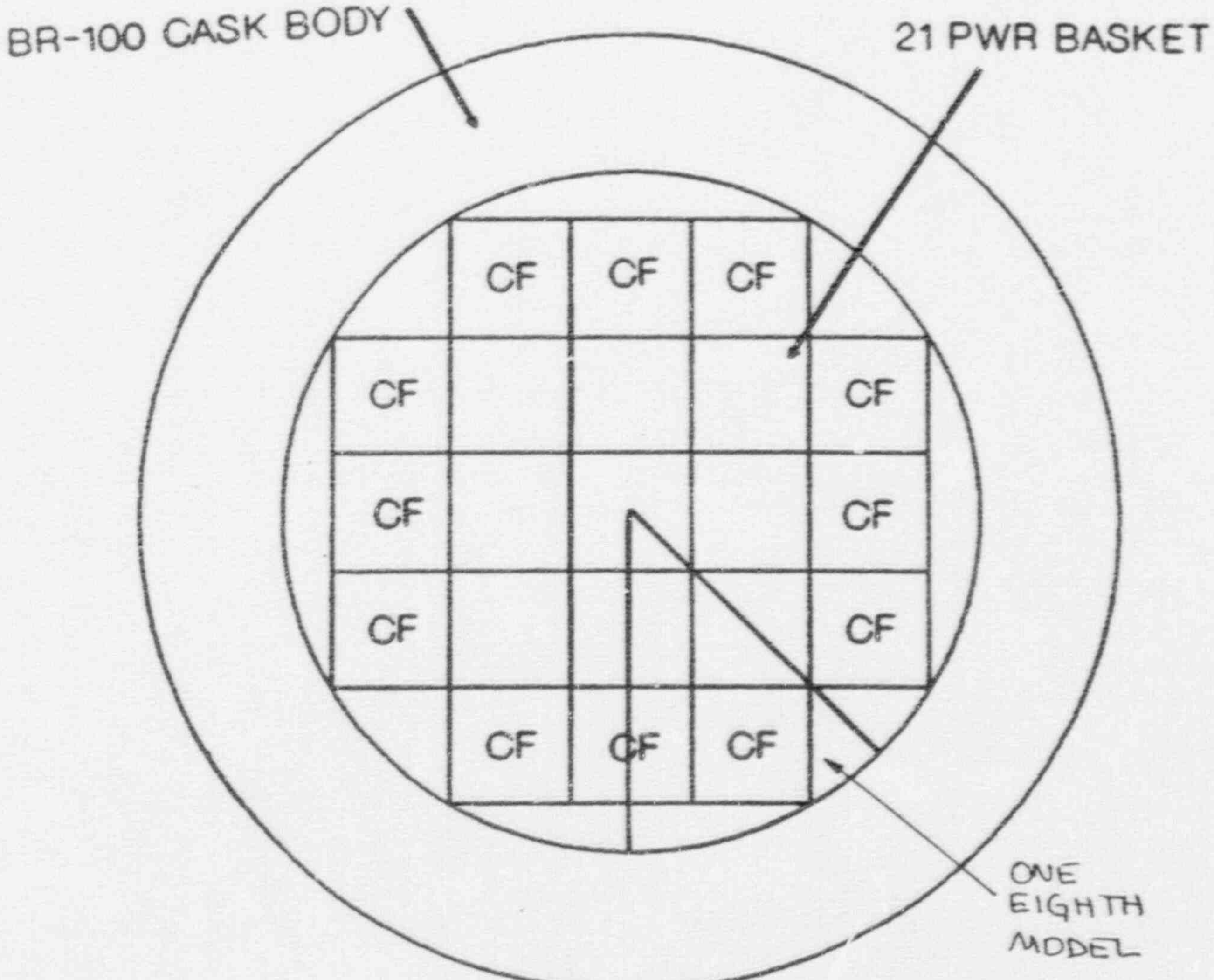
FUEL-CELL MATERIALS



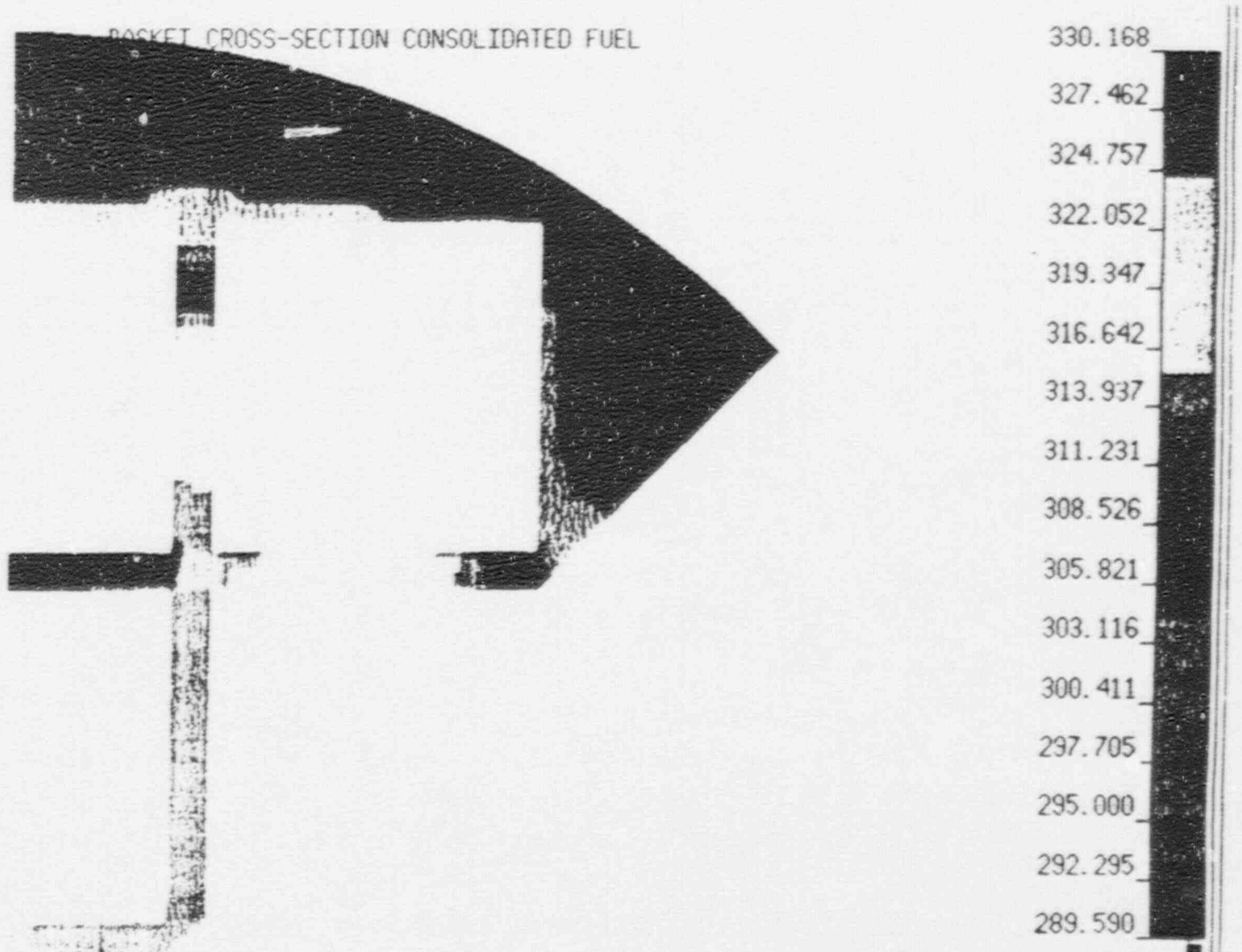
BASKET CROSS-SECTION TEMPERATURE DISTRIBUTION, BASE-LOAD FUEL MAX TEMP



Consolidated Fuel Model



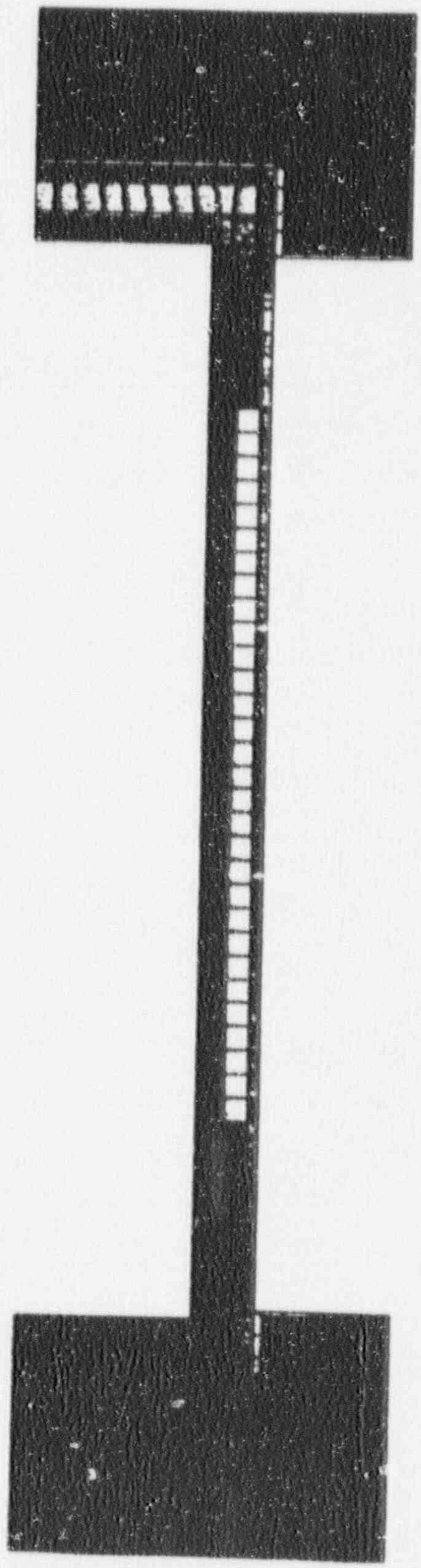
B&W Fuel Company


BASKET CROSS-SECTION CONSOLIDATED FUEL
330.168
327.462
324.757
322.052
319.347
316.642
313.937
311.231
308.526
305.821
303.116
300.411
297.705
295.000
292.295
289.590

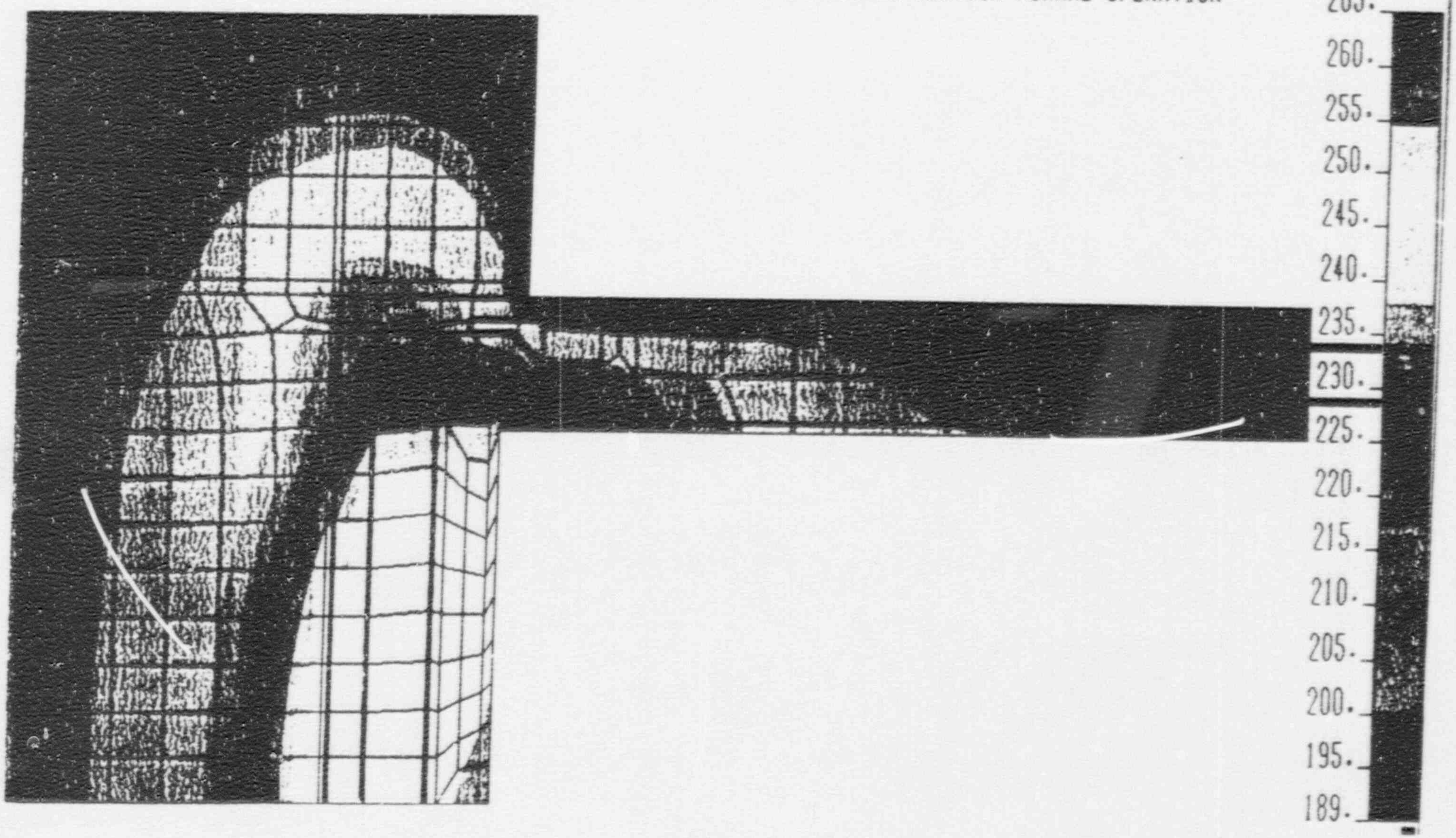
Longitudinal Section Model

- Peak component temperatures
  - Seals
  - Lead
  - Kevlar/Epoxy
- Thermal stress
  - Shield plug
  - Closure lid
  - Cask wall

B&W Fuel Company



TEMPERATURE DISTRIBUTION UPPER CASK LONGITUDINAL SECTION NORMAL OPERATION

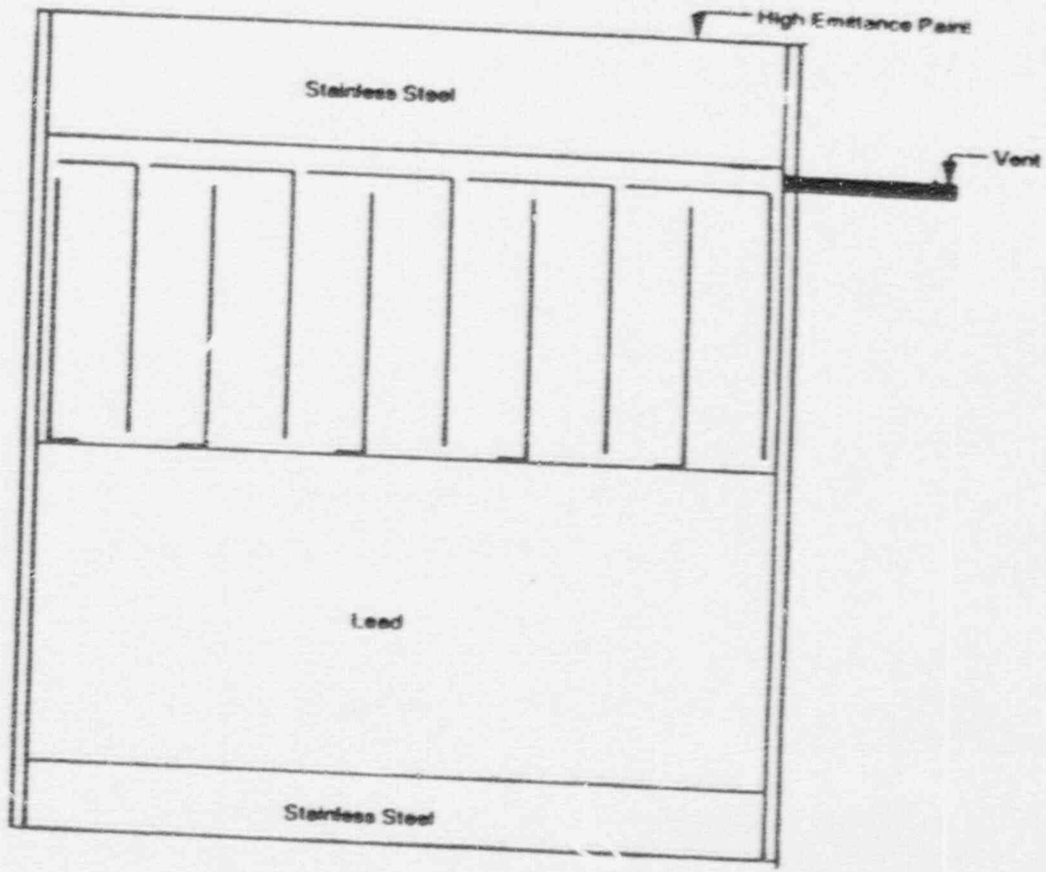


Thermal Transient Testing

- Pre-test thermal conductivity measurement
- Establish realistic thermal gradient
- Exposure to 1475 F heat flux for 30 minutes
- Controlled cooldown
- Post-cooldown steady-state thermal conductivity measurement
- Post-cooldown destructive analysis

B&W Fuel Company

Hypothetical Accident Thermal Test Section



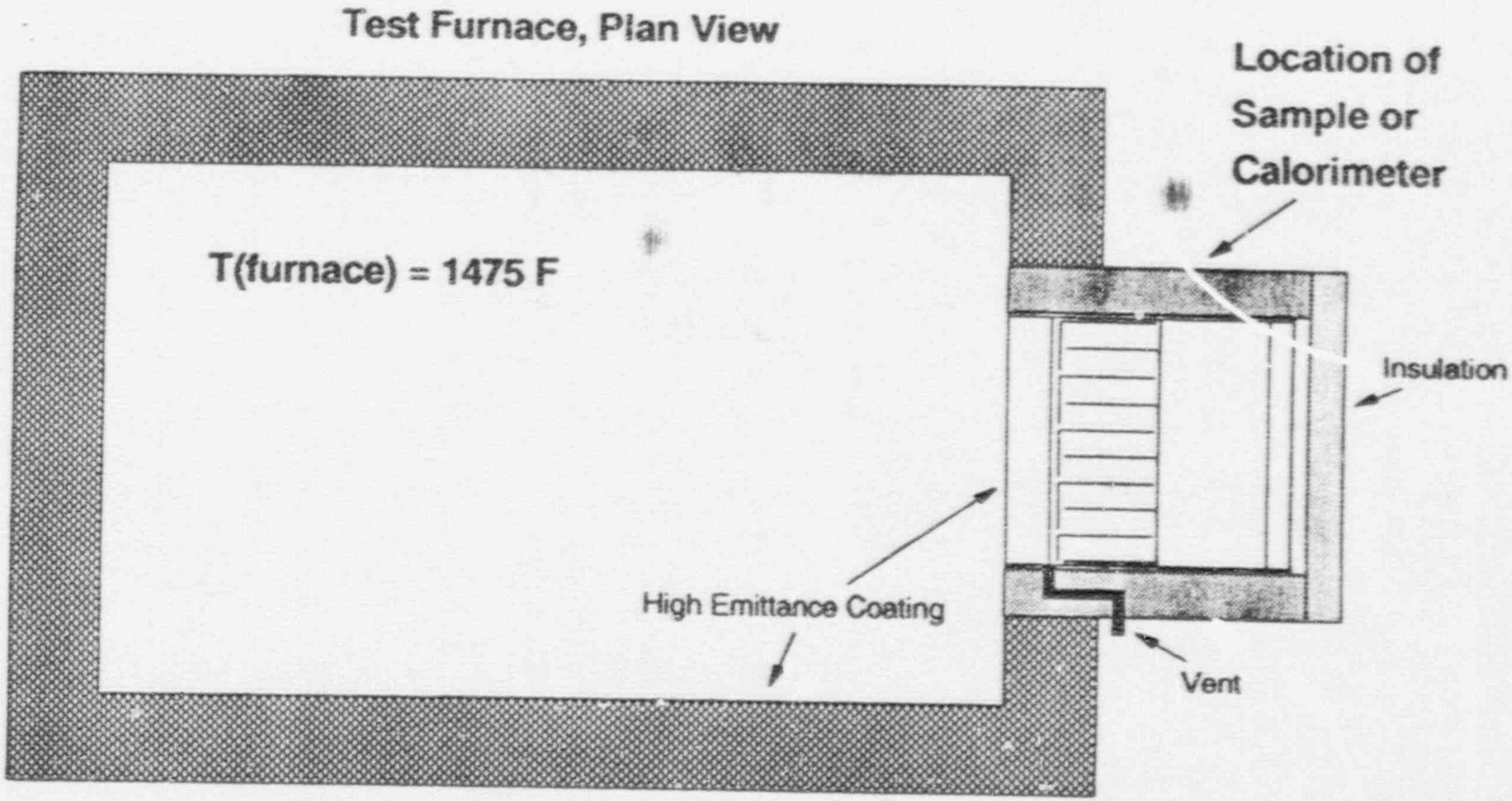
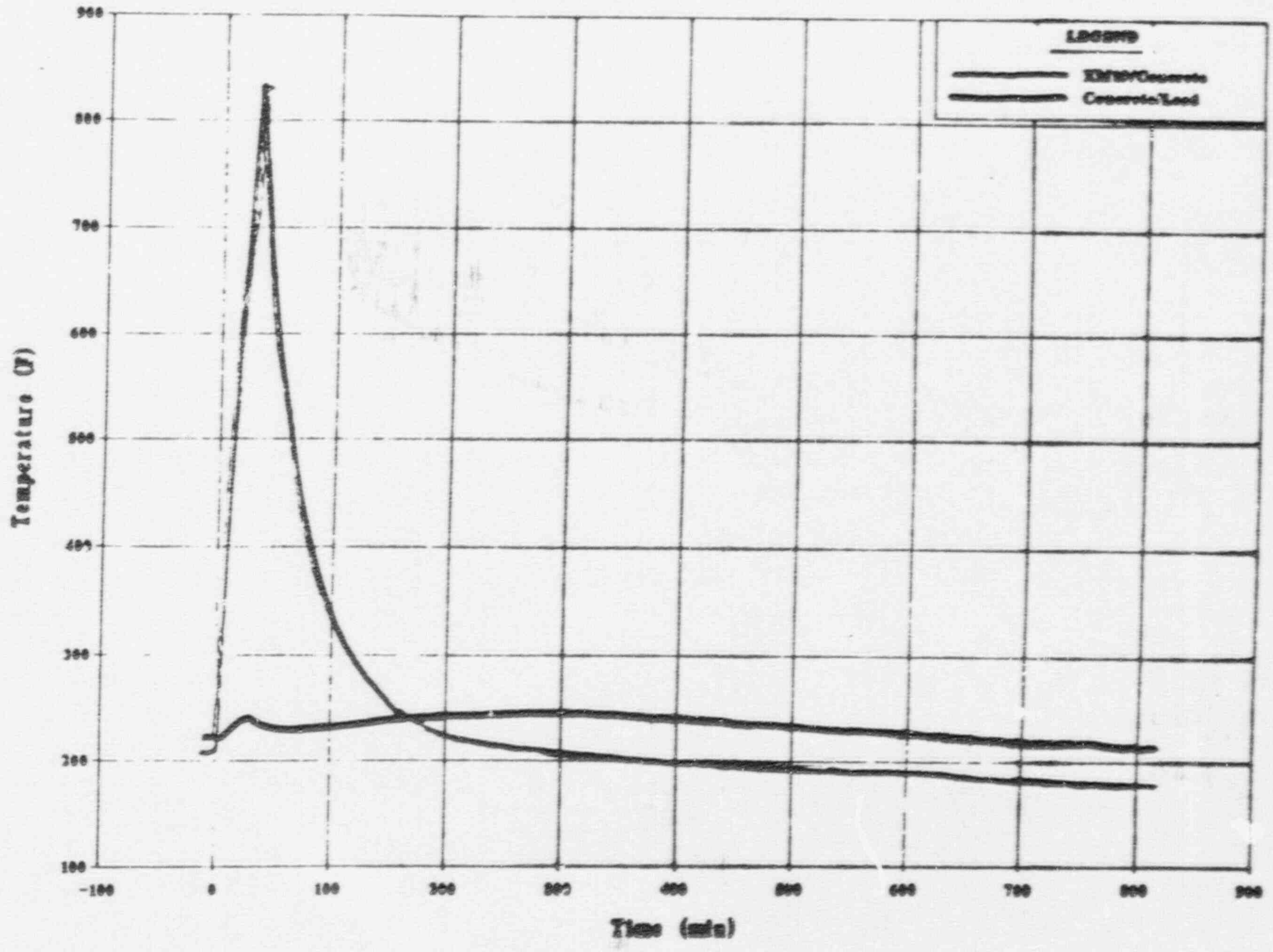


Figure 4. HAT Test Configuration

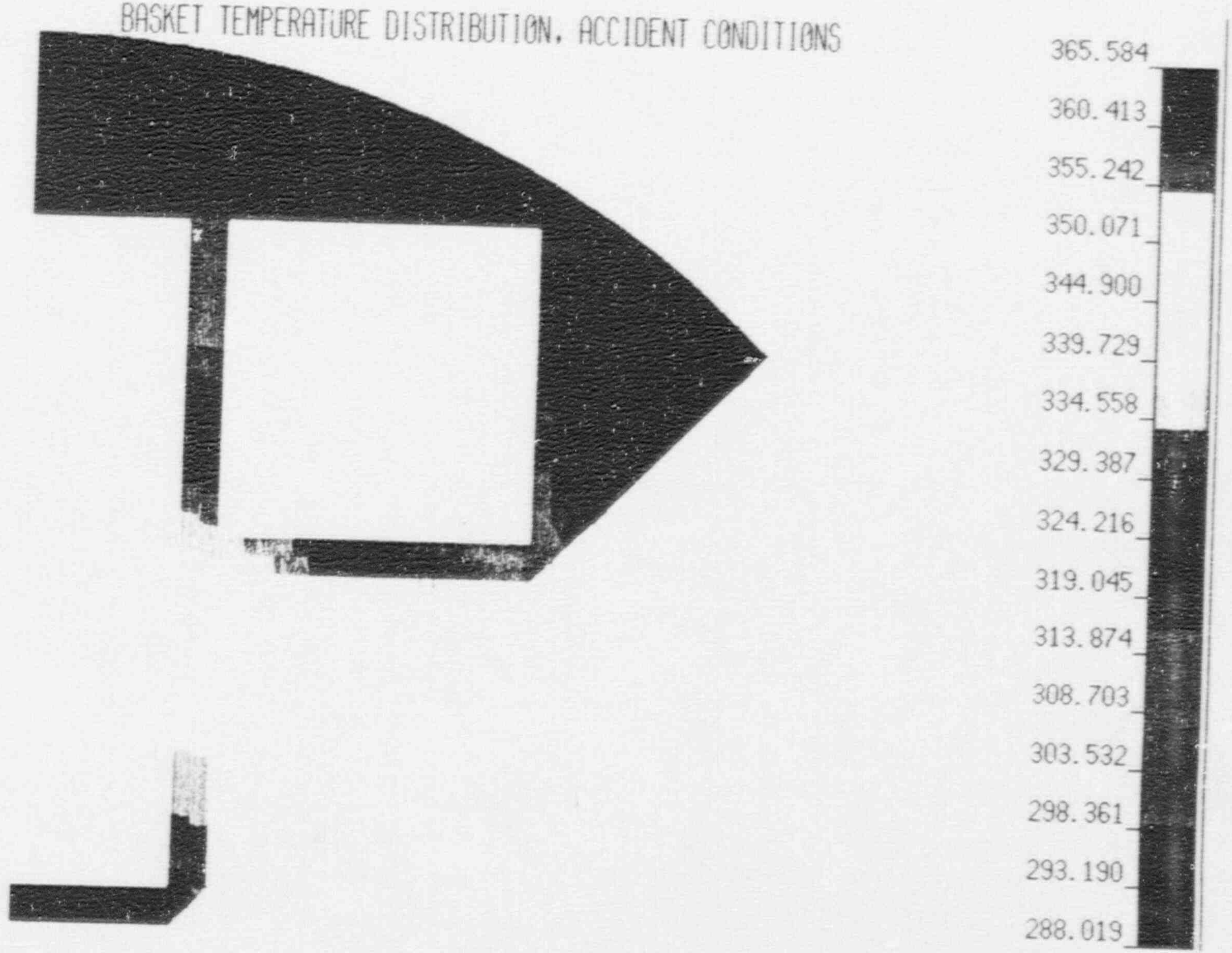
PTP-89012, Rev:3
CLD

ARC Fire Test Temperature Response
Channel 70 and 64



Thermal Design Limits for the Hypothetical Fire Accident

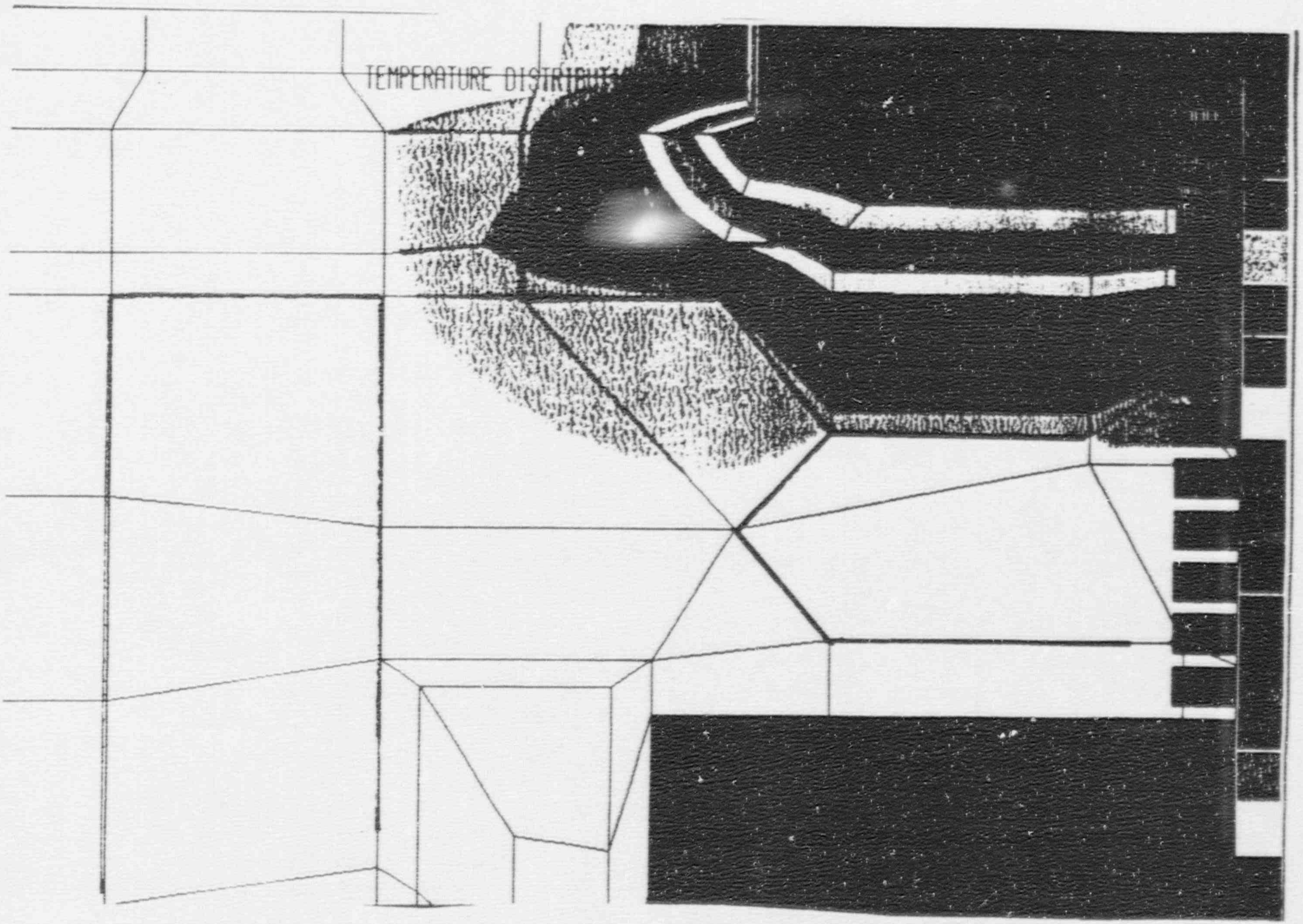
- Cladding temperature limit of 680 F
- Lead temperature limit of 621 F
- Closure lid seal temperature limit of 300 F
- Acceptable thermal stress and temperatures for structural analyses

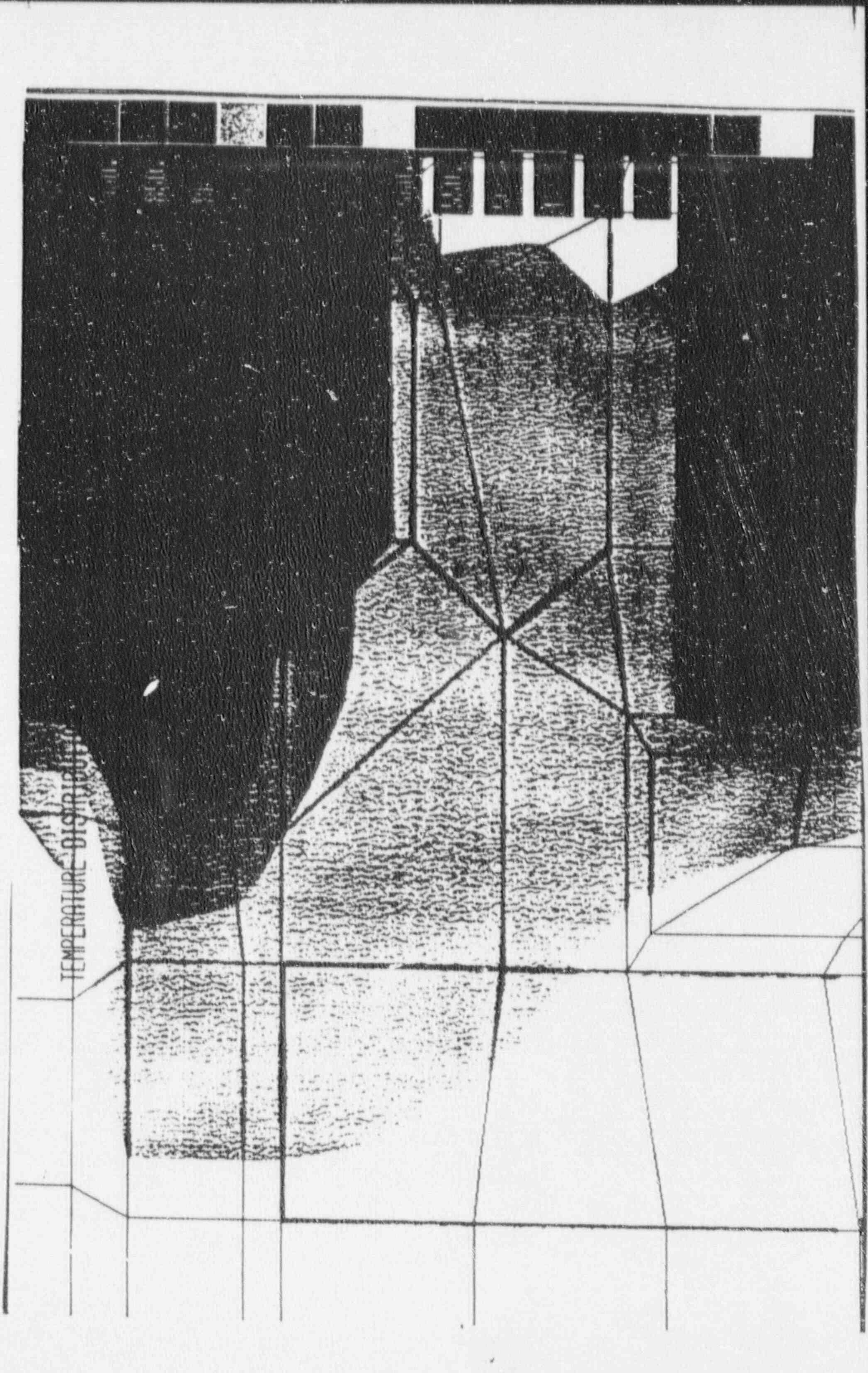

BASKET TEMPERATURE DISTRIBUTION, ACCIDENT CONDITIONS
365.584
360.413
355.242
350.071
344.900
339.729
334.558
329.387
324.216
319.045
313.874
308.703
303.532
298.361
293.190
288.019

Longitudinal Section Model

- Impact limiter crushed by 80%
- Boundary conditions
  - All external temperatures from hypothetical accident thermal test
  - Concrete/lead interface temperature is from the HAT test
- Initial temperatures from the time zero results

B&W Fuel Company


TEMPERATURE DISTRIBUT



TEMPERATURE DISTRIBU

Conclusions

- The temperatures in the basket and cask are less than the temperature limits for
  - PWR normal operation
  - PWR hypothetical accident
  - BWR normal operation
  - BWR hypothetical accident
- The thermal analyses have been completed with documentation and QA remaining