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

DMB 016

December 1, 1982

Dockets Nos. 50-269/270/287

LICENSEE: Duke Power Company

FACILITY: Oconee Nuclear Station Units 1, 2 and 3

SUBJECT: MINUTES OF MEETING HELD WITH DUKE POWER COMPANY ON NOVEMBER 30, 1982

A meeting was held on November 30, 1982, at Duke Power Company's request, to discuss the use of Mark BZ fuel assemblies in future Oconee Nuclear Station reload cores. Duke requested the meeting to obtain NRC feedback on what types of information would be required to approve the use of Mark BZ fuel assemblies. A list of attendees is enclosed (Enclosure 1); a copy of the slide presentation is also enclosed (Enclosure 2).

B&W personnel presented the design description and performance evaluations which have been performed on the Mark BZ design. SMUD personnel were also in attendance since usage of the Mark BZ design is scheduled for the Rancho Seco facility earlier than that planned for Oconee.

The Mark BZ fuel assembly is essentially identical to the approved Mark B fuel assembly, except for the intermediate spacer grids. Both assemblies utilize the 15 x 15, zircaloy clad fuel rods, zircaloy guide tubes, stainless steel end fittings, and six intermediate spacer grids. The spacer grids are Inconel 718 on Mark B assemblies and Zircaloy-4 on Mark BZ assemblies. There are also some design changes to the BZ grids.

The licensees plan to use the Mark BZ assemblies for improved Uranimum utilization to improved economy with lower axial peaking and also ease of fuel handling.

The licensees expressed the following needs from NRC:

1. Agreement on their overall approach,
2. Identification of concerns which need to be addressed,
3. Approval of the Mark BZ design by September 1983 to support manufacture of fuel for Rancho Seco Cycle 7 restart, and
4. Approval of BWC Critical Heat Flux correlation for Mark BZ assemblies.

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PDR ADOCK 05000269
P PDR

OFFICE ▶							
SURNAME ▶							
DATE ▶							

Members of the staff indicated that there should be little technical difficulty with our review, however, scheduling the necessary manpower may be limiting. A number of subjects which should be included in the licensee's report were discussed and an advance copy was requested for an overview to ensure completeness prior to formal submittal.

Original Signed By
Philip C. Wagner, Project Manager
Operating Reactors Branch #4
Division of Licensing

Enclosures:
1. List of Attendees
2. Slide Presentation

OFFICE	ORB#4:DL						
SURNAME	PWagner;cf						
DATE	12/1/82						

ORB#4:DL

MEETING SUMMARY DISTRIBUTION

Licensee: Duke Power Company

* Copies also sent to those people on service (cc) list for subject plant(s).

Docket File
NRC PDR
L PDR
ORB#4 Rdg
GLainas
JStolz
Project Manager-PWagner
Licensing Assistant-RIngram
OELD
Heltemes, AEOD
IE
SShowe (PWR) or CThayer (BWR), IE
Meeting Summary File-ORB#4
RFraley, ACRS-10
Program Support Branch

ORAB, Rm. 542

Meeting Participants Fm. NRC:

GSchwenk
MDunenfeld
RMeyer
CBerlinger
SMiner

Enclosure 1

LIST OF ATTENDEES
NOVEMBER 30, 1982 MEETING
DUKE POWER COMPANY

Name	Organization
P. C. Wagner	NRC/Project Manager
R. L. Gill	DPC/Licensing
W. D. Reckley	DPC/Reactor Safety
R. G. Snipes	DPC/Fuel Cycle Operations
R. J. Walker	B&W/Fuel Services
E. J. McGuinn	B&W/Fuel Engineer
L. L. Losh	B&W/Fuel Engineering
C. F. McPhatter	B&W/Fuel Engineering
M. R. Oren	SMUD
C. E. Barksdale	B&W
R. V. DeMars	B&W
J. B. Andrews	B&W
R. Powers	SMUD
G. A. Schwenk	NRC/CPB
M. Dunenfeld	NRC/CPS
R. Meyer	NRC/CPB Fuels
C. H. Berlinger	NRC/CPB

Zircaloy Intermediate Spacer Grid Design and Licensing Review

November 30, 1982

Duke Power Company

Sacramento Municipal Utility District

Babcock & Wilcox

Nuclear Regulatory Commission

Requested NRC Actions

- Agreement with overall approach
- Identification of any additional technical information required
- Approval of BZ design by September 1983
- Approval of BWC CHF correlation for BZ fuel

Meeting Objectives

- Present synopsis of development history
- Present design description and verification of the BZ fuel
- Present operating performance evaluation of the BZ fuel
- Demonstrate acceptability of BZ for full batch implementation
- Concurrence on scope of submittal
- Agreement on review and implementation schedule

Agenda For Mark BZ Review Meeting

Introduction	C.F. McPhatter
Mark BZ Design Description and Verification	E.J. McGuinn
Mark BZ Operating Performance Evaluation	L.L. Losh
Summary	C.F. McPhatter

Introduction

- Development History
- Schedule
- Benefits

Design Phase

Program Start	Late 1976
Prototype Design	Mid 1978
Initial Presentation to NRC	Dec. 1978
Licensing Report	May 1979
Flow Testing	Mid 1979
Life & Wear Test	Feb. 1980
Lead Demo Licensing Report	Feb. 1980

Verification Phase

Lead Demo - Oconee 2	June 1980
Critical Heat Flux Test	Dec. 1980
Demo Licensing Report	March 1981
Demo Assemblies - Oconee 1	Dec. 1981
First Cycle Post Irradiation Exam	Dec. 1981

Implementation Phase

Mark-BZ Portion of Rancho Seco Reload Report	Apr. 1983
NRC Approval of Mark BZ	Sept. 1983
Production Zircaloy Grids Fabrication	Dec. 1983
Mark BZ Assembly Fabrication	Dec. 1983
Rancho Seco Cycle 7 Reload Report	Apr. 1984
Fuel Delivery	June 1984
Rancho Seco Cycle 7 Startup	Sept. 1984

MK-BZ Benefits

- Improved Uranium Utilization
- More Economical
- Lower Axial Peaking
- Improved Handling Characteristics

MK-BZ Fuel Assembly

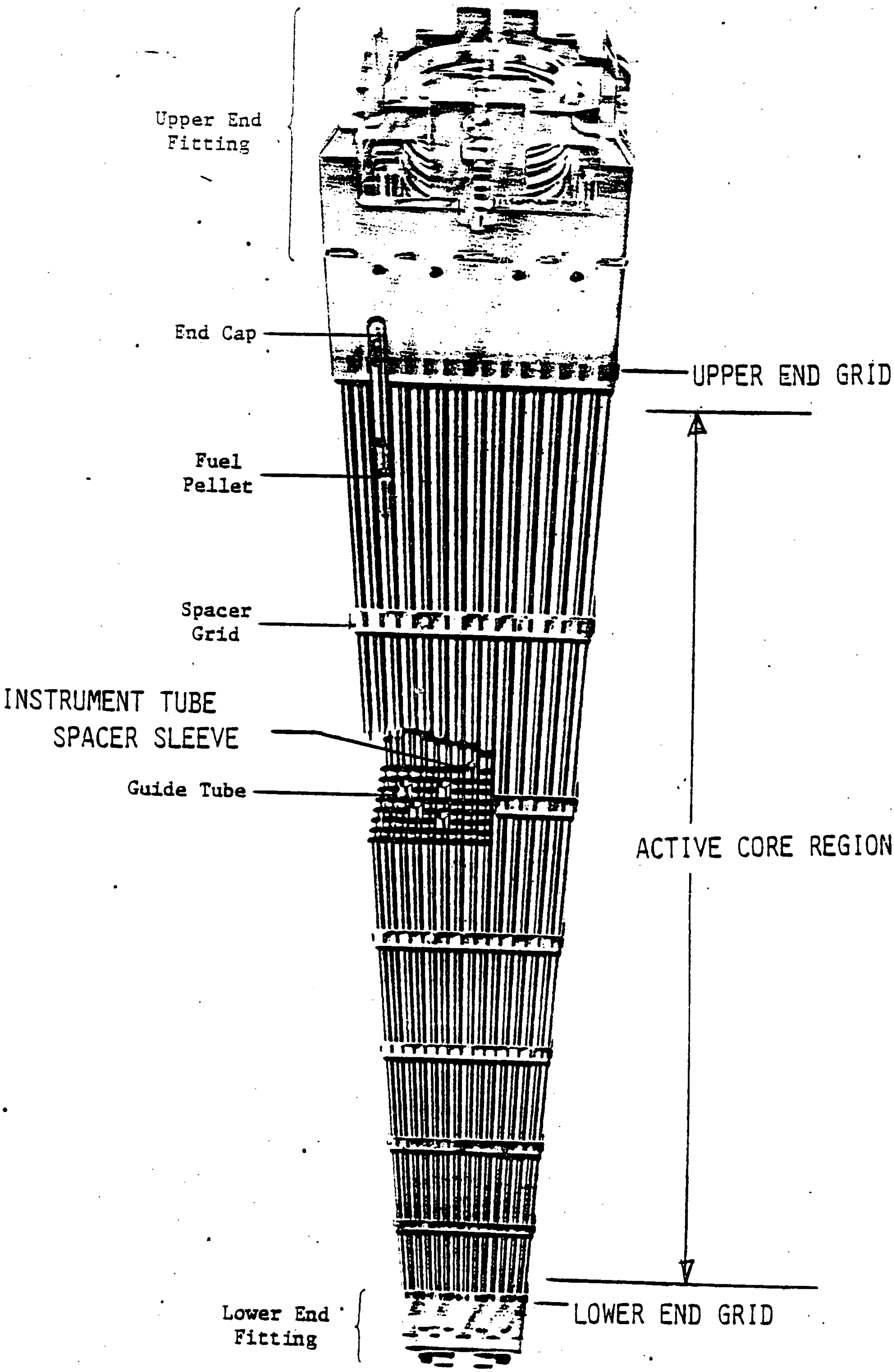
MK-BZ Design Description

- Standard MK-B fuel assembly design
- MK-BZ spacer grid
  - Material properties
  - Zircaloy-4 grid design

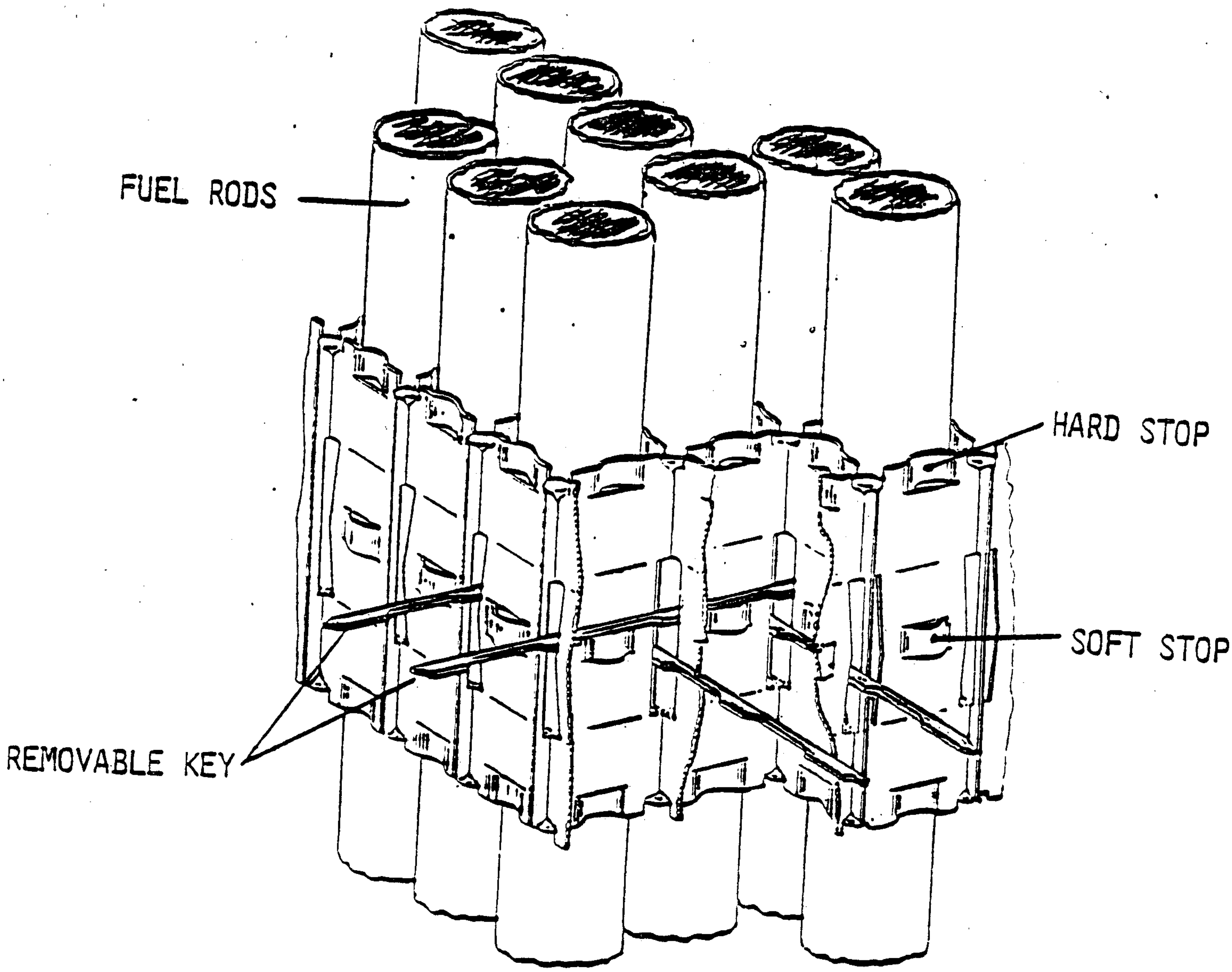
MK-BZ Verification Program

- Key performance factors
  - Relaxation (fretting)
  - Corrosion
  - Structural integrity
  - Local flow parameters
  - Handling characteristics
- Operating experience

STANDARD MK-B FUEL ASSEMBLY



MK-B Spacer Grid Design

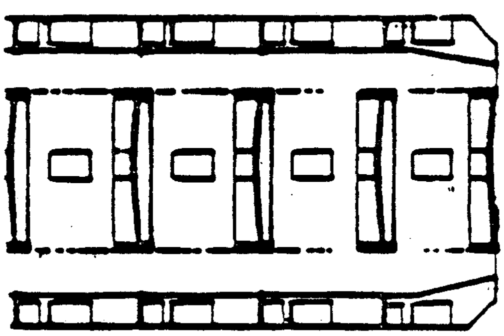


MK-BZ Spacer Grids

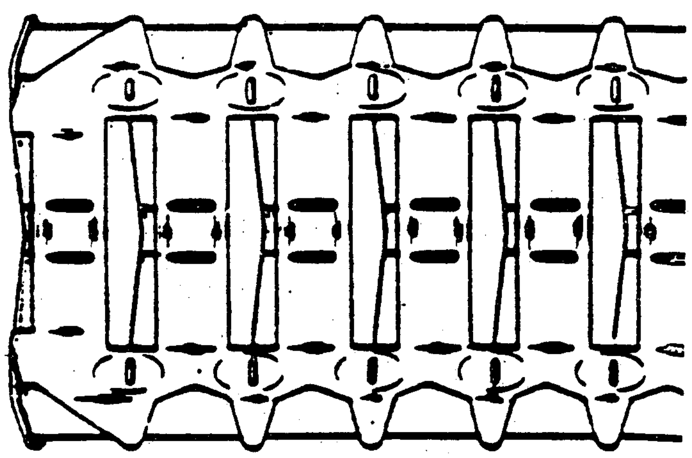
MK-BZ Grid Design - Functionally unchanged from MK-B

- Material properties
  - Zircaloy-4 vs. Inconel 718
- Design configuration
  - Increased grid height by 33%
  - Improved outside strip design
    - Lead - in tabs
  - Increased internal strip thickness
  - Reinforced center grid cell

MK-B



MK-BZ



Spacer Grid Material Properties

	MK-B Inconel-718	MK-BZ Zircaloy-4
Typical Chemical Composition	Ni - 52% Cr - 20% Fe - 18% Nb - 3% Mo - 3%	Zr - 98% Sn - 1.5% Fe - .2% Cr - .1% Ni - .05%
Cross Section	3.6 Barns	.2 Barns
Condition	Age Hardened	Alpha Annealed
Elongation	38% (Annealed)	14%
Elastic Modulus	$29x10^6$ psi (70°F) $26x10^6$ psi (650°F)	$14x10^6$ psi (70°F) $11x10^6$ psi (650°F)
Yield Stress	163 ksi (70°F) 141 ksi (650°F)	35 ksi (70°F) 15 ksi (650°F)
Tensile Strength	200 ksi (70°F) 195 ksi (650°)	60 ksi (70°F) 31 ksi (650°F)

MK-BZ Fuel Assembly

The MK-BZ fuel assembly design achieves improved uranium utilization by replacing the six intermediate spacer grids with grids fabricated from Zircaloy-4 material vs. Inconel 718 for the MK-B

- Basic fuel assembly design unchanged
- Fuel handling equipment interfaces unchanged
- Control rod interfaces unchanged
- Spacer grids are functionally unchanged

MK-BZ Verification Program

Structural Evaluation

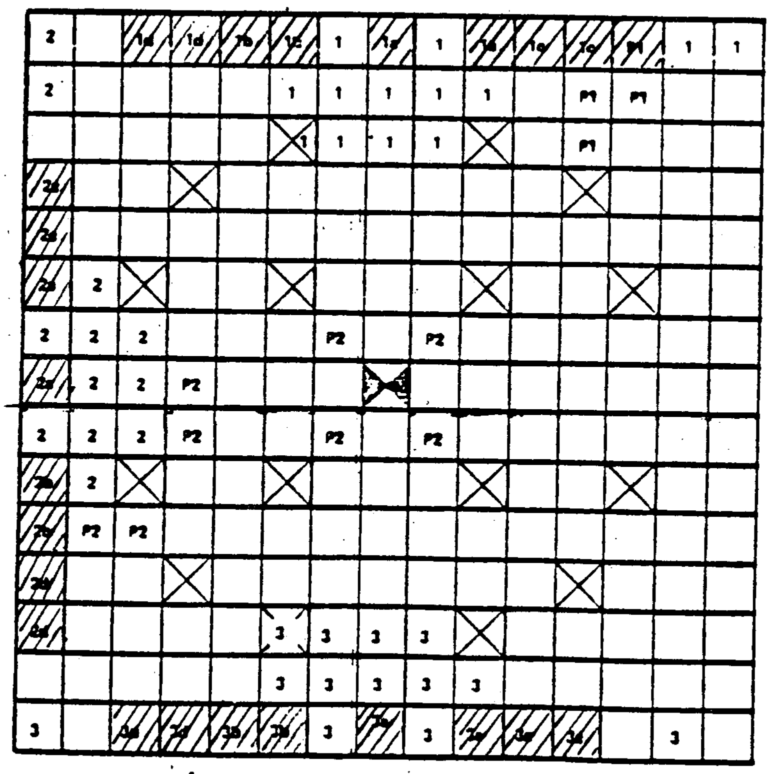
Fretting wear (relaxation)	Life & wear test
Grid corrosion	Life & wear test
Structural integrity	LOCA & seismic evaluation Grid crush test
Handling characteristics	F.A. handling test

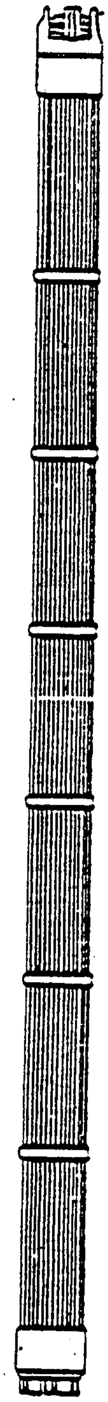
Operating Experience

Oconee - 2	Lead BZ demo assembly
Oconee - 1	Four BZ demo assemblies

MK-BZ Life & Wear Test

- Test environment simulates reactor conditions
- Full size prototype fuel assembly
    - Zircaloy grid
        - Relaxed cells
        - Loose rods (oversized cells)
    - Std. upper and lower end grid





Oversize cells at 2 or 6 grid locations

BZ Life & Wear Test Synopsis

- Inspections at 500 hours
  1000 hours
  1500 hours
- Fuel rod/grid interface

  Zircaloy grids

  Standard cells---1296 sites
  Oversized cells--1876 sites

  Inconel end grids

  Normal cells-----1056 sites

  Total 4228 sites

Results

- No significant wear (.001 inch)
- No indication of progressive wear
- No evidence of high amplitude fuel rod vibration

Conclusion:

- Spacer grid relaxation does not adversely effect the MK-BZ fuel assembly performance

MK-BZ Fuel Assembly

MK-BZ Zircaloy - 4 Spacer Grid

- Corrosion resistance factors
    - Oxidation during manufacturing
    - Surface contamination
- Evaluation
    - Autoclave testing (development)
    - Life and wear test

Results

- MK-BZ Zircaloy - 4 grid did not exhibit any significant corrosion in a reactor environment

MK-BZ Fuel Assembly

The structural integrity of the MK-BZ fuel assembly design was verified for seismic and LOCA events:

- Standard methods as described in topical report BAW-10133
- Generic analysis applicable to all operating skirt support plants
- Both all BZ and mixed core configurations investigated

MK-BZ Fuel Assembly

Structural Evaluation

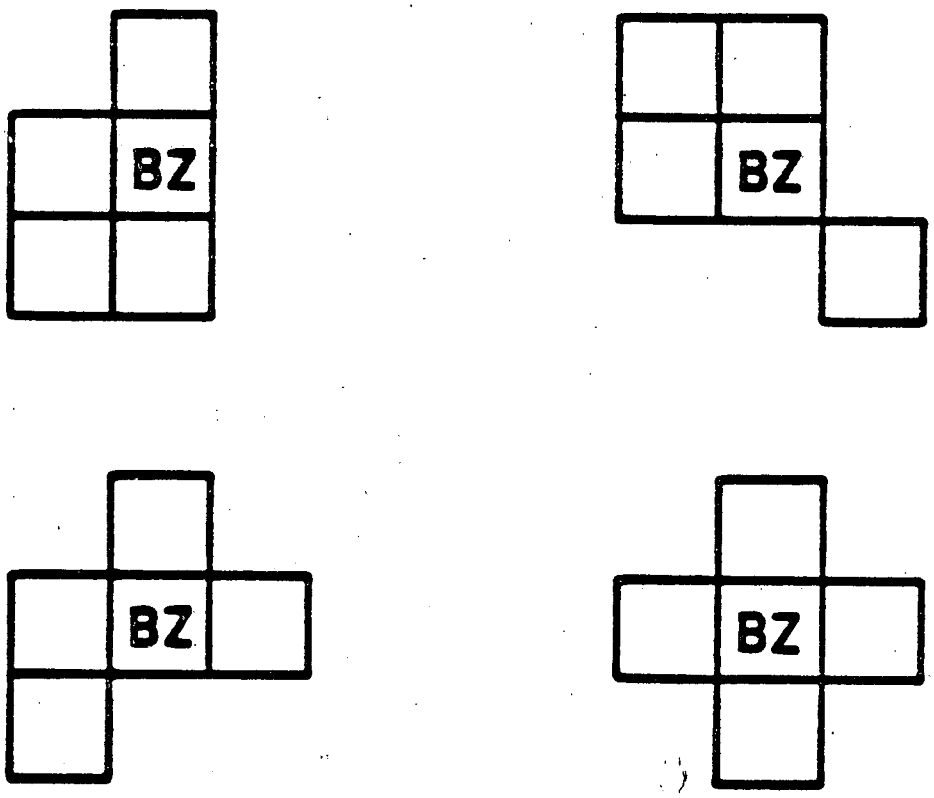
Grid Impact Loading Case	Acceptance Criterion	Margin
OBE (Operational basis earthquake)	Elastic Load Limit	50%
LOCA + Seismic (SSE)	Coolable Geometry	75%

MK-BZ Fuel Assembly

The shipping analysis verified the structural integrity of the MK-BZ spacer grids

- Evaluation of spacer grid for clamping load
- Crush test of zircaloy spacer grid
- Margin = 150%

Handling Test Configurations



Simulated conditions:

- Fuel assembly bow
- Handling bridge misalignment (¼ inch)

The MK-BZ grids refused to 'Hang Up' under any of the simulated conditions

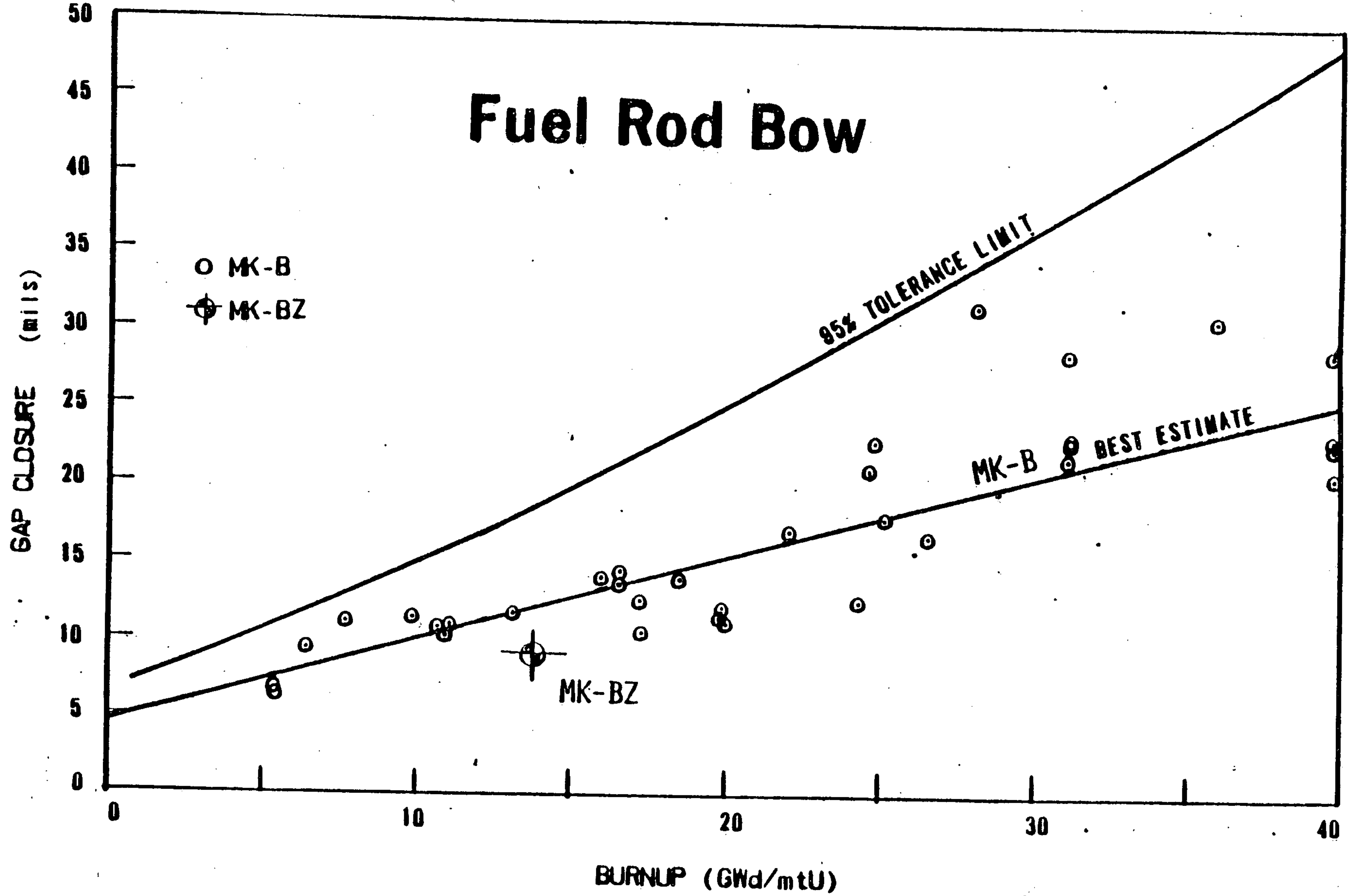
MK-BZ Fuel Assembly Operating Experience

Oconee - 2 Lead BZ Assembly

June 1980 to Dec. 1981
14000 MWd/MtU, 400 EFPD
PIE completed
Discharged

PIE (Post Irradiation Examination) Results

Visual	No evidence of fretting or corrosion Grids structurally sound Minor abnormality on one grid
Grid position	Top 5 intermediate grids moved to limits of constraints
Grid width growth	As expected ~ .003"
Fuel rod bow	Same or better than MK-B



Fuel Rod Bow
O MK-B
MK-BZ
95% TOLERANCE LIMIT
MK-B BEST ESTIMATE
MK-BZ
GAP CLOSURE (mils)
BURNUP (GWd/mtU)
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40

MK-BZ Fuel Assembly Operating Experience

Oconee - 1

- Four BZ assemblies	Startup Dec. 1981 Three cycles PIE after each cycle
- Five extended burnup assemblies	Startup mid-1983 (1) - one cycle (4) - three cycles PIE after each cycle

MK-BZ Assembly

- Achieved a fuel assembly design with high structural integrity, good corrosion resistance, and improved handling characteristics

- Design has been verified through an extensive test program and incore demonstrations

- MK-BZ fuel assembly design is acceptable for full batch implementation

MK-BZ Fuel Assembly

Thermal Hydraulic Evaluation

- Minor change to core/fuel assembly
- Evaluation supported by testing and analysis
- Implementation will have minor impact on operation

MK-BZ

Thermal Hydraulic Analysis

- Hydraulic effects
- Flow distribution
- CHF testing
- DNB analysis
- Impact on RPS

ECCS Analysis

- Core ΔP
- Increased zirc
- Impact on operating limits

MK-BZ
Flow Testing

- Full bundle prototype
- Operating temperature & pressure
- Measure component ΔP's
- Grid loss coefficient increase 10%
- Core ΔP increase
- LDV testing - subchannel loss coefficients

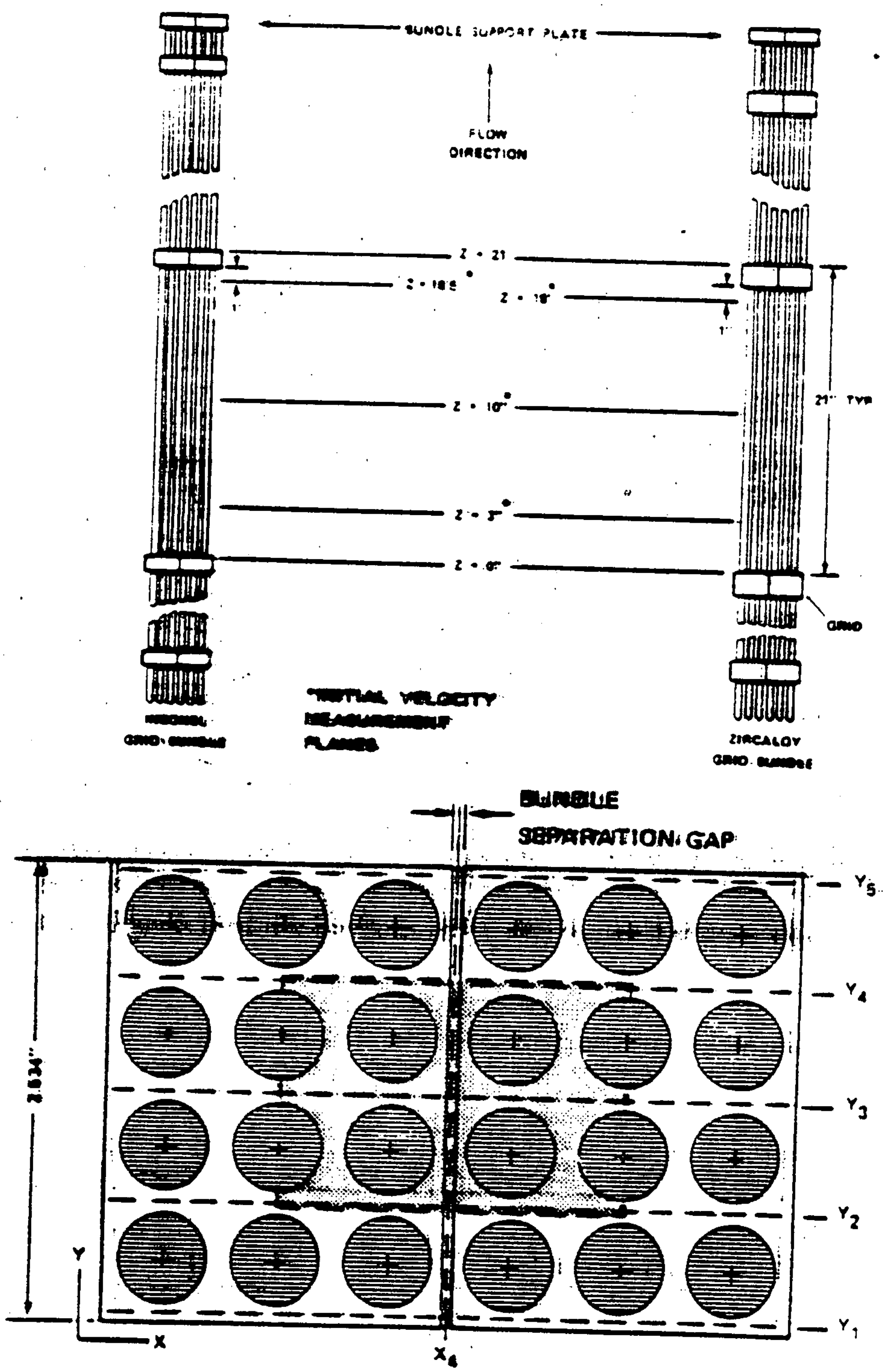
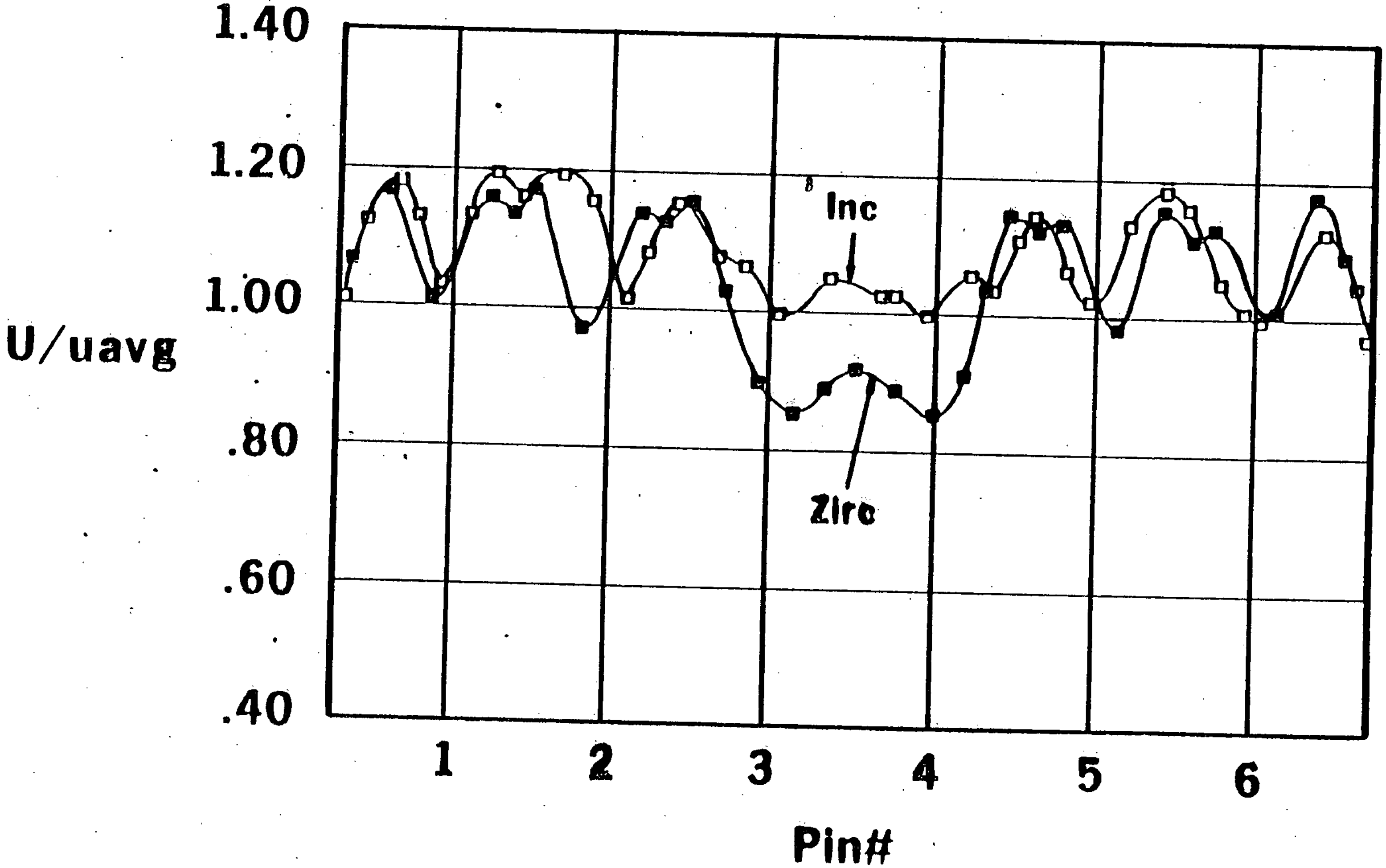


FIGURE 2.1 VELOCITY MEASUREMENT LOCATIONS

Fluid Velocity Profile



MK-BZ

Critical Heat Flux Testing

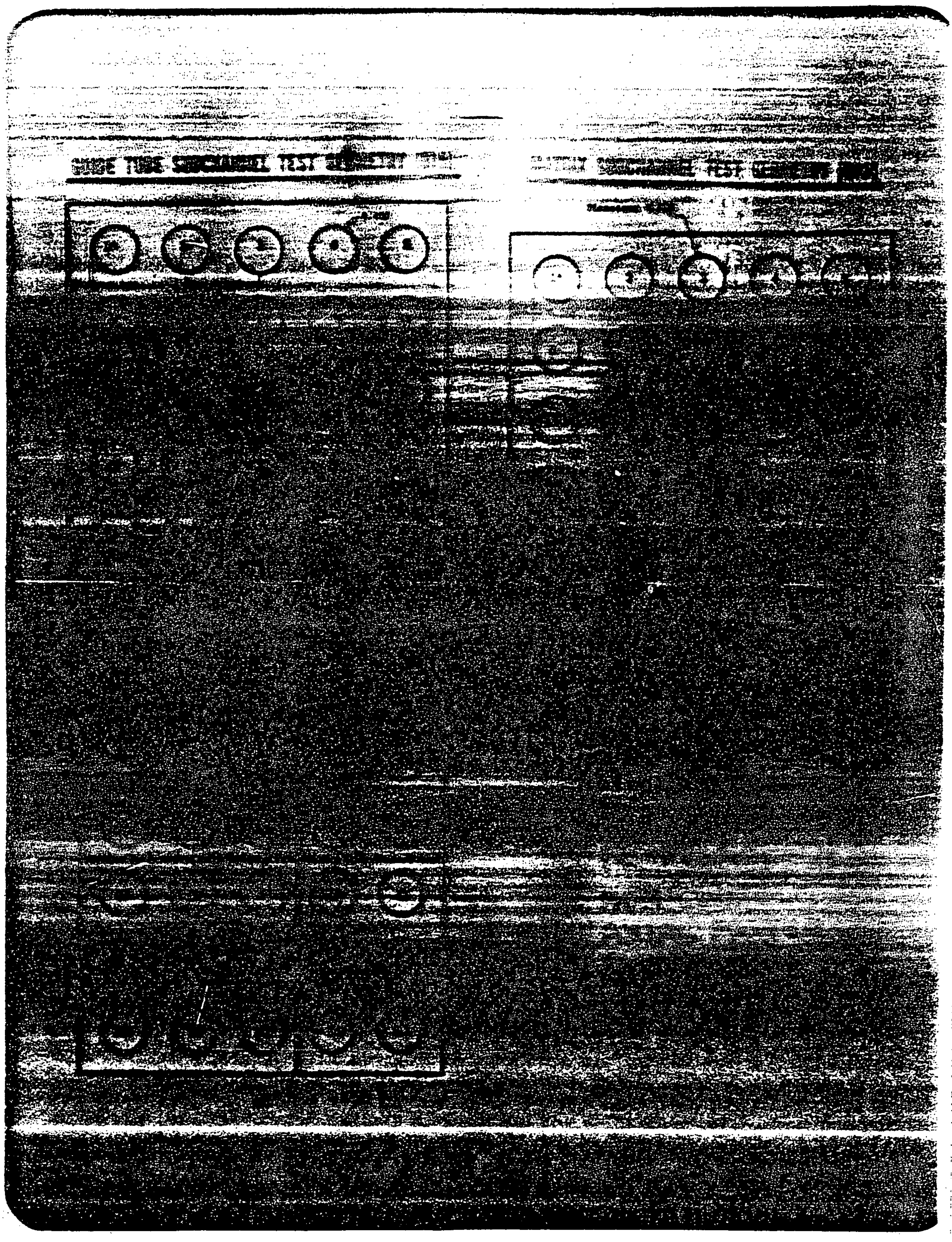
- ARC heat transfer facility

  10 MW
  12 ft/5x5 test section
  Acoustic temperature

- Three MK-BZ tests

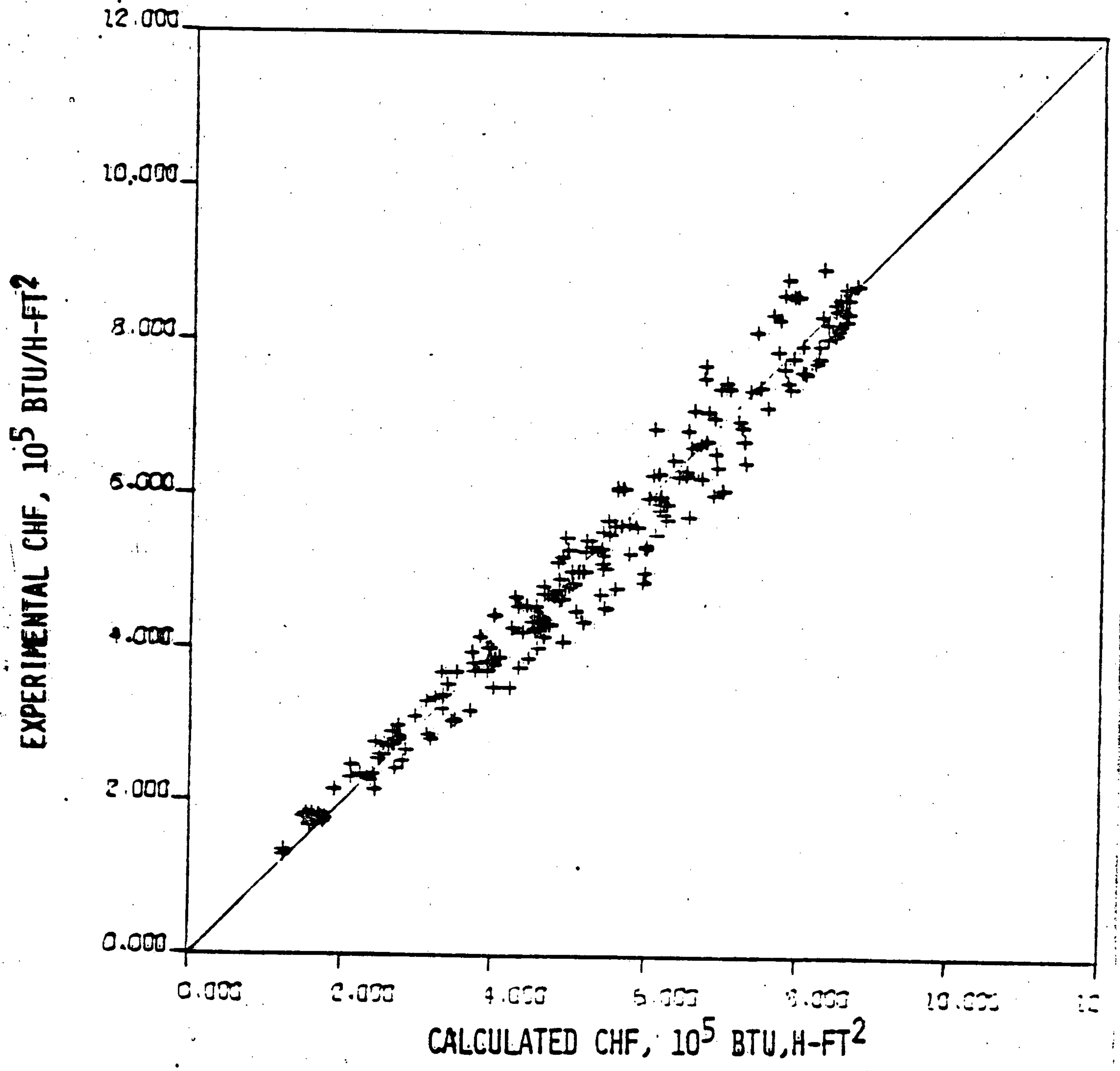
  Unit
  Guide tube
  Intersection

- Correlation with BWC
- Design limit



chart

MARK BZ DATA WITH BWC



Mark BZ Data With The BWC Correlation

Bundle(s)	Type	No. Of Points	Mean	Std. Dev.
B16	Matrix	70	.985	.083
B15	Guide Tube	44	.971	.072
B17	Intersection	97	.976	.057
	All	211	.978	.070

DESIGN LIMIT ANALYSIS

– Determine Protection Criteria

There will be 95 percent confidence that 95 percent of those pins calculated to be at the DNBR design limit will not experience CHF.

– Compute the Correlation Statistics

Compute the mean measured to predicted CHF (M/P) and the associated standard deviation (σ).

– Calculate the DNBR Design Limit

Using one sided tolerance limit theory,

$$DNBR(L) = \frac{1}{M/P - K\sigma}$$

where K is a function of the confidence level, the population protected, and the number of data points.

BWC Correlation Limit For MK-BZ

Mean M/P	.978
Std. Dev. σ	.070
Points, n	211
K (95/95)	1.83

Design Minimum DNBR

-1.18-

MK-BZ
Fuel Assembly Lift

- Based on flow testing
- Maximum at lower temperature
- Holddown requirement

    Increase - ~ 50 lb.

MK-BZ
Core DNB Analysis

- BWC correlation
- 1.18 correlation design
  Minimum DNBR
- Steady state DNBR
- Transient (limiting) DNBR
- RPS limits - minimal impact

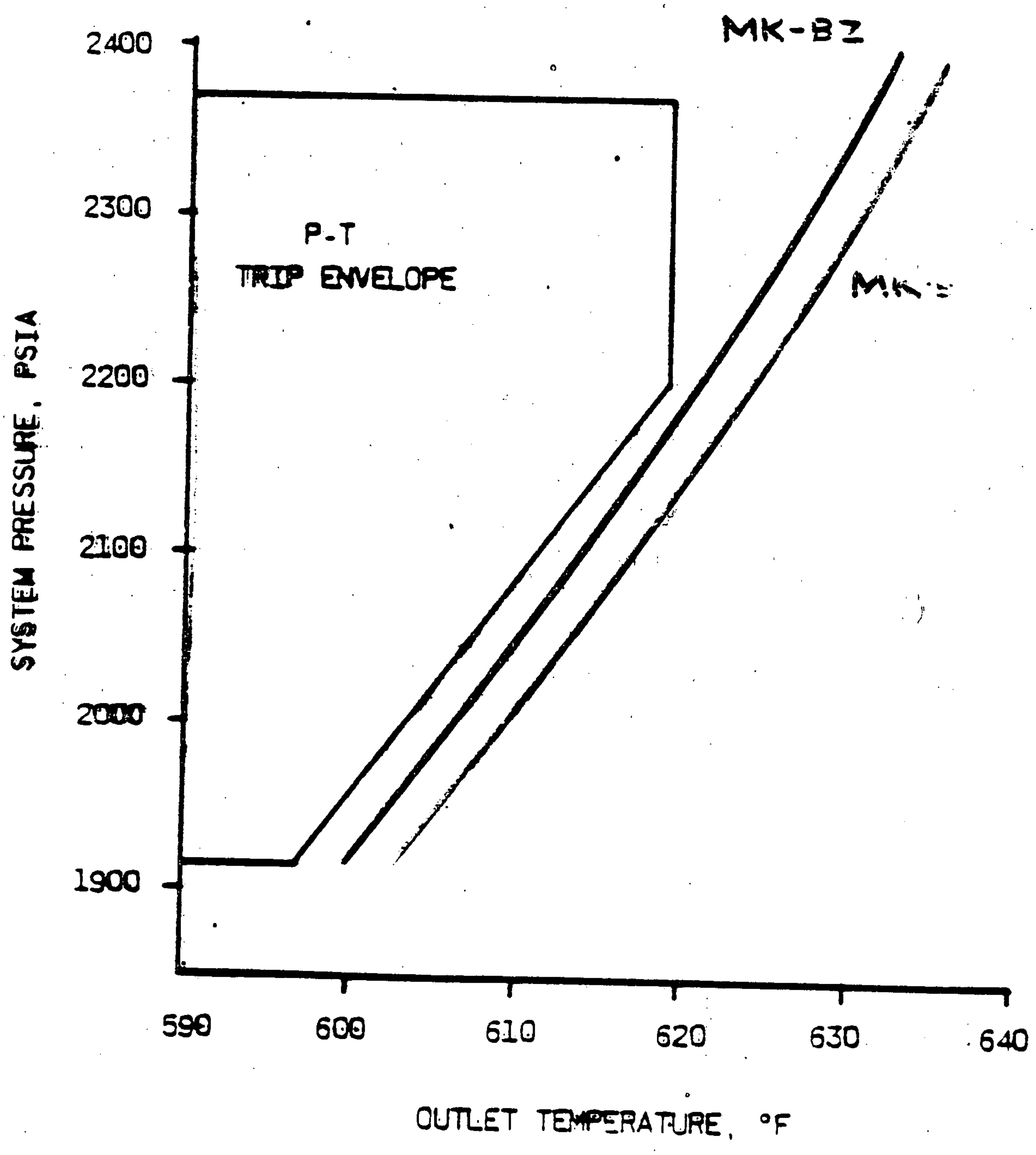
MK-BZ Fuel Assembly RPS Limits

DNB - Insignificant Impact

- Improvement in
  - Four pump coastdown DNB
  - Flux/flow setpoint
- Decrease in
  - P/T limits (~ 2°F)
- Change in allowable peaking

  -1.6% to +3.5%

RPS LIMITS



MK-B2
P-T
TRIP ENVELOPE
2400
2300
2200
2100
2000
1900
SYSTEM PRESSURE, PSIA
590
600
610
620
630
640
OUTLET TEMPERATURE, °F

MK-BZ
ECCS Evaluation

- Increased core ΔP
- Increased Zirc in core

  H_2 production
- Impact on operating limits

MK-BZ Fuel Assembly
ECCS Evaluation

Core ΔP

- Increase of only 3%
  (17.8 psi to 18.4 psi)
- Insignificant impact

MK-BZ Fuel Assembly
Eccs Evaluation

Metal/water reaction

- **Additional Zirc**
- **Grid at fuel rod temperature**

	MK-B	MK-BZ	Limit
Local	6.2%	12.4%	17%
Whole core	.58%	.65%	1%

MK-BZ Fuel Assembly
ECCS Evaluation

MK-BZ/BWC Impact

- No impact @ 2 ft, 4 ft
- Increase in T_{clad} @ 6 ft & above
- Reduction in LOCA limit

  @ 6 ft elevation only
  18 kw/ft → 17 kw/ft

- Available margin

  @ 8 ft and 10 ft
  T(clad) increase of 100F

- LOCA limits maintained

  8 ft - 17 kw/ft
  10 ft - 16 kw/ft

MK-BZ Fuel Assembly Operating Limits

- Reduction in 6 ft LOCA limit 18 kw/ft → 17 kw/ft
- Insignificant impact on rod insertion limits

MK-BZ Fuel Assembly Thermal Hydraulic Evaluation

-Conclusion-

Implementation will have minor impact on operation

Summary

- Improved Uranium Utilization
- More economical
- Lower axial peaking
- Handling characteristics are improved
- Mechanical design is acceptable
- Thermal hydraulic design is acceptable
- Impact on safety and operating limits is small

Conclusions

- Zirc grid is a small change to a proven fuel design

- All safety issues have been addressed

- The information presented today supports full batch implementation