South Carolina Electric and Gas Company Virgil C. Summer Nuclear Station

Spent Fuel Pool Rerack Presentation

August 28, 2001

Enclosure 2

Agenda

April Rice

- Introduction
- Current Pool Configuration
- Technical Overview
- Project Schedule
- Technical Specification Revisions
- Summary

Introduction

- South Carolina Electric and Gas
  - April Rice, Manager, Plant Support Engineering
  - Bill Herwig, Supervisor, Reactor Engineering / Nuclear Fuel Management
  - Dale Krause, Project Manager, Design Engineering
  - Phil Rose, Engineer, Nuclear Licensing and Operating Experience

Introduction

- Holtec International
  - Dr. Alan Soler, Executive Vice President & Vice President of Engineering
  - Dr. Stanley Turner, Senior Vice President & Chief Nuclear Scientist
  - Dr. Indresh Rampall, Principal Engineer
  - Kris Cummings, Associate Engineer
  - Scott Pellet, Project Manager

Introduction

- Why Rerack?
  - Available open pool space
  - Final resolution of Boraflex issue
  - Cost beneficial deferment of dry storage
  - Full core offload capability extended to the Fall of 2018

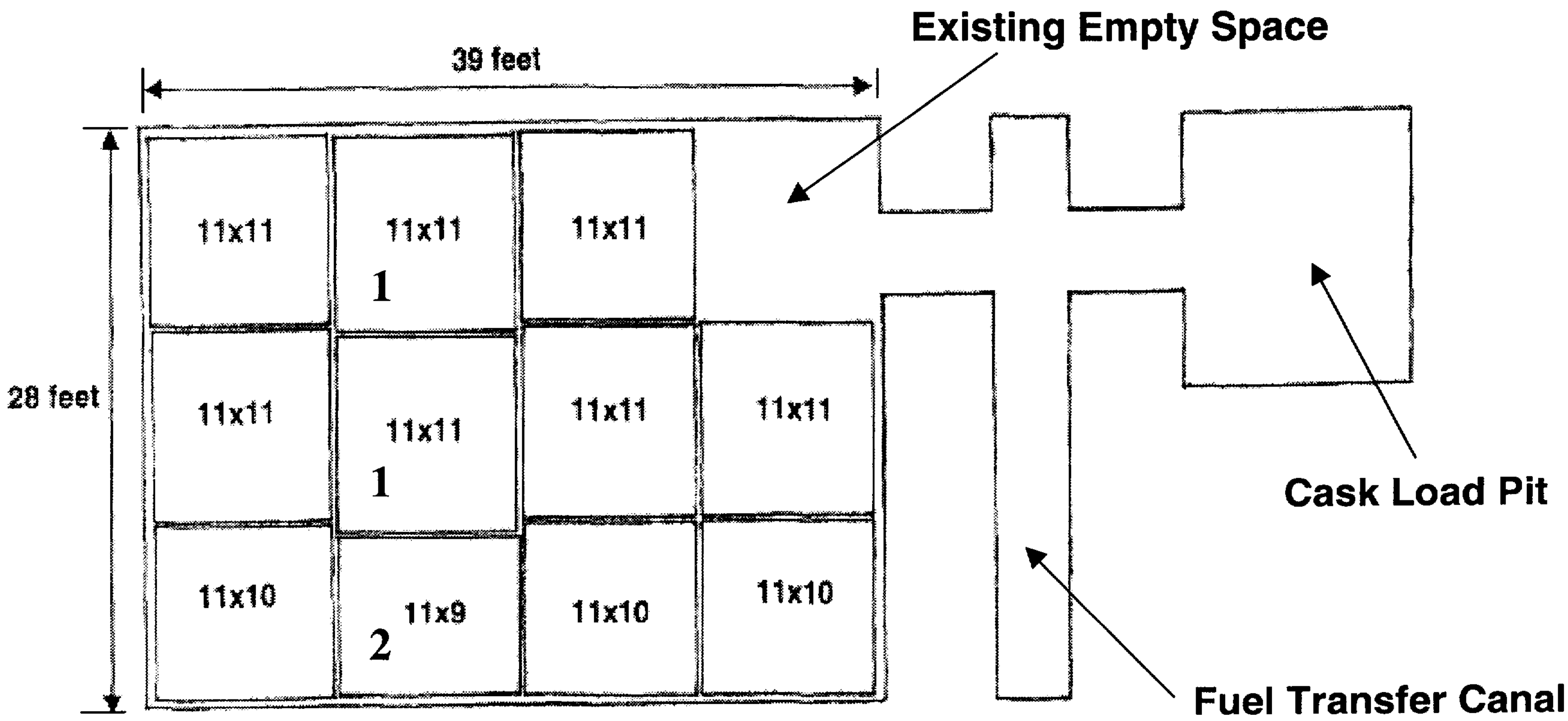
Introduction

- Project will be accomplished with proven analytical methods, technology and supplier
- Project scope is consistent with current reracking projects
- Project schedule supports:
  - NRC 13 month review
  - Site installation window during Cycle 14

Current Pool Configuration

Bill Herwig

- Current pool configuration includes 11 racks
  - Three region pool
    - Two regions with Boraflex poison
    - One region with no poison
- Racks were supplied by Joseph Oat Co.



PLAN - CURRENT SFP RACKS

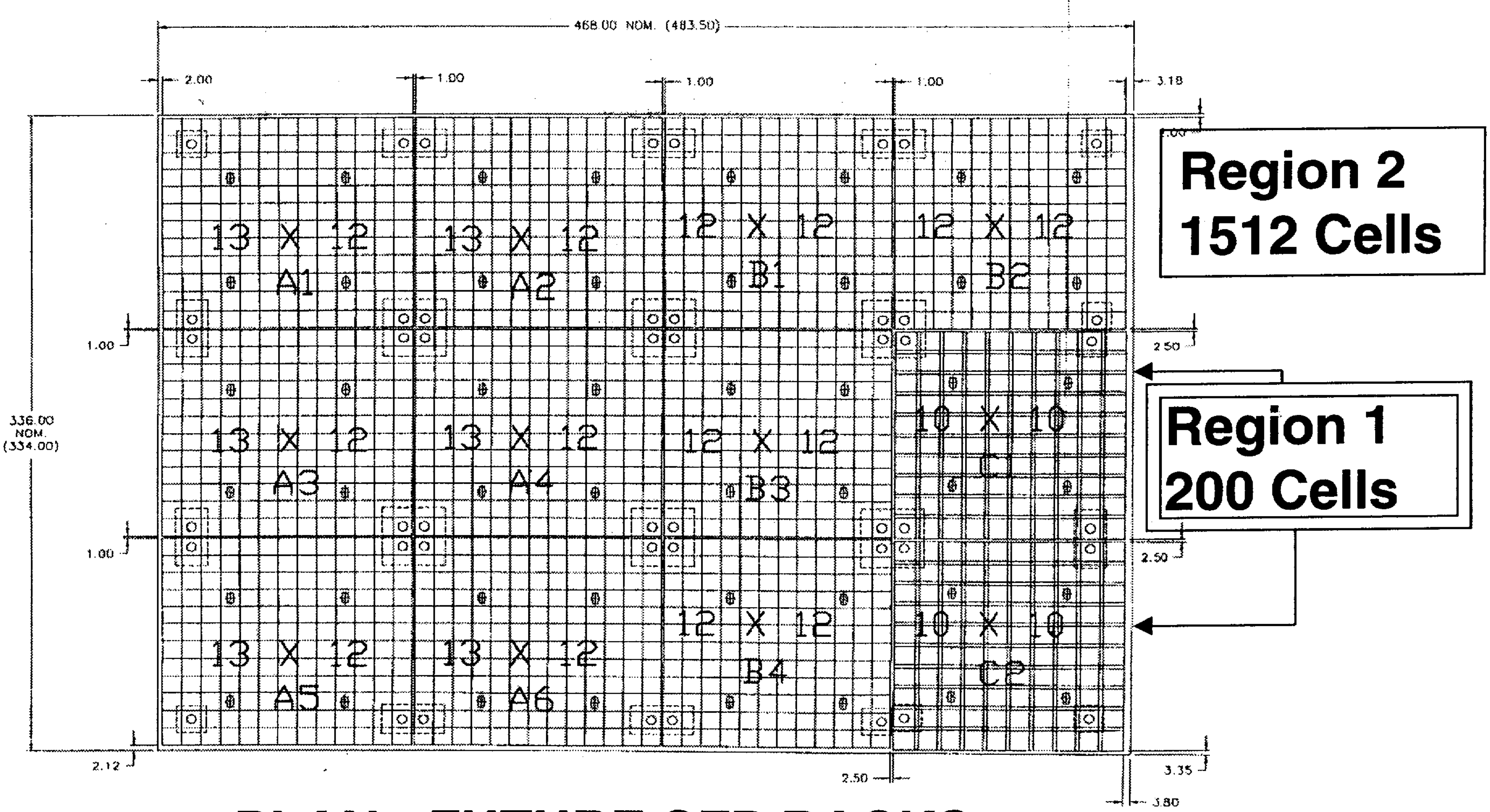
- 11 Racks
- 1276 Cells

Current Pool Configuration

- Current inventory of 769 fuel assemblies
  - Westinghouse fuel design (Various 17X17 Designs, Standard thru Performance +)
- Full core offload capability until the end of Cycle 17 in the Spring of 2008

New Configuration

- Twelve new racks supplied by Holtec International
- Number of cells increased to 1712
- Two region pool with Boral poison
- Full core offload capability extended to the Fall of 2018



PLAN - FUTURE SFP RACKS

- 12 Racks
- 1712 Cells (436 Additional)

Technical Overview

- Criticality
- Radiological
- Thermal-Hydraulic
- Structural/Seismic
- Mechanical Accidents
- Installation

Criticality Analysis

Kristopher Cummings

- Codes Used
- Region I
- Region II
- Manufacturing Tolerances
- Accident Conditions
- Summary

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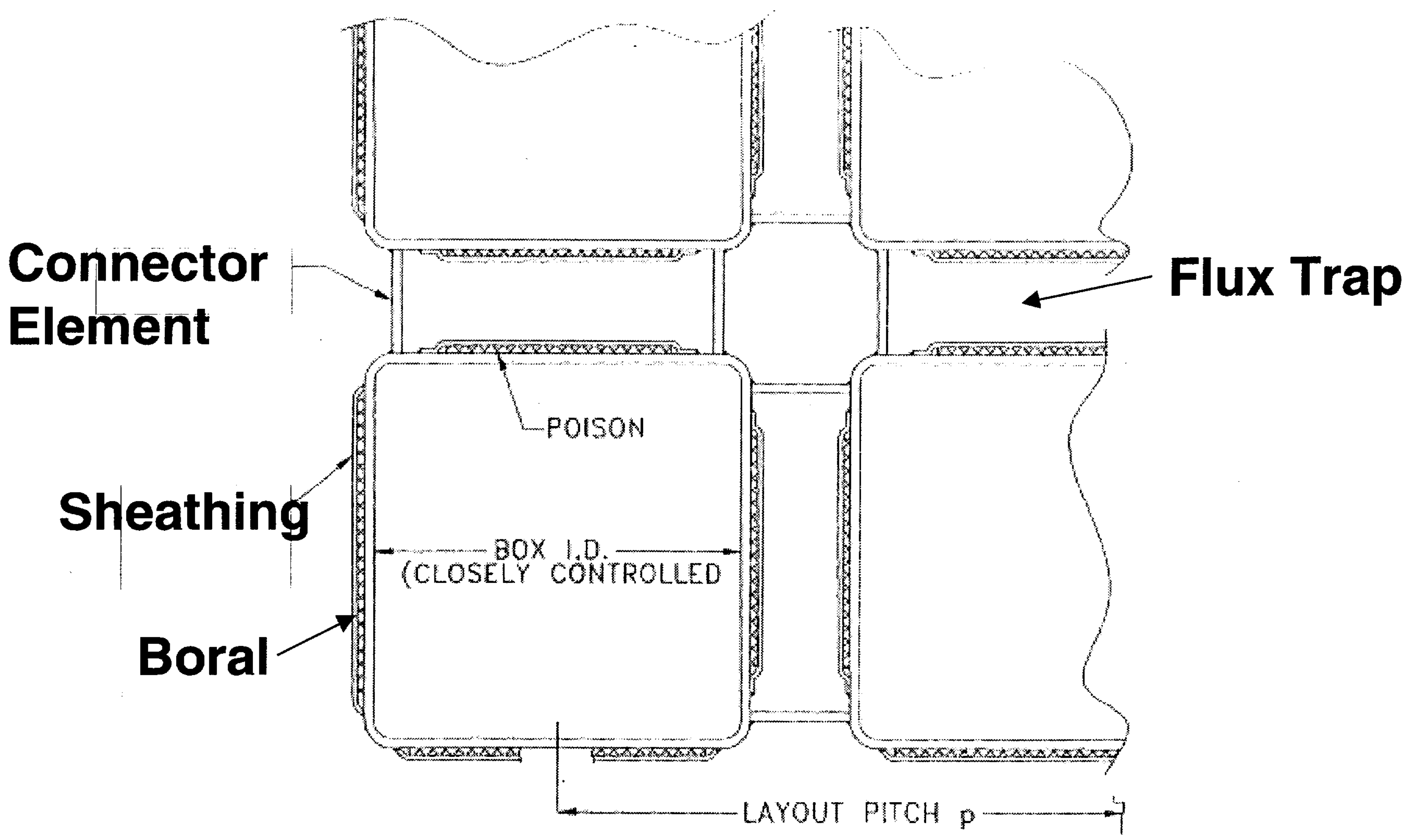
Codes Used

- CASMO-4: Used for fuel depletion analyses during core operation. Restart the calculation in the storage rack geometry to yield k_{inf} for the storage rack.
- MCNP4a: Used to accurately represent accident conditions in a 3-D geometry.
- KENO5a: Used for independent verification calculations.

Region 1

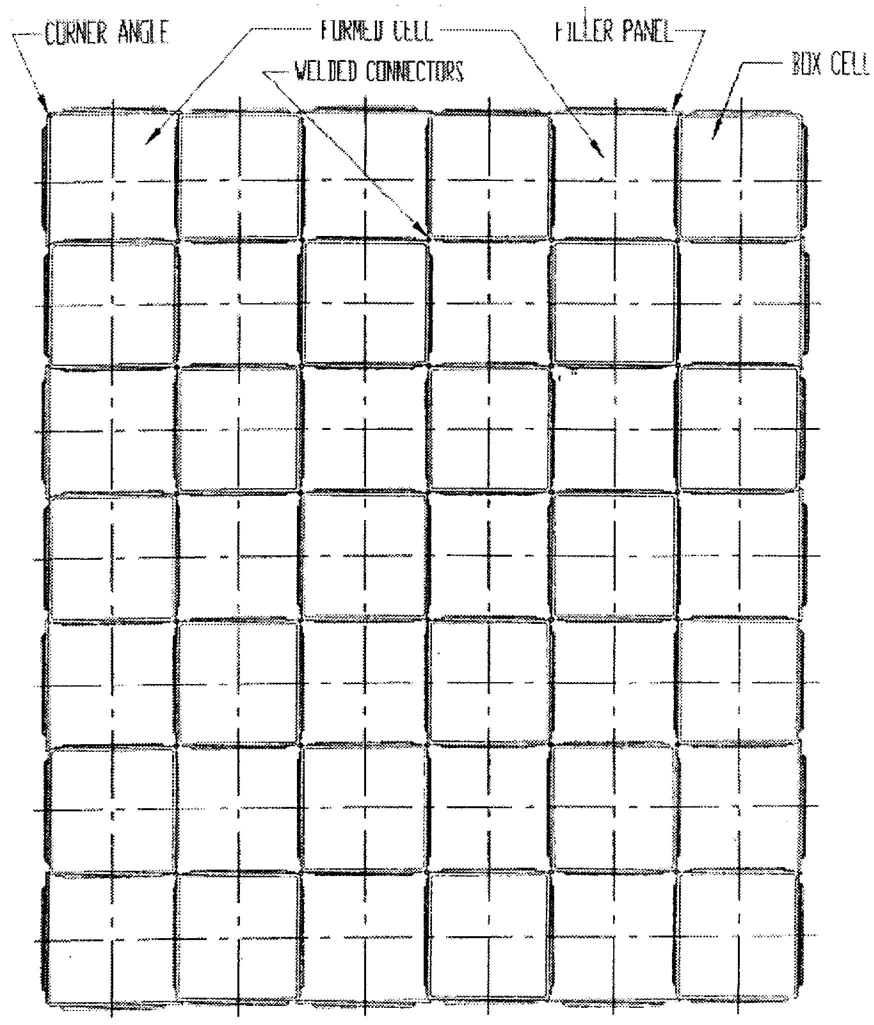
- Qualified for storage of fresh fuel up to 4.95 wt% ^{235}U nominal initial enrichment.
- Maximum k_{eff} includes manufacturing tolerances and margin for uncertainty in the reactivity calculations (i.e. bias uncertainty and calc. statistics).
- Maximum k_{eff} of 0.9333



PLAN - REGION 1 CELL ASSEMBLAGE

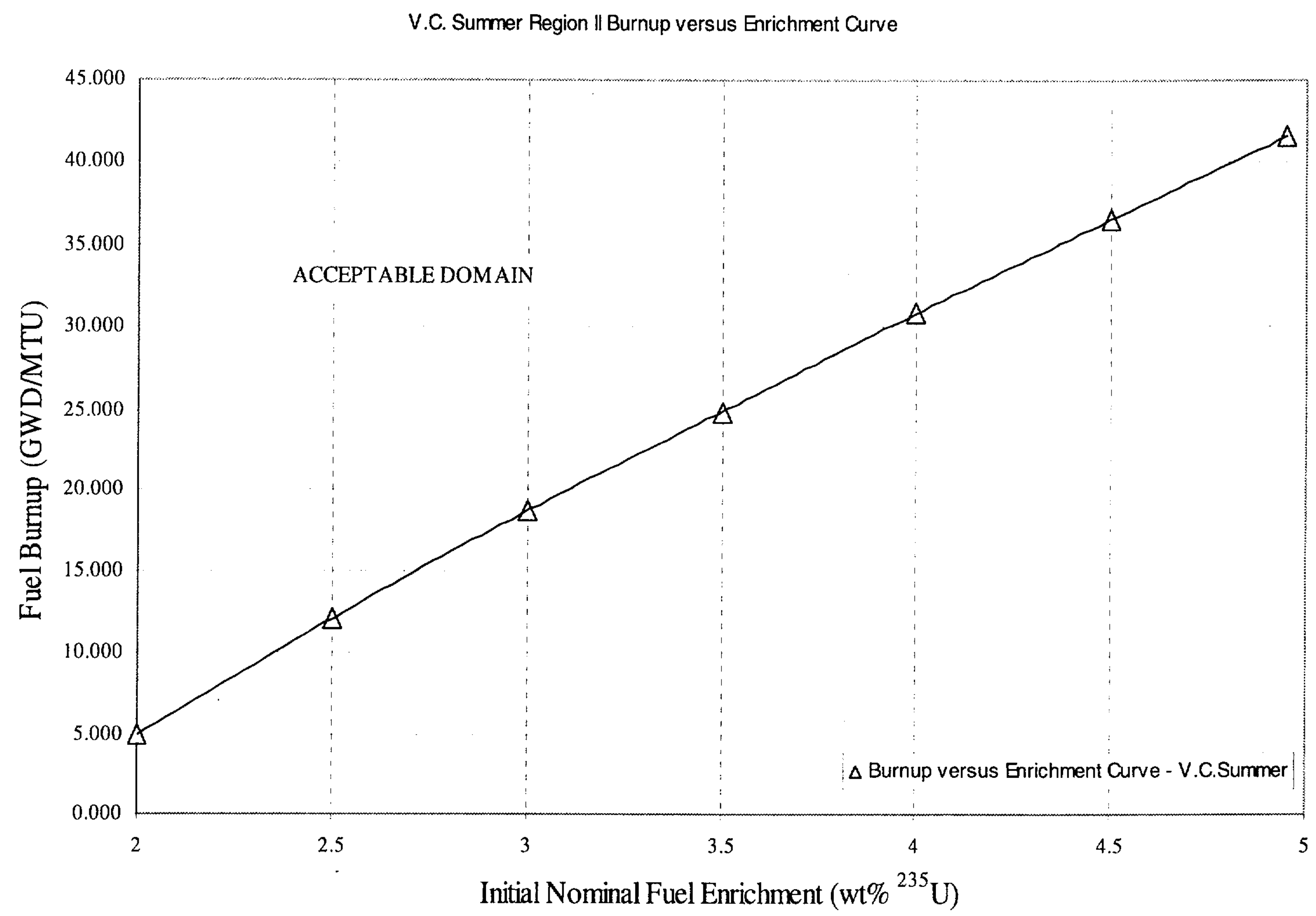
Region 2

- Qualified for storage of fuel up to 4.95 wt% ^{235}U nominal initial enrichment that have acquired a specified burnup (42 GWD/MTU).
- Use of Reactivity Equivalent Enrichments.
- Uncertainty in Depletion Calculations (5% of the reactivity decrement).
- Axial Burnup Distribution.
- Reactivity Effect of WABA, BPRA, IFBA and Erbia.
- Burnup versus Enrichment Curve.
- Maximum k_{eff} of 0.9485.
- Maximum k_{eff} includes manufacturing tolerances and margin for uncertainty in the reactivity calculations.



PLAN - TYPICAL REGION 2 ARRAY OF CELLS

Figure 1


V.C. Summer Region II Burnup versus Enrichment Curve
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0.000
ACCEPTABLE DOMAIN
Fuel Burnup (GWD/MTU)
Δ Burnup versus Enrichment Curve - V.C.Summer
2
2.5
3
3.5
4
4.5
5
Initial Nominal Fuel Enrichment (wt% 235U)

Manufacturing Tolerances

- UO_2 density
- Enrichment
- Box I.D. and Pitch
- Box Wall Thickness
- Boral width
- B-10 loading
- Water Gap (Region I only)

Accident Conditions

- Temperature and Water Density Effects
- Eccentric Fuel Positioning
- Dropped Assembly – 3” Baseplate Deformation
- Lateral Rack Movement
- Abnormal Location of a Fuel Assembly
  - Mislocated fresh fuel assembly outside Region II rack. (407 ppm required)
  - Misloaded fresh fuel assembly in Region II rack. (347 ppm required)

Summary

- Region I racks qualified for storage of fresh fuel with nominal enrichment up to 4.95 wt% ^{235}U.
- Region II racks qualified for storage of fuel with initial enrichment and burnup combinations within the acceptable domain in Figure 1.
- Minimum soluble boron requirement of 500 ppm required for accident conditions.
- Effective neutron multiplication factor (k_{eff}) is less than 0.95 with a 95% probability at a 95% confidence level.

RADIOLOGICAL ASSESSMENT

Dr. Stanley E. Turner

- Shielding Evaluations (Dose Rates)
  - At specified points near pool
  - Above pool surface (w/fuel assembly in transit)
- Offsite Doses from Fuel Handling Accidents
  - Accident in Fuel Handling Building
  - Accident in Reactor Building

RADIOLOGICAL SUMMARY

- Reduced decay time (100 hours to 72 hours) yields higher dose rates
- Offsite doses remain less than limits
- Dose rates remain acceptable (Zone Limits)
- 6 –12 person-rem estimated during installation
- Fuel Transfer Canal area behind gate requires aged fuel in closest rack

FUEL HANDLING ACCIDENT

- RG 1.25 Methodology
- Conservative and limiting design inputs
- Number of failed rods: 314
- Offsite doses Increase due to reduced decay time, but remain below Regulatory limits w/safeguards

FUEL HANDLING ACCIDENT DOSES, REM

	Post-Mod	Limit
• Fuel Handling Bldg.		
- Thyroid	13.0	75
- Whole Body	0.68	6
- Skin	3.02	
• Reactor Bldg.		
- Thyroid	259*	75
- Whole Body	0.68	6
- Skin	3.02	

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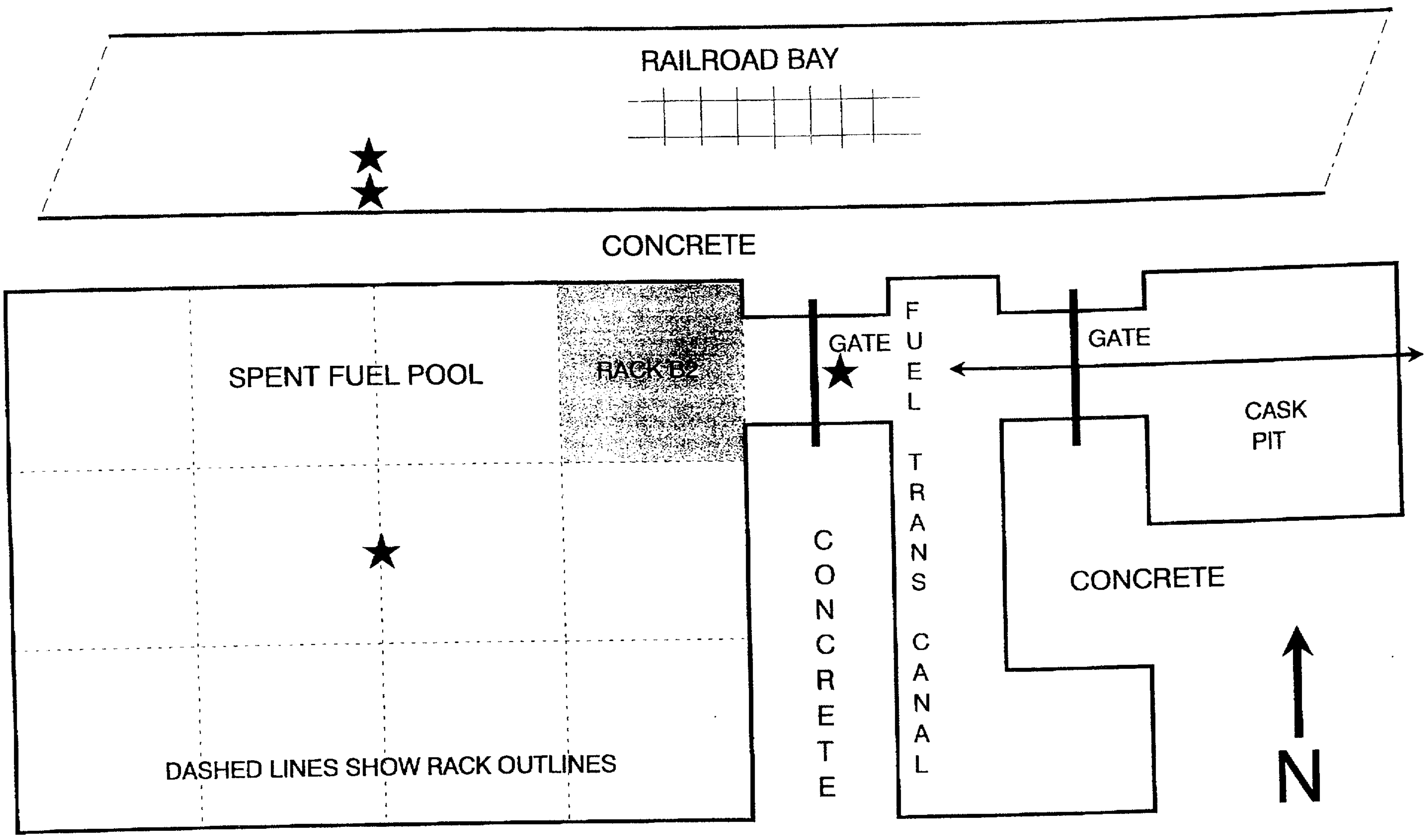
* Without Safeguards (Isolation)

SHIELDING EVALUATIONS

- Conservative and limiting assumptions
- Increased burnup and reduced cooling time
- Source terms: SAS2H-ORIGEN-S/ARP
- Dose rate calculations: QAD-CGGP
- Radiation Zone classifications unchanged



REACTOR ↓

PLAN VIEW OF SPENT FUEL AREA

IN ABOVE SKETCH, ←——→ OR ★
INDICATES RANGE OR LOCATION OF DOSE RATE POINTS
DOSE RATES SHOWN ON LATER VIEWS

NOT TO SCALE

Thermal-Hydraulic

Dr. Indresh Rampall

- Scenarios and Limits
- Transient Pool Bulk Temperature Calculations
- Transient Time-to-Boil and Boil-off Rate Analysis
- Local Water and Cladding Temperature Analyses

Scenarios and Limits

Normal Conditions – Peak Bulk Temperature Limited to 165°F

- Partial Core Offload – One SFPCS Cooling Loop Active (i.e., single active failure)
- Full Core Offload –Two SFPCS Cooling Loops Active

Upset Conditions – Peak Bulk Temperature Limited to 170°F

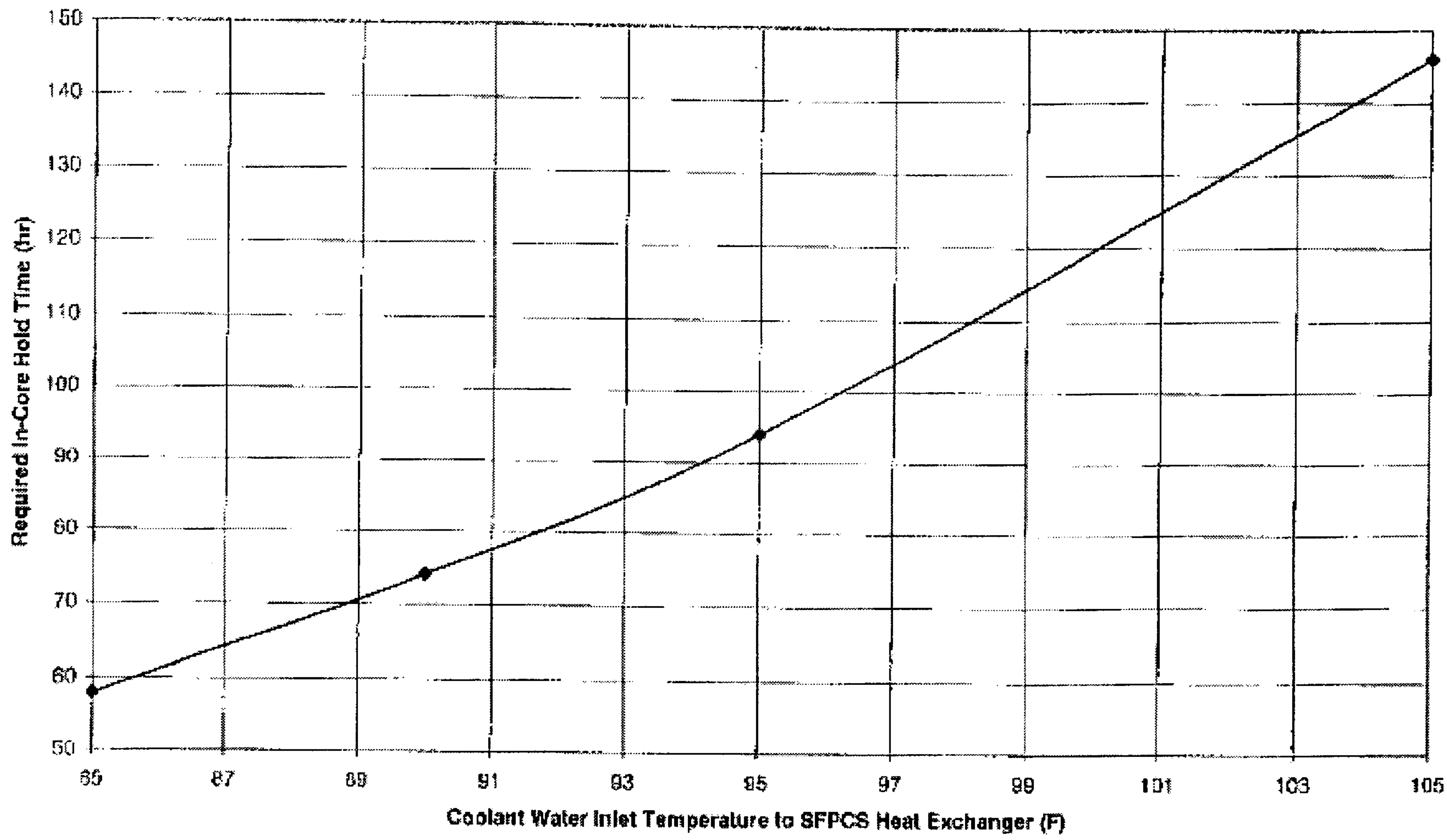
- Full Core Offload –One SFPCS Cooling Loop Active (i.e., single active failure), 2400 gpm SFP Flow Rate, Varying CCW Temperature (85-105°F). Flow Testing Performed to Confirm 2400 gpm Capacity.
- Abnormal Offload – Full Core Offloaded 36 Days After Normal Refueling, Two SFPCS Cooling Loops Active

Transient Bulk Temperature Calculations

- **Decay Heats Calculated Using the ORIGEN2 Program From ORNL**
- **Fuel Transfer to Pool Modeled as Uniform Rate for 20 Hours**
- **Credit for Passive Heat Losses Included Using Holtec-Developed Model**
- **Holtec Passive Heat Loss Model Benchmarked Against Test Data**

Scenario	Number of Active Cooling Loops	Maximum Bulk Temperature (°F)	Bulk Temperature Limit (°F)	Minimum In-Core Hold Time (hrs)
Partial Core	1	152.53	165 (normal)	72
Full Core	2	150.97	165 (normal)	72
Full Core 105 °F CCW	1	169.90	170 (upset)	146
Full Core 95 °F CCW	1	169.57	170 (upset)	94
Full Core 90 °F CCW	1	169.75	170 (upset)	74
Full Core 85 °F CCW	1	169.88	170 (upset)	58
Abnormal Full Core	2	149.53	170 (upset)	72

Required In-Core Hold Time vs. CCW Temperature
Full Core Offload with One Cooling Loop Scenarios



TRANSIENT TIME-TO-BOIL CALCULATIONS

- Decay Heats Calculated Using the ORIGEN2 Program From ORNL
- SFPCS Failure Assumed Coincident with Peak Bulk Temperature
- Credit for Passive Heat Losses Included Using Holtec-Developed Model
- No credit is Taken for Makeup Water during Heatup to Boiling
- Time to Boil Exceeds 3 Hours for All Normal Condition Scenarios and 2 Hours for All Upset Condition Scenarios

STEADY-STATE LOCAL WATER AND CLADDING TEMPERATURE ANALYSES

- Peak Local Water Temperatures Determined using Three Dimensional Computational Fluid Dynamics (CFD) Modeling
- Hydraulic Resistance of Dropped Assembly Cell Blockage on Every Cell
- Hydraulic Resistance of Blocked Baseplate Holes on Pedestal Cells
- Maximum Local Water Temperature is More Than 45°F Below Saturation Temperature
- Peak Local Fuel Cladding Temperatures Determined via Bounding Analytic Calculation Using Laminar Flow Heat Transfer Theory
- Fuel Cladding Superheat Calculated for Peak Burnup Levels
- Location of Peak Heat Flux (axial mid-height) and Location of Peak Local Water Temperature (cell exit) Assumed Coincident
- Maximum Local Cladding Temperature is Nearly 10°F Below Saturation Temperature

Structural/Seismic

Scott Pellet

- Rack Structural Details
- Rack Evaluation Methodology
- Load & Stress Factor Results
- Pool Structure Assessment

Rack Structural Details

- Region 1 vs. Region 2
- Cell walls, Baseplate, Sheathing – 304L
- Male Pedestals – SA 564-630
- Bearing Pads 304

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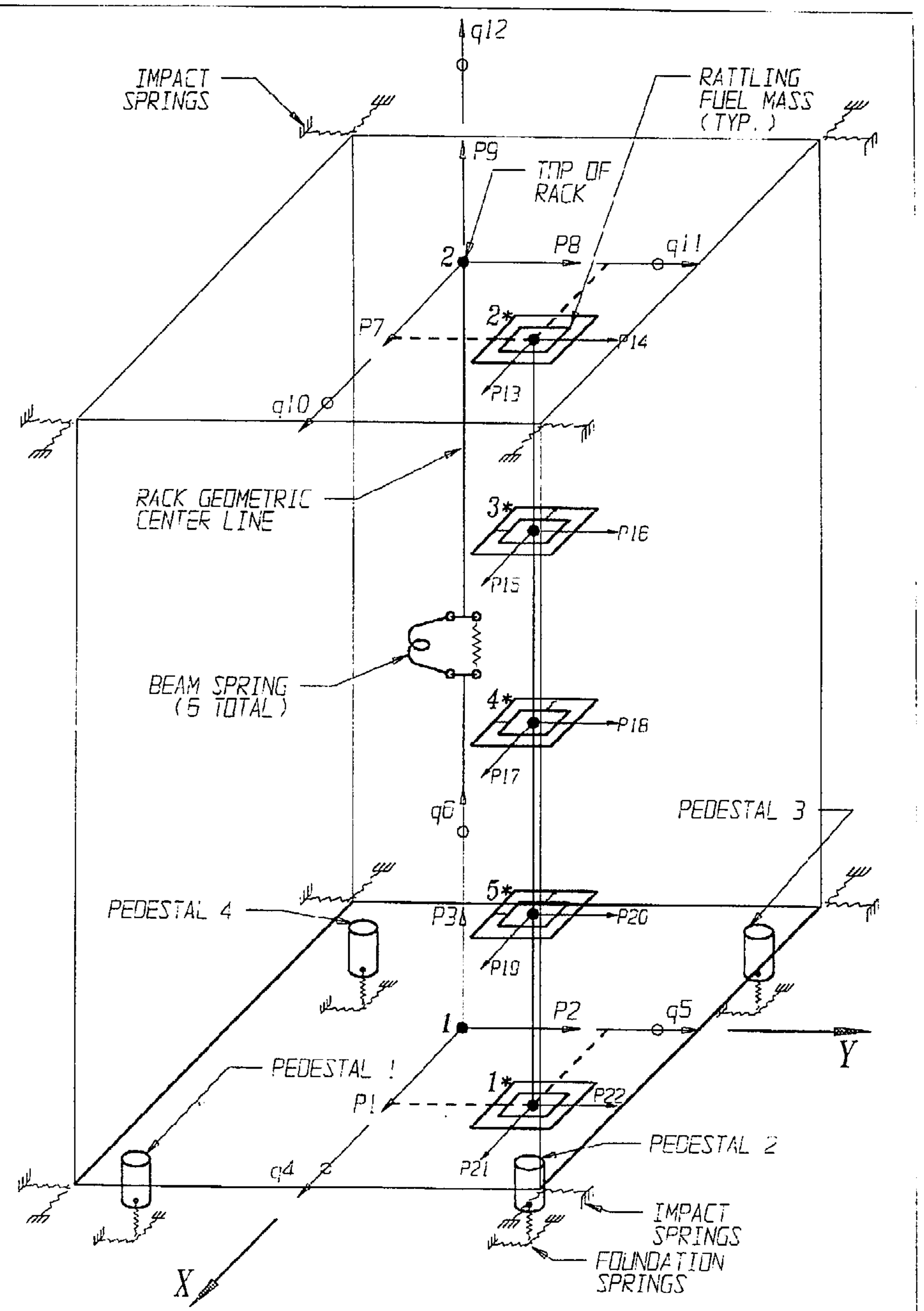
Rack Evaluation Methodology

- Time History Analysis - DYNARACK
- ASME NF Linear Class 3 Structures
- Multiple and Single Rack Simulations
- Load and Stress Factor Results



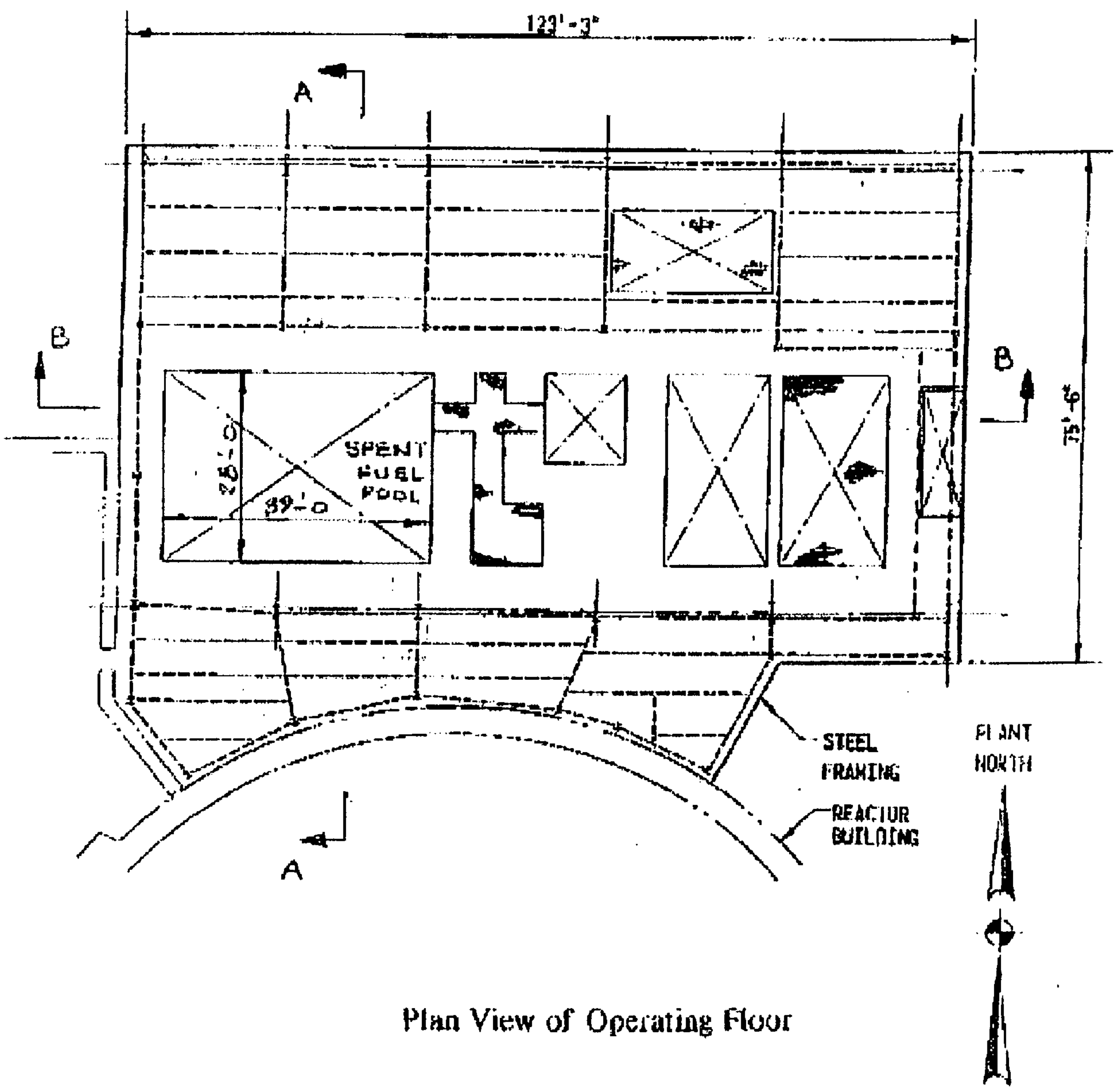
SCHEMATIC OF THE DYNAMIC MODEL FOR DYNARACK

Design Margin Results

Condition	Max. Values	Margin
Displacement	1.154”	50
Pedestal Impact	319 k	1.4
Cell Wall Stress	10,020 psi	1.5
Cell Base Weld	21,846 psi	1.3
Pedestal Weld	32,051 psi	1.2

Pool Structure Assessment

- Overview of Structure
- Pseudo-Static Evaluation using ANSYS
- Pool Structure Evaluation Results
- Liner Integrity Assured



Plan View of Operating Floor

Safety Factors for the SFP Structural Members

Member	Direction	Evaluation	Safety Factor	Critical Load Combination
Slab	E-W	Bending	1.24	LC 100
		Shear	1.05	LC 200
	N-S	Bending	1.26	LC 100
		Shear	2.35	LC 100
West Wall	Vertical	Bending	2.19	LC 200
		Shear	6.12	LC 100
	Horizontal	Bending	1.80	LC 200
		Shear	2.90	LC 200
North & South Walls	Vertical	Bending	1.14	LC 100
		Shear	5.77	LC 100

Mechanical Accidents

- Ensure Structural Integrity of Racks and Spent Fuel Pool
- Develop Design Inputs for Criticality and Thermal-Hydraulic Evaluations
- LS-DYNA3D Models
  - 3 Fuel Drop Scenarios
  - 1 Rack Drop Scenario
- Stuck Fuel Assembly

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Rack Installation

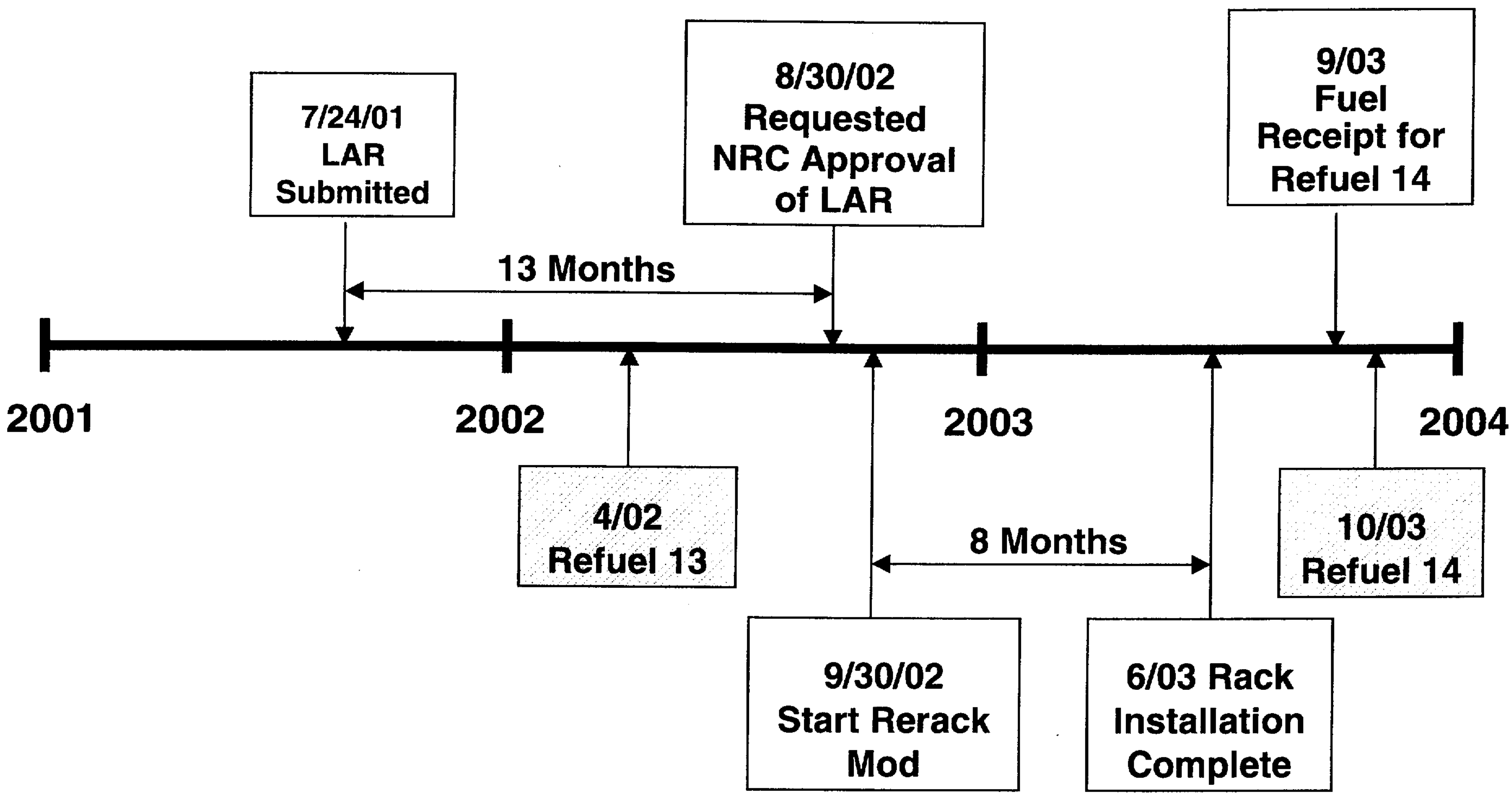
- Defense in Depth Approach
- Temporary Crane per CMAA 70
- Rigging per NUREG 0612
- Heavy Load Paths
- Rack Shuffle Plan
- Cask Pit Rack
- Sparger Pipe Modification

Project Activities Completed

Dale Krause

• Options/Feasibility Study	• July 99
• Open Project Work Order	• Dec 99
• Notify NRC of Rerack Plans	• Jan 00
• Issue Purchase Spec for Quote	• June 00
• Award Fixed Price Contract	• Aug 00
• Complete Analyses, LAR	• June 01
• File License Amendment Request	• July 01

RERACK SCHEDULE



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Tech Spec Changes

Phil Rose

- Affected Sections
  - 3.7 Plant Systems
  - 3.9 Refueling Operations
  - 5.3, 5.6 Design Features
- Criticality
  - 3 Regions to 2 Regions
  - 1276 to 1712 storage capacity
  - 500 ppm Boron now required in SFP water
  - Burnup versus enrichment figure
  - Maximum nominal enrichment 4.95 w/o

Tech Spec Changes

- Thermal Hydraulic
  - Min. Incore Hold Time 100 hrs to ≥ 72 hrs
  - Incore Hold Time related to CCW temp
- Other
  - Move specs from Refueling Operations to Plant Systems section -
  - Bases sections also affected

Summary

- Project will be accomplished with proven analytical methods, technology and supplier
- Project scope is consistent with current reracking projects
- Request for Additional Information
  - 30 Calendar Day Turnaround
- Project schedule supports:
  - NRC 13 month review
  - Site installation window during Cycle 14