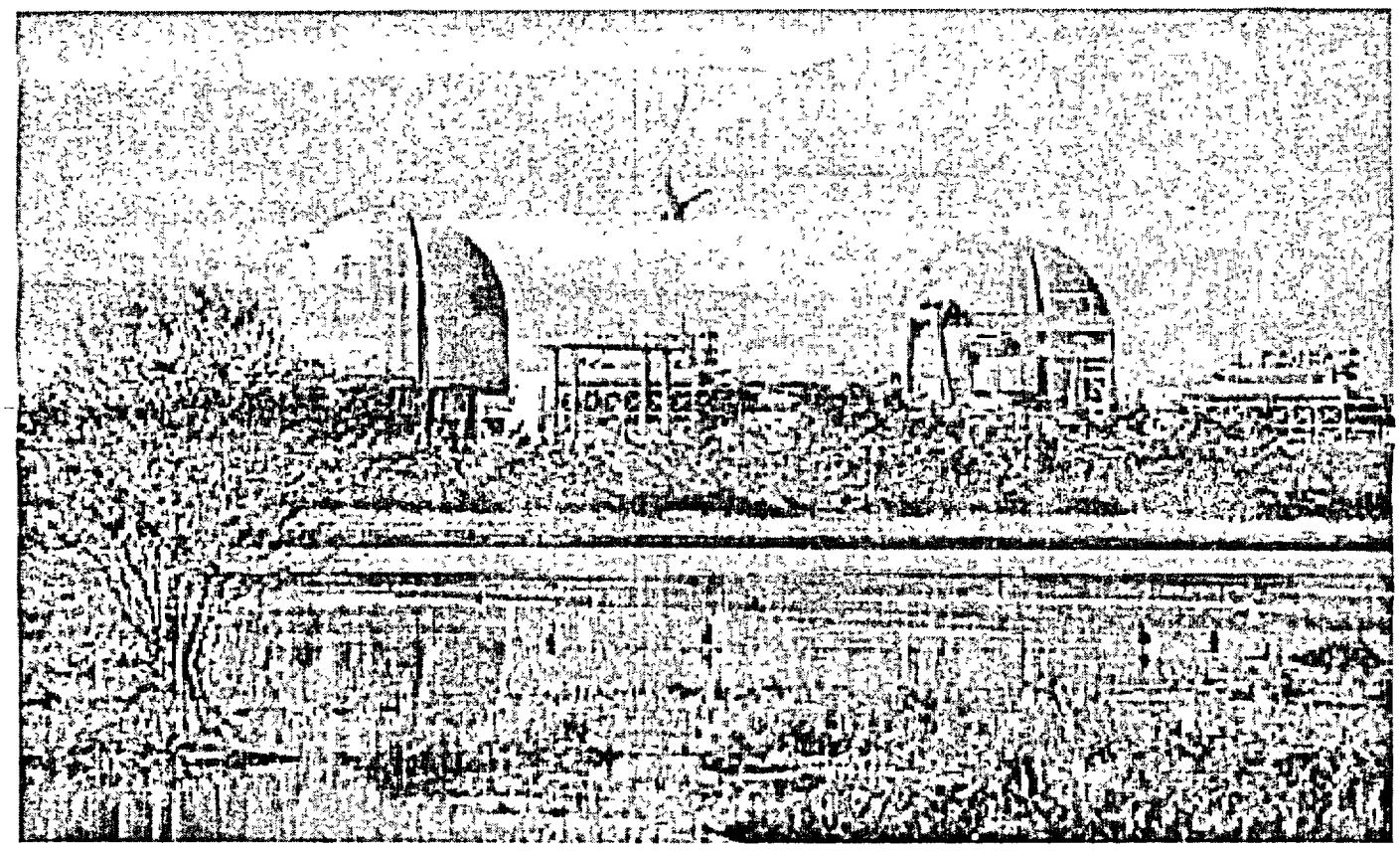
STPEGS

Proposed Containment Tendon Surveillance Alternative



PROPOSED CONTAINMENT TENDON SURVEILLANCE ALTERNATIVE

A proposal to revise containment tendon surveillance requirements to reduce the number of tendons examined

STP Participants

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Purpose of Meeting

- Explain rationale for revising the containment tendon surveillance requirements
- Present enhanced concept using risk-based insights
- Receive NRC feedback regarding proposed relief request

Agenda

- Background
  - Design Characteristics
  - Requirements
  - Reason for Request
- Proposal
- Summary/Conclusions

Containment Design Characteristics

- Each containment building is a post-tensioned concrete cylinder with steel liner plates, hemispherical top and flat bottom.
- Horizontal and vertical tendons pre-stress the containment cylinder and dome.
- Three buttresses spaced 120 degrees apart provide anchor points for the horizontal tendons. Horizontal tendons make a full circumference with both ends attached at the same buttress.

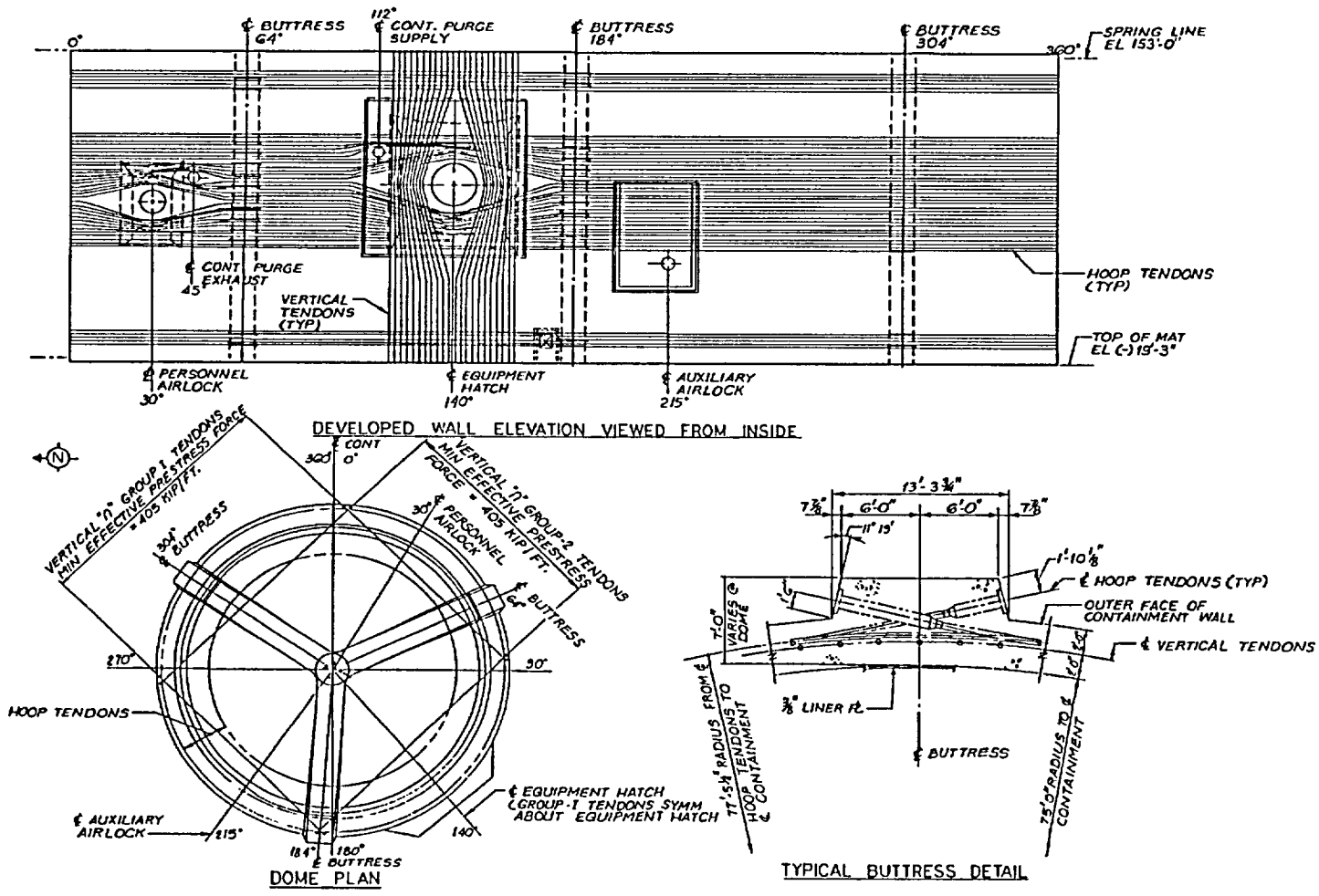
Tendons

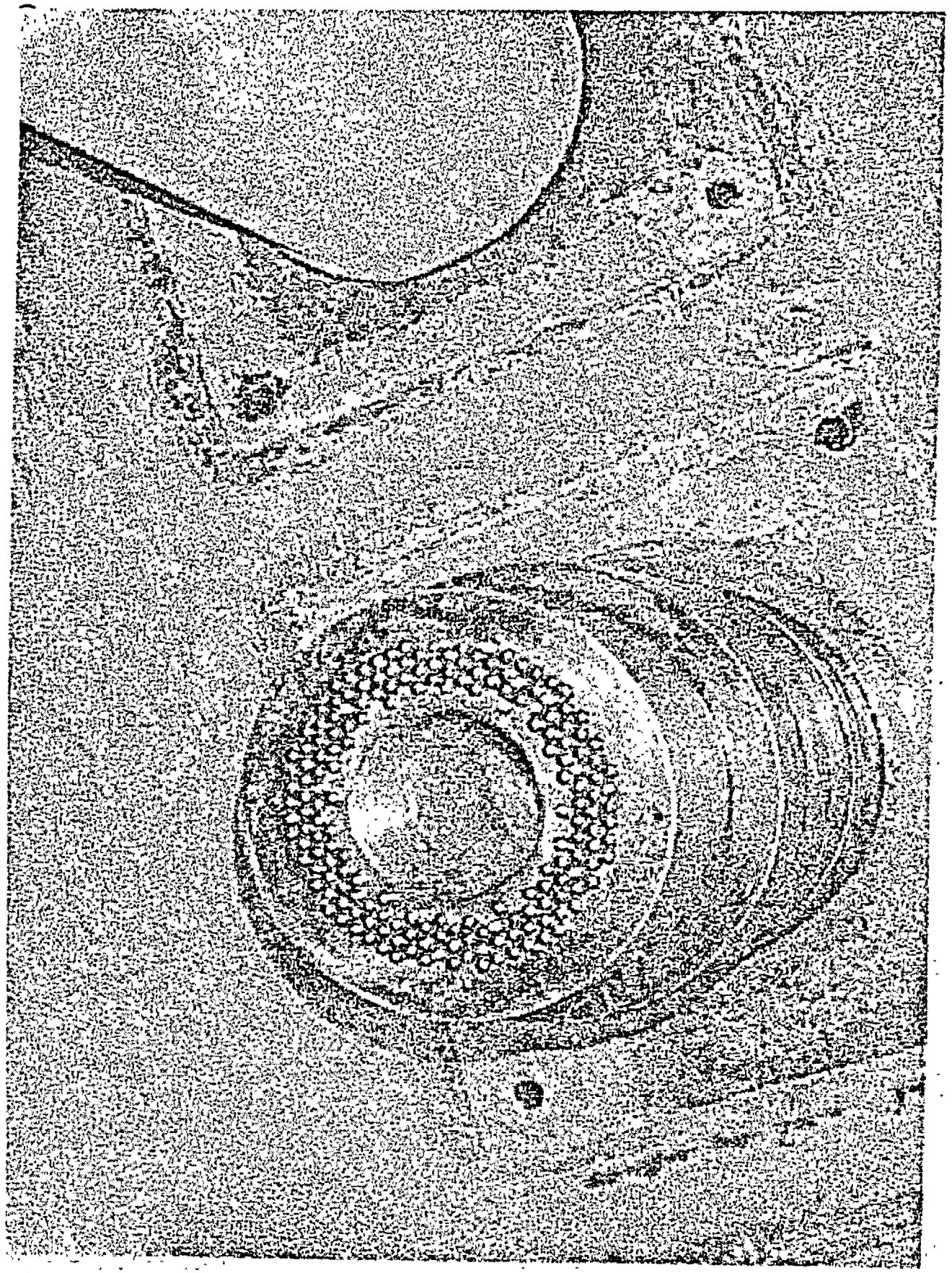
- Each unit has 133 horizontal tendons and 96 vertical (inverted "U") tendons.
- Each tendon is composed of 186 stress-relieved, high-strength wires 1/4-inch in diameter.
- Minimum ultimate strength of wire is 240,000 psi.
- Minimum yield strength is not less than 85 % of the minimum ultimate strength.
- Minimum initial tension is 70% of minimum ultimate strength.
- Tendons are sized to supply an average end-of-life pre-stress force 20% greater than the force required to statically balance DBA LOCA pressure inside containment.

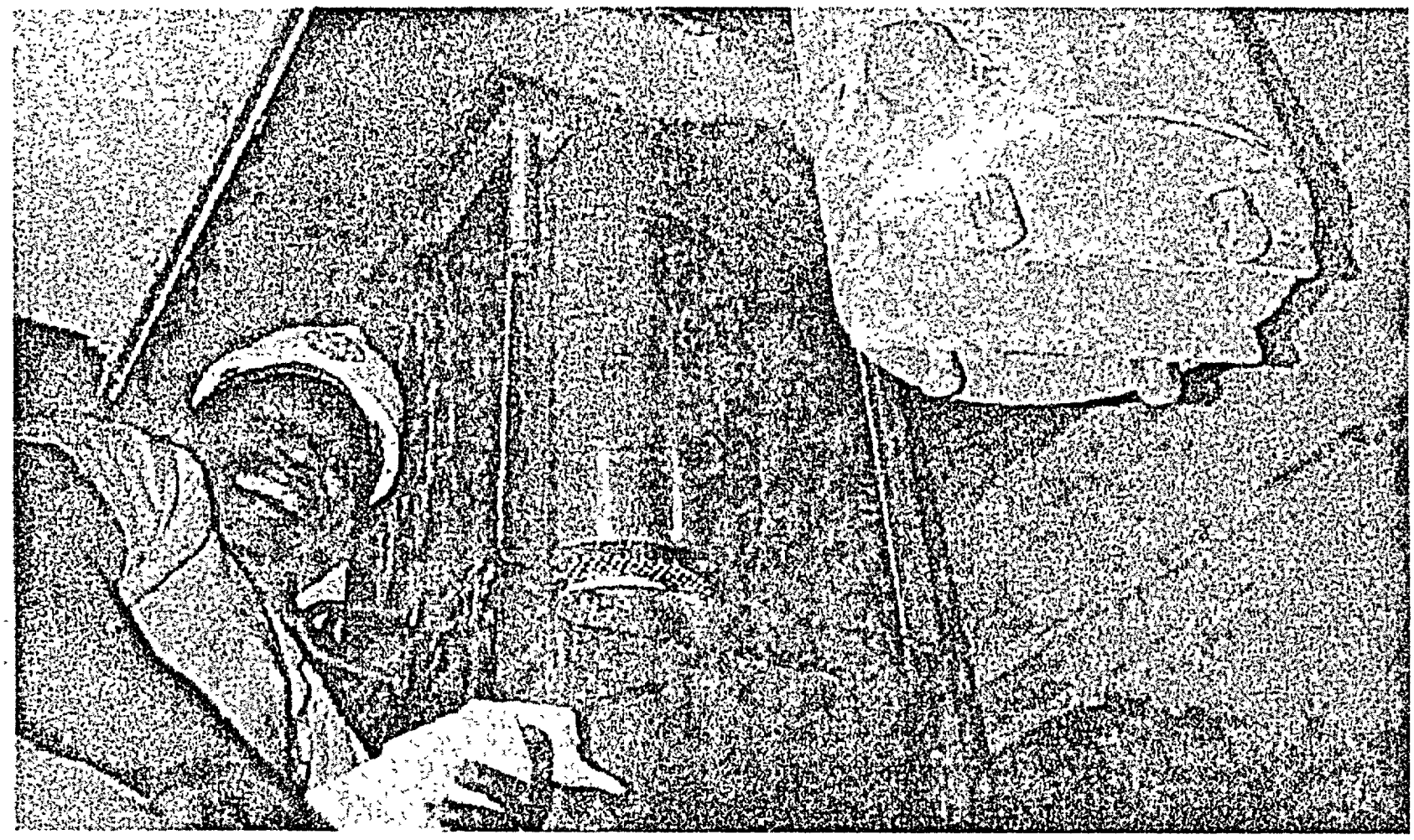
Pre-Stress Losses

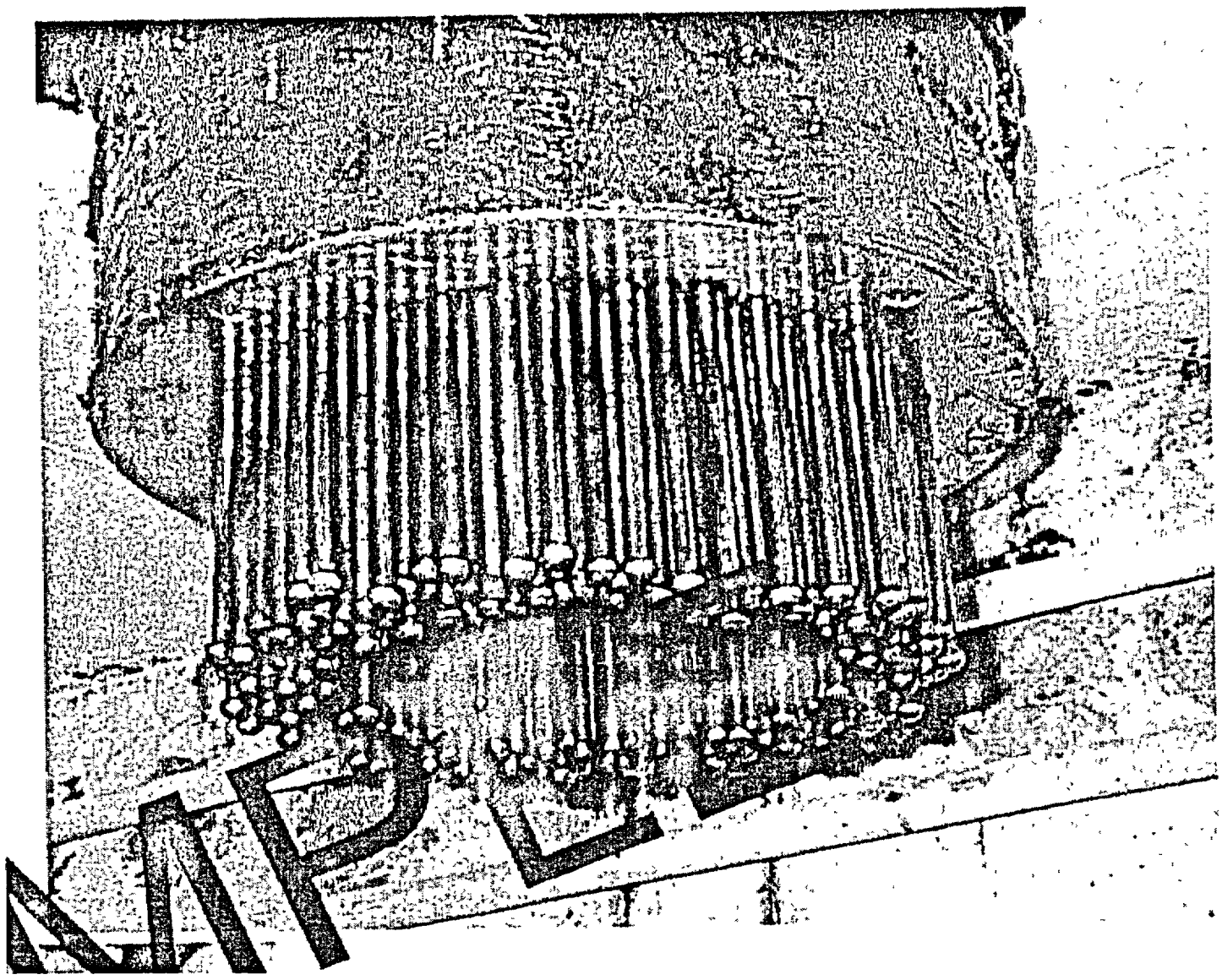
- Time-dependent losses follow a logarithmic pattern.
- 20 - 25% of pre-stress is expected to be lost over the life of the plant.
- Most of lifetime pre-stress loss occurs during year 1.
- Accuracy of predictions confirmed through year 10.
- Predicted loss rate after year 10 could be increased by a factor of 10 without consuming the available STP pre-stress design margin.

Tendon Arrangement









Current Requirements

IWL-2421: Surveillance schedule

IWL-2500: Examination of concrete and tendons

- IWL-2521: Random selection of tendons
- IWL-2522: Liftoff testing
- IWL-2523: Tendon detension and wire testing
- IWL-2524: Examination of anchorage areas
- IWL-2525: Examination of corrosion protection medium and free water

Current Schedule

Unit 1

- Examinations required by IWL-2500 are performed at 20 (2008) and 30 (2018) years.
- Only IWL-2524 and IWL-2525 are performed at 15 (2003), 25 (2013), and 35 (2023) years.

Unit 2

- Examinations required by IWL-2500 are performed at 15 (2004), 25 (2014), and 35 (2024) years.
- Only IWL-2524 and IWL-2525 are performed at 20 (2009) and 30 (2019) years.

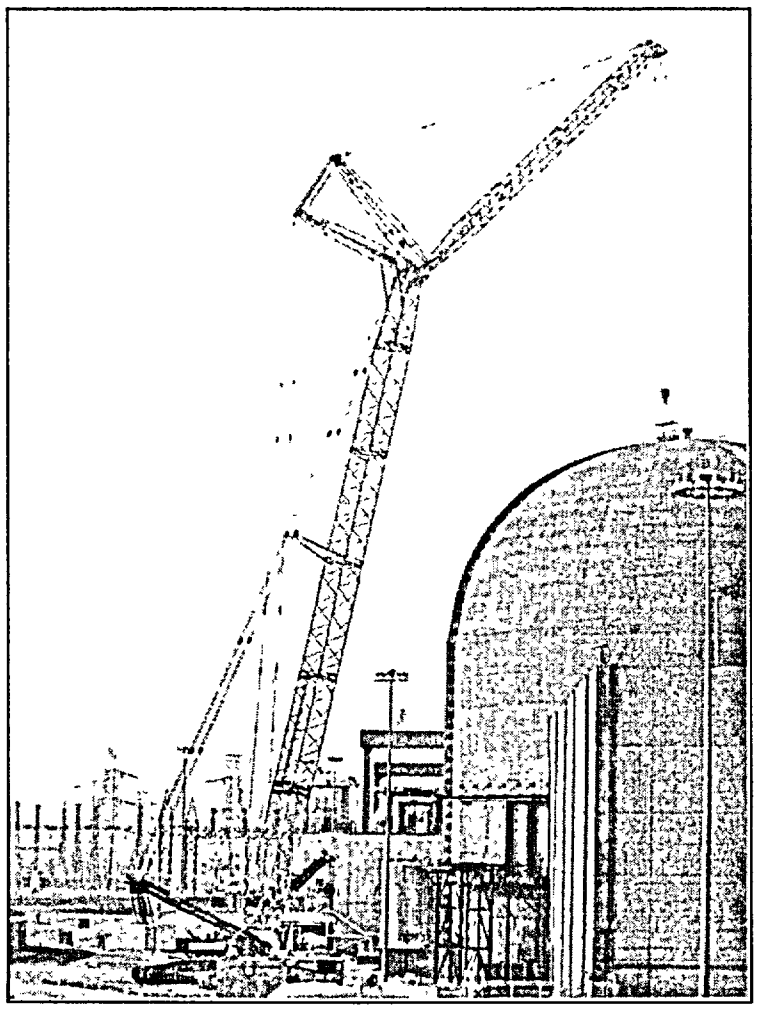
Reason for Request

- Total estimated savings over life of the plant:

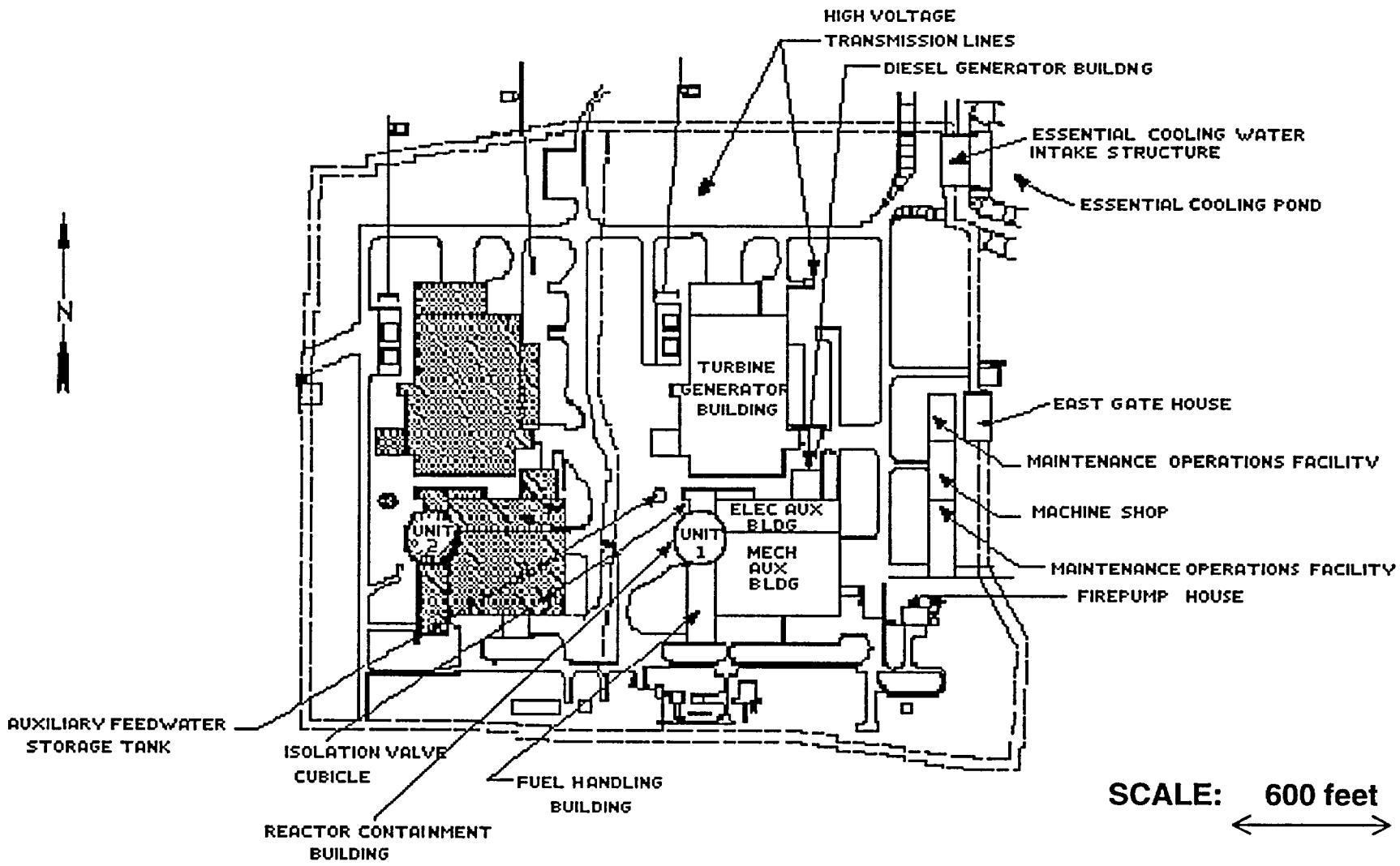
  $2,000,000

- Many tendons require a large crane able to reach over the top of the containment for access. Use of a large crane increases risk to plant personnel.
- Adjacent buildings limit crane location.
- Code surveillance requirements increase cost without comparable increase in benefit to public safety, compared to the proposed alternative surveillance.

Typical Crane Application



Plant Layout



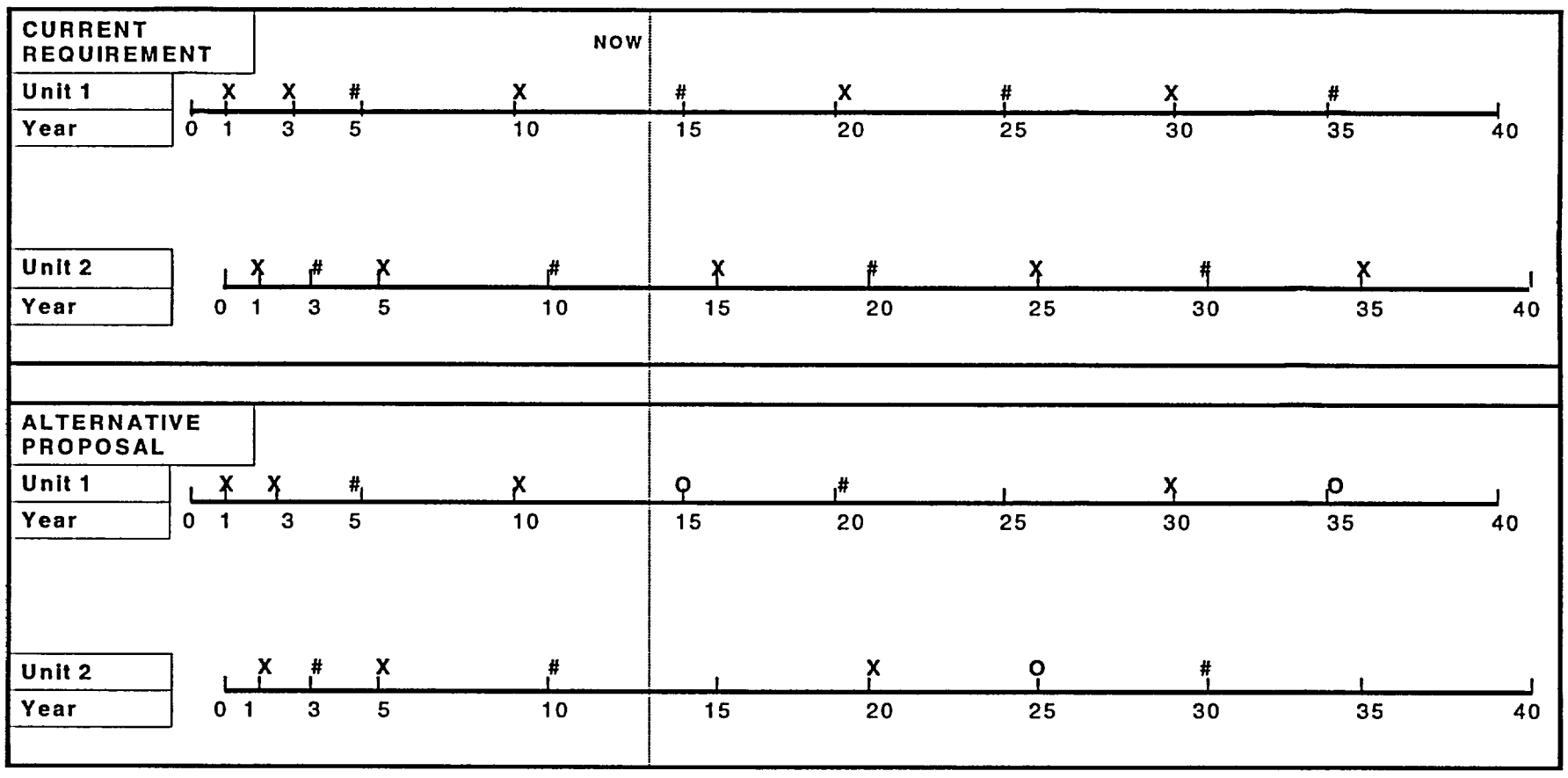
History of Submittals

- September 26, 2001 - Initial Proposal
- August 20, 2002 - Alternative Proposal
- January 6, 2003 - Response to RAI

Alternative Surveillance

- Perform IWL-2522 (Liftoff testing) on two horizontal tendons chosen from a group that does not require a crane or special equipment for access.
- One tendon shall be adjacent to the main steam penetration. This tendon is the most susceptible to thermal-induced relaxation, which was discussed in IEN 99-10.
- **This ensures liftoff testing is done at STP at 5-year intervals.**

Timeline Comparison



X = ALL EXAMINATIONS REQUIRED BY IWL-2500
# = SURVEILLANCES REQUIRED BY IWL-2524 AND IWL-2525
O = ALTERNATIVE SURVEILLANCE WITH REDUCED TENDON SAMPLE POPULATION

Regulatory Guide 1.174

- Regulatory Requirements for Tech Spec Changes
  - Reason for Proposed Change
  - Engineering Evaluation
  - Implementation and Monitoring Program
  - Documentation and Submittal
- Regulatory Guide 1.174 criteria can be applied to risk-based analysis of a proposed alternative to a code surveillance.

Justification for Proposed Alternative

- Level of risk remains acceptable.
- Post-tensioning system has behaved as designed over the ten-year history of test and examination.
- Projected trends of all tendon groups remain acceptable for 40 years of plant life.
- Margin of safety is substantial.
- Proposed surveillance schedule maintains assurance of degradation detection.

Engineering Evaluation

Traditional Engineering Considerations

- Defense-in-Depth
- Safety Margin

Defense-in-Depth

- There is no reduction of defense-in-depth. Compliance with the General Design Criteria, Appendix A to 10 CFR Part 50, is maintained.

Safety Margin

- If we lose 43% of all tendons, with the other 57% behaving as designed, we still meet Tech Spec basis (41.2 psi) using ASME allowables.

Safety Margin

- Design margins are based on end-of-life tendon strength. The current margins are greater.
- Calculated peak accident pressure inside containment is 40.5 psig.
- Design pressure is 56.5 psig (40% above peak)
- Ultimate strength estimated to be 141 psig (348% above peak)
- These margins do not include consideration of rebar and seismic effects.

Test Result Summary

- STP has performed 116 tendon liftoff tests
  - 38 vertical
  - 78 horizontal
- The greatest negative deviation from predicted values is 5.9% less than expected.

Tendon Force Measurement Summary

Table 1

Deviation from Predicted Values (%)

	Unit 1-Horizontal	Unit 1-Vertical	Unit 2-Horizontal	Unit 2-Vertical
Low	-5.9	-1.7	-5.9	-1.0
Median	1.1	0.7	0.3	2.3
Mean	0.7	0.9	1.3	2.5

Tendon Force Projected Trends (Based on Linear Regression)

Table 2

Projected Deviation from Predicted Values (%)

Trend	Unit 1-Horizontal	Unit 1-Vertical	Unit 2-Horizontal	Unit 2-Vertical
Yr. 15	-1.91	1.71	-0.75	5.32
Yr. 20	-2.38	1.87	-1.08	5.75
Yr. 30	-3.03	2.09	-1.55	6.35
Yr. 40	-3.50	2.25	-1.88	6.78

Information Notice 99-10

STP has not experienced the concerns of IEN 99-10:

- There has been no inservice wire breakage.
- Pre-stress losses have not been higher than predicted.
- Trend lines show pre-stress degradation will not exceed design limits after 40 years.

Engineering Evaluation

- Evaluation of Risk Impact
  - Scope of the PRA
  - PRA Modeling

Scope of the PRA

- Plant fires, seismic events, tornadoes, and external flooding are included in the PRA as external events.
- Plant systems necessary to mitigate the consequences of plant transients are included in the PRA (limited modeling of turbine systems)
- Linked event trees (RISKMAN) and large fault trees are used for model quantification

Event Tree

- The STP Level 2 PRA includes internal and external events.
- The Containment Event Tree is linked to the front line event trees for Level 2 quantification. The containment response tree uses Zion and NUREG-1150 information, modified by STP-specific design considerations, to determine the frequency of four release categories
  - Large Early Release
  - Large Late Release
  - Small Early Release
  - No Containment Release

Current Level 2 Results

- Large Early Release is dominated by:
  - Induced SGTR with bypass: 87.35%
  - Interfacing LOCA: 5.80%
  - Other Large Bypass: 4.21%
  - Direct Containment Heating (R01U): 2.00%
  - Other Causes: 0.64%
- LERF Total: 5.76E-07 per year

The only release mechanism potentially affected by this proposed change is Direct Containment Heating.

Level 2 Analysis - Best Estimate

- Based upon current understanding of containment tendon pre-stress loss and upon the analyses presented in SAND2001-1762, no effect on containment response is expected for the proposed change in surveillance requirements.

PRA Modeling - Techniques

To support this surveillance relief request, an analysis using the following Level 2 modeling techniques is proposed:

- Proposed alternative surveillance criteria will have a direct effect on containment pressure capability. (This is a highly conservative assumption.)
- Changes in pressure capability will result in increases in Large Early Release from Direct Containment Heating phenomenon.

PRA Modeling - Assumptions

- Median Containment capacity is 163 psi:
  - 5th percentile 130 psi
  - 95th percentile 205 psi
- Median (50th percentile) pressure increase due to Direct Containment Heating is 85 psi for state R01U.
- Median initial pressure is 13 psig
- Final containment pressure from DCH:
  - 5th percentile 83 psi
  - Median 98 psi
  - 95th percentile 129 psi

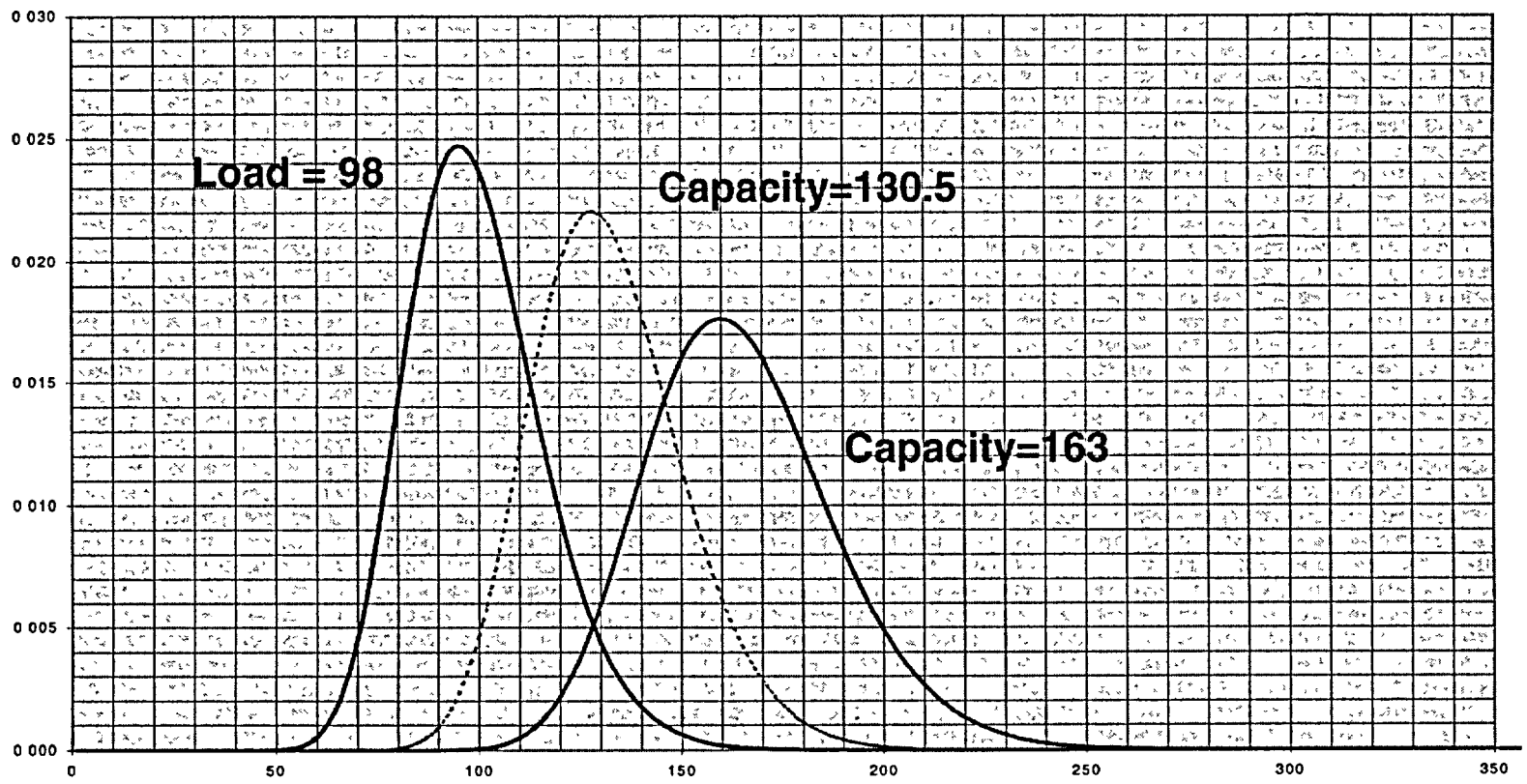
Effects on LERF

- LERF = 5.76E-07 per year
- 2.0% of LERF due to DCH (R01U)
- For a change in LERF:

  5.76E-07 * 0.02 * ((0.0944-0.00978)/0.00978) = 1.0E-7
- CCFP = 0.00978 with median capacity of 163 psi

  CCFP =0.0944 with median capacity of 130.5 psi

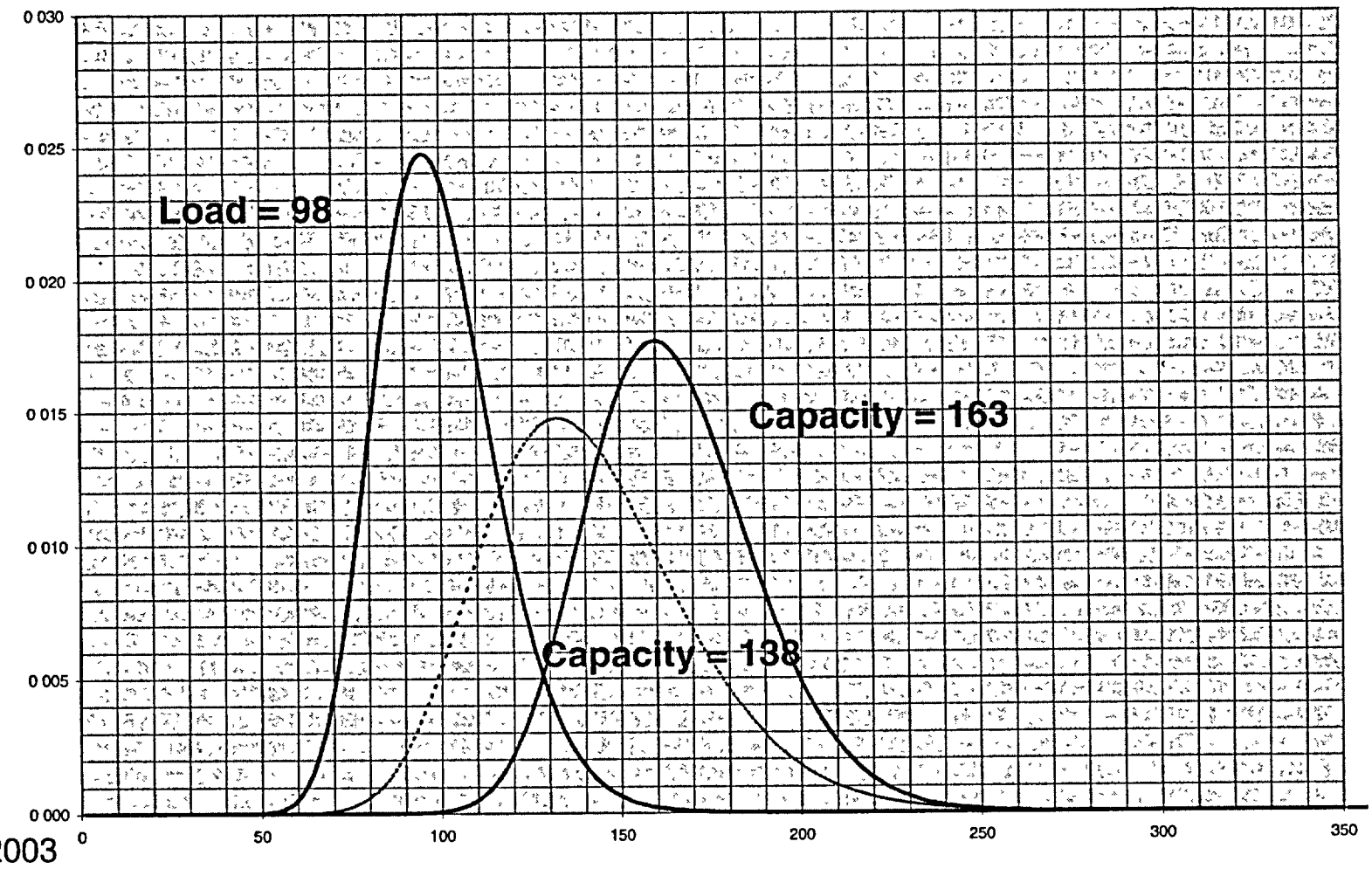
Distributions for DCH Pressure and Initial Hoop Capacity of 163 Psi and Reduced Hoop Capacity of 130.5 Psi (Both Capacity Curves With $\beta_C = 0.14$)



Change in LERF

- Alternative Sensitivity Case to address potentially increased uncertainty associated with longer surveillance interval
- Increased $\beta_c = 0.20$
- Median capacity reduced to 138.0 psi (from initial $\beta_c = 0.14$ and median of 163 psi)

Distributions for DCH Pressure and Initial Hoop Capacity of 163 Psi (With $\beta_C = 0.14$) and Reduced Hoop Capacity of 138 Psi (With Increased $\beta_C = 0.20$)



Summary of Level 2 Analysis

- Two sensitivity cases:
  - Current Level 2 - capability curve modified to reflect 1.0E-7 LERF [Median = 130.5 psi]
  - Modified Level 2 - capability curve modified to reflect increase in uncertainty [Median = 138 psi]
- Proposed alternative surveillance does not appear to significantly affect large early release.

Significance of Proposed Changes

- There are no physical or design changes.
- Previous surveillances through year 10 show behavior is close (2-3%) to that predicted.
- Large design margin means tendons satisfy design requirements even if the pre-stress loss rate is 10 times greater than expected after year 10

Conclusion

- Proposed alternative surveillance is expected to provide timely detection of tendon degradation severe enough to threaten the ability to withstand a design basis accident.
- Risk analysis shows that the increase in risk is very small.
- Proposed alternative provides an acceptable level of quality and safety pursuant to 10CFR50.55a(a)(3)(i).