Ice Condenser Ice Fusion

December 12, 2007

Indiana Michigan Power Company
Donald C. Cook Nuclear Plant Units 1 and 2

Duke Power Company
McGuire Nuclear Station Units 1 and 2
Catawba Nuclear Station Units 1 and 2

Tennessee Valley Authority
Sequoyah Nuclear Plant Units 1 and 2
Watts Bar Nuclear Plant Unit 1

Westinghouse Electric Company

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Agenda

- Introduction
- Ice Condenser Overview
- Historical Perspective
- NRC and Licensee Positions
- Ice Bed Maintenance Practices
- Issue Resolution

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Ice Condenser Overview

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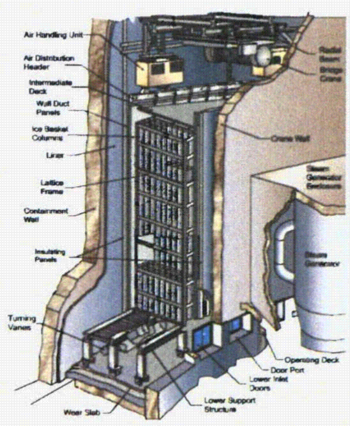
Ice Condenser Sectional View



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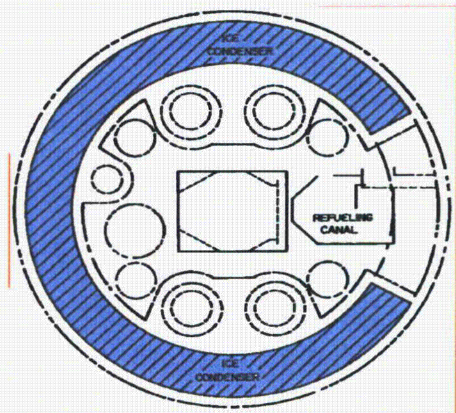
Ice Condenser Layout



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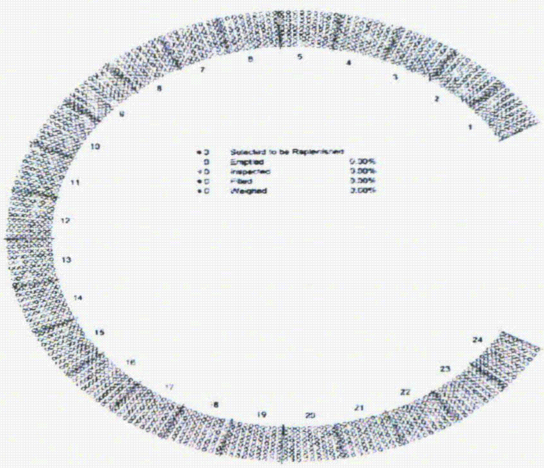
Ice Condenser
24 bays



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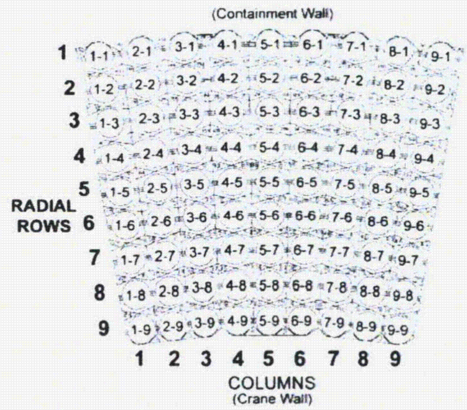
Typical Ice Condenser Bay
81 baskets/bay; 1944 total baskets



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Ice Basket
Typical sections prior to installation

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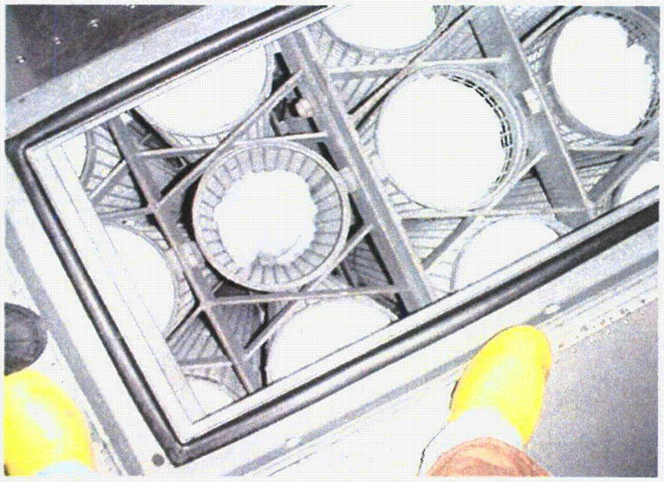
Ice Baskets
Top view from upper plenum



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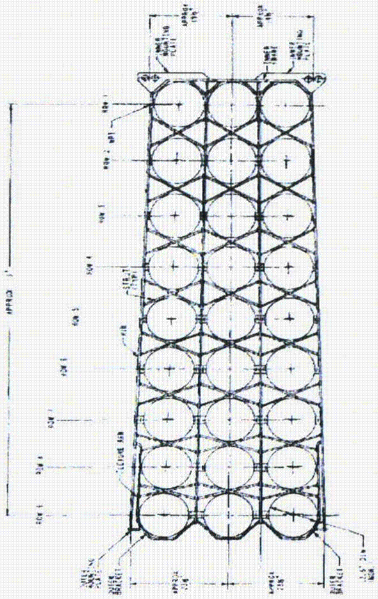
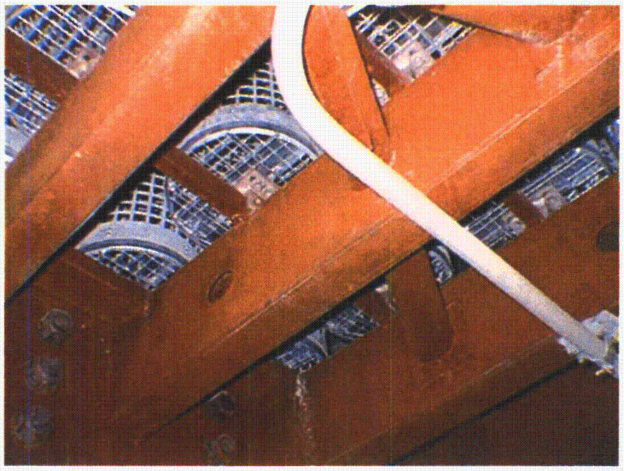
Lattice Frame



Drawing shows 1/3 of a bay

Note the tight spacing between baskets and lattice frames due to spacer tabs

Lower Support Structure
Viewed from below prior to ice loading



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Ice Fusion History

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Ice Fusion History

Dec 1973
- Seismic testing of fused ice baskets started at Westinghouse Waltz Mill
- Minimum ice fusion time not determined

Apr 1974
- AEC staff evaluation of ice condenser testing indicated a need to establish a "preoperational limit for minimum storage time" of ice

May 1974
- WCAP-8110, Supplement 9 issued
  - Qualified ice basket design for acceptable fallout from fused ice baskets
  - Included results that indicated 5-7 weeks was an acceptable fusion time

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Ice Fusion History

Oct 1974
- Ice condenser design for CNP accepted by AEC (SER, Supplement 2)

Nov 1974
- AEC issued topical SER for WCAP-8110, Supplement 9
  - Imposed 5-week fusion time for land-based ice condenser plants prior to initial ascent to power

Nov 1974
- Westinghouse issued ice basket maintenance procedure
  - Addressed direct addition of ice or water
  - Did not consider emptying/refilling of ice baskets

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Ice Fusion History

Dec 1975

- CNP evaluated ice loss during plant operation
  - Baskets weighed in July and October 1975
  - Ice loss more than originally expected

Nov 1977

- Westinghouse issued ice bed maintenance program document
  - Advocated mass addition, but included meltdown of individual ice columns
  - Remained silent on ice fusion time

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Ice Fusion History

1978-1997

- Maintenance strategy
  - I&M and Duke - empty and refill baskets
  - TVA - thermal drilling and mass addition

May 1998

- Both CNP ice beds melted
- Refurbishment of ice condensers initiated

Jan 2000

- CNP recognized that impact on ice fallout was not evaluated during basket mods
  - Performed "Use-as-Is" evaluation

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Ice Fusion History

Jun 2000
- CNP Unit 2 restarted
  - Available fusion time >5 weeks

Oct 2000
- CNP prepared evaluation supporting startup of Unit 1 with <5 weeks fusion time

Dec 2000
- CNP Unit 1 restarted
  - Available fusion time >5 weeks, so evaluation was not needed
- TIA 2000-08 issued
  - Affirmed 5-week fusion time requirement
  - Option for licensees to change via 50.59

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WCAP-8110, Supplement 9
"Ice Fallout From Seismic Testing of Fused Ice Basket"

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WCAP-8110, Supplement 9
Historical Summary - Objective

- "The objective of these tests was to determine the ice fallout from 1" x 1" perforated metal baskets, with 64% open area, as a result of simulated plant time history seismic disturbances after the baskets have had time for the ice to fuse."
  - Ice fusion time was not an objective of the test
  - Test did indicate an ice column was acceptably fused in a period of 5-7 weeks

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WCAP-8110, Supplement 9
Historical Summary - Method

- Documented results of seismic tests of ice baskets to qualify redesigned ice basket
  - Used seismic time histories for CNP, Sequoyah, McGuire, and Ohi
- Tested 6 ice baskets containing ice fused for various time periods
- Results were compared to 1% fallout
- Test details documented in Westinghouse Astronuclear Laboratory Report EL:407 (not docketed)

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WCAP-8110, Supplement 9
Historical Summary - Tests

- 12/20/73: One basket with ice fused via temperature control
  - Resonant search and sine beat testing
- 1/11/74: Two baskets with freshly loaded ice
  - One solid and one mesh bottom basket
  - Sine beat testing
- 1/25/74: Test ice baskets loaded

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WCAP-8110, Supplement 9
Historical Summary - Tests

- 2/15/74: One ice basket tested with AEP time history
  - Did not meet 1% criterion due to flawed basket support arrangement
- 3/1/74: Test arrangement modified
- 3/8/74: One basket tested successively with all four plant time histories
  - Met 1% criterion
- 3/18/74: One basket tested successively with all 4 plant time histories
  - Met 1% criterion

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WCAP-8110, Supplement 9
Historical Summary - Test Results

- WCAP-8110, Supplement 9 issued by Westinghouse in May 1974
  - "This test is an extremely conservative approach to the ice fallout during a seismic disturbance in that the basket is floating freely in the lattice frames and not fixed at one end; the amount of loss, after the first cycle, is not representative of a basket receiving its first seismic disturbance; and all of the six foot baskets except the top one, have baskets above them and do not have open tops."

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WCAP-8110, Supplement 9
Historical Summary - Test Results

[quote cont'd]

- "If each six feet of an ice column behaves as the test basket, then the total ice loss per ice basket for the AEP Plant Time History seismic disturbance will be less than 1%. This assumes that each section has a bottom and free top. This is not the case in that there is only one bottom and one top in a complete 48' column. Therefore, the actual percent loss per column should be less than that observed in these tests."

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WCAP-8110, Supplement 9
Attributes and Conservatisms

- Purpose was to qualify ice basket design given fused ice and ensure that ice fallout during a seismic event was not excessive; it did not determine minimum fusion time

- Ice fallout was not linked to a specific ice condenser performance attribute (*e.g.*, lower inlet door clearance or maintaining ice bed geometry)

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WCAP-8110, Supplement 9
Attributes and Conservatisms

- Stored ice baskets were wrapped in polyethylene, which limited interaction with air and thus retarded fusion
- Reference to force gage measurements on stored ice indicates that ice fused much earlier than the first successful test
  - Definitive force gage data is not available
- Test at three weeks had flawed test setup
  - Not properly restrained, no representative weight over ice, no basket rim

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WCAP-8110, Supplement 9
Historical Summary - AEC SER

- 11/21/74: AEC issued SER
  - "...we have concluded that the data presented in WCAP-8110, Supplement 9 are adequate to conclude that land-based plants using ice condenser type containments should begin their initial ascent to power after a minimum of five weeks following ice loading. Therefore, WCAP-8110, Supplement 9 may be referenced in license applications as an accepted topical report when used in support of this conclusion."

Ice Fusion Issue - Licensee Understanding of NRC Position

- Region III views WCAP-8110, Supplement 9 as prescribing a required fusion time for freshly loaded ice baskets before ascent to power operation (Mode 2)
- Deviation from this fusion time under any conditions should be evaluated under 10CFR50.59

Ice Fusion Issue - Licensee Position

- Licensee and Westinghouse position has been that:
  - Test program documented in WCAP-8110, Supplement 9 was never intended to derive a minimum ice fusion time
    - Tested baskets were assumed fused
  - AEC intended to establish a preoperational fusion time based on WCAP 8110, Supplement 9 data
  - Individual ice column emptying was not originally considered based on:
    - Maintenance practices initially described only mass addition techniques, and
    - Technical Specifications did not recognize ongoing ice fusion time requirements

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Ice Fusion Issue – Licensee Position (continued)

- The 5-week fusion time prescribed by WCAP-8110 Supplement 9A SER is very conservative and was intended to be applied to complete ice bed loading
- Freshly loaded ice fuses much more quickly than the times reported in WCAP 8110, Supplement 9

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Ice Fusion Issue – Licensee Position (continued)

- Ice condenser credited for mitigation of LOCA/MSLB
- Ice condenser has no specified safety function for achieving and maintaining safe shutdown following seismic event
- Ice fusion issue is a short-term, self-correcting condition
- Ice fusion is a qualification issue with low risk significance

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Ice Fusion Issue – Licensee Position (continued)

- Routine maintenance practices developed over decades of ice condenser operation limit potential exposure due to ice fallout
  - CNP and Duke - complete basket empty and refill
    - Inherent compaction of 48 ft ice column
  - TVA - thermal drill and mass addition
    - Outer crust largely undisturbed

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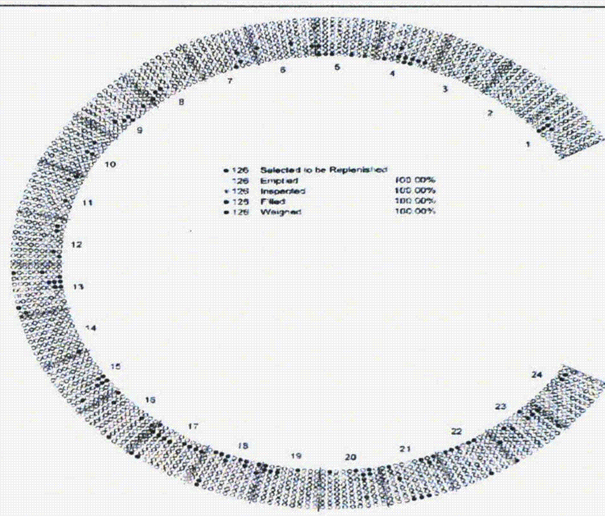
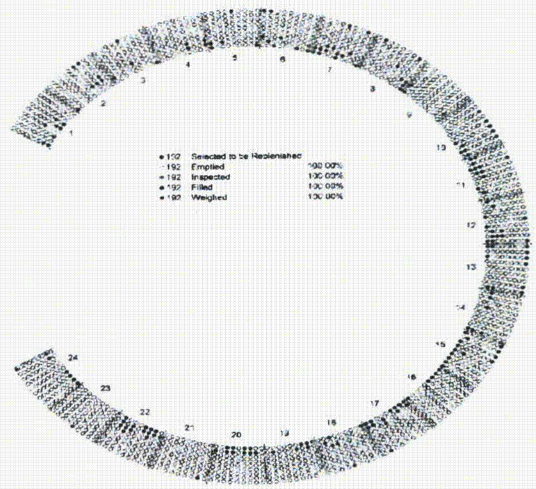
Typical Ice Bed Maintenance Practices

- Typical refueling outage ice loading
  - 10 - 20% of 1944 baskets
  - Limited number of baskets per bay
  - Freshly loaded ice inherently contains moisture, which promotes fusion
  - Basket maintenance followed by flow channel cleaning, basket weighing, and surveillances prior to startup
- Ice production capability limited to approximately 20 complete baskets per day
- Force gage measurements taken at CNP during U2C17 outage show that outer crust develops within a few days

Typical Outage Ice Loading Pattern – CNP U1C20 (126 baskets)



Typical Outage Ice Loading Pattern – CNP U2C16 (192 baskets)



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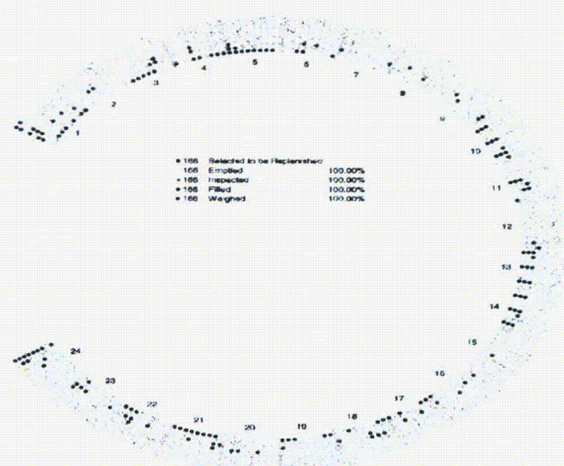
Typical Outage Ice Loading Pattern – McGuire U1C20 (166 baskets)



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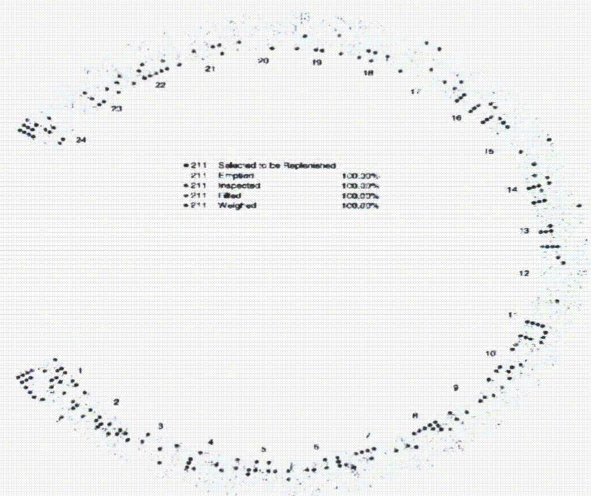
Typical Outage Ice Loading Pattern – McGuire U2C17 (211 baskets)



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Ice Fusion Issue Resolution

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Ice Fusion Issue Resolution

- Conservative five-week criterion for ice fusion time for initial ice bed loading raises the need to clarify the licensing basis for ice basket maintenance activities other than a complete ice bed reload

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Planned Actions

- In interim, perform evaluation following ice basket emptying/refilling prior to power operation
- Revise licensing basis to require performance of ice condenser inspections within 24 hours if seismic activity (≥OBE) occurs within 5 weeks following ice basket filling

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Questions

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