Westinghouse Electric Company
CE Nuclear Power LLC

2000 Day Hill Road
Windsor, CT 06095

January 5, 2001
LD-2001-0002

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Transmittal of BWR Control Rod and Fuel Performance Discussion Materials
((Contains Proprietary Information))

The purpose of this letter is to transmit one (1) proprietary and one (1) non-proprietary copy of the BWR control rod and fuel performance slide package materials to be discussed with the staff on January 9, 2001.

CE Nuclear Power has determined that information contained in the attached slide package is proprietary in nature. We request that this material be appropriately safeguarded and withheld from public disclosure in accordance with the provisions of 10 CFR 2.790. The reasons for the classification of this material as proprietary are delineated in the attached affidavit.

If you have any questions regarding this matter, please do not hesitate to call me or Virgil Paggen of my staff at 860-285-4700.

Sincerely,
CE Nuclear Power LLC

Philip W. Richardson
Licensing Project Manager

Attachments: As stated

copy: J. Cushing (OWFN, 4 D7)
C. Brinkman (Rockville)

NRC 001

I, Philip W. Richardson, depose and say that I am the Licensing Project Manager of CE Nuclear Power LLC (CENP), duly authorized to make this affidavit, and have reviewed or caused to have reviewed the information which is identified as proprietary and described below.

I am submitting this affidavit in conformance with the provisions of 10 CFR 2.790 of the Commission's regulations for withholding this information. I have personal knowledge of the criteria and procedures utilized by CENP in designating information as a trade secret, privileged, or as confidential commercial or financial information.

The information for which proprietary treatment is sought, and which document has been appropriately designated as proprietary, is contained in the following:

- *Meeting Materials to Discuss BWR Control Rod Designs and BWR Fuel Performance to be presented to the NRC on January 9, 2001.*

Pursuant to the provisions of Section 2.790(b)(4) of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information included in the document listed above should be withheld from public disclosure.

i. The information sought to be withheld from public disclosure is owned and has been held in confidence by CENP. It consists of information concerning the development, application and qualification of BWR control rod designs and BWR fuel performance information.

ii. The information consists of presentation slides or other similar data for the design, evaluation or application of BWR control rods and fuel performance information, the application of which results in substantial competitive advantage to CENP.

iii. The information is of a type customarily held in confidence by CENP and not customarily disclosed to the public.

iv. The information is being transmitted to the Commission in confidence under the provisions of 10 CFR 2.790 with the understanding that it is to be received in confidence by the Commission.

v. The information, to the best of my knowledge and belief, is not available in public sources, and any disclosure to third parties has been made pursuant to regulatory provisions or proprietary agreements that provide for maintenance of the information in confidence.

vi. Public disclosure of the information is likely to cause substantial harm to the competitive position of CENP because:

   a. A similar product is produced by major competitors of CENP.

   b. Development of this information by CENP required hundreds of thousands of dollars and thousands of manhours of effort. A competitor would have to undergo similar expense in generating equivalent information.

   c. The information consists of design, qualification and licensing information for BWR control rods, and performance information for BWR fuels, the application of which provides a competitive economic advantage. The availability of such information to competitors would enable them to design their product to better compete with CENP, take marketing or other actions to improve their product's position or impair the position of

CENP's product, and avoid developing similar technical analysis in support of their processes, methods or apparatus.

d. In pricing CENP's products and services, significant research, development, engineering, analytical, manufacturing, licensing, quality assurance and other costs and expenses must be included. The ability of CENP's competitors to utilize such information without similar expenditure of resources may enable them to sell at prices reflecting significantly lower costs.

e. Use of the information by competitors in the international marketplace would increase their ability to market competing systems by reducing the costs associated with their technology development.

Philip W. Richardson
Licensing Project Manager

Sworn to before me this 3rd day of January 2001

Laurie J. White
Notary Public

My Commission expires: 8/31/04

Westinghouse BWR Control Rods and Fuel Update

January 9, 2001

Today's Agenda

Design and Evolution of the Westinghouse BWR Control Rod

- Design
- Evolution
- Operation & Compatibility
- Disposal

Deliveries

Westinghouse BWR Control Rod Experience

- Pool Side Neutron Radiography
- Japan (Bulge) Update
- Hope Creek (Blister) Update
- Recent U.S. Inspection Results
- Generic Inspection Results / Guidelines

Today's Agenda - Continued

BWR Control Rod Cracking

- Mechanism
- Remedies

Westinghouse BWR Control Rod Development - CR 99

- CR 99 Design Expectations
- Concept with Dense B_4C Pins
- B_4C Pin Placement
- CR 99 Concept Demonstrations
- CR 99 Design Summary
- CR 99 Lead Rod Programs
- Introduction of CR 99
- CR 99 Inspections

Today's Agenda - Continued

Licensing of Westinghouse Control Rods

- General History
- U.S. Licensing History
- Generic Licensing Approach
- Proposed Approach for CR 99

Control Rod Summary

BWR Fuel Update

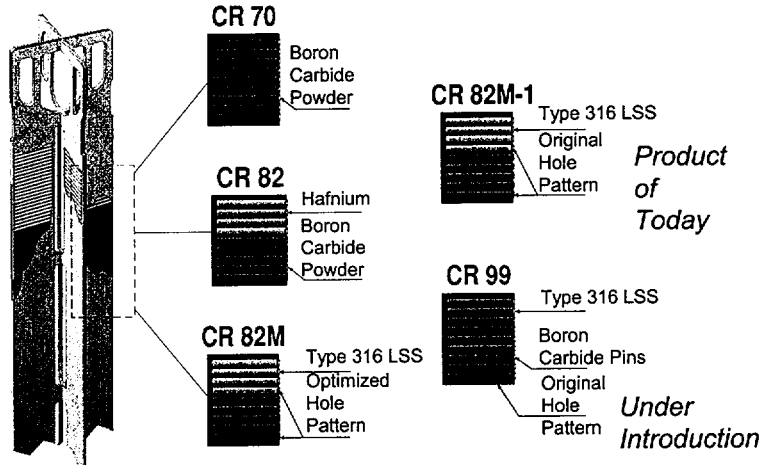
- Fuel Design and Production Update
- BWR Fuel Performance Update
- BWR Licensing Plans
- Summary

DESIGN AND EVOLUTION OF THE WESTINGHOUSE BWR CONTROL ROD

Design

- **Same Basic Design Since 1969/1970**
  - Solid 304L stainless steel wings with horizontally drilled holes
  - B4C Powder / Hafnium Pin Design
  - Velocity Limiter dimensions are identical to Original Equipment
  - Uses buttons rather than pins and rollers
  - No crevices
  - 30 years of operating experience

Evolution



Evolution

Hole Patterns in Westinghouse BWR Control Rods

Evolution

- 316L Stainless Steel

Evolution

Design features of the BWR control rod types

Operation & Compatibility

- Compatible with all BWR type fuel
- Westinghouse BWR Control Rods in all types of BWR Reactors - Atom, Siemens and GE
- Currently being used in GE BWR-3 through 6
- Envelope within Original Equipment envelope
- Scram times well within performance envelope

Disposal

- Actions Necessary for Disposal
  - Cut off velocity limiter
  - Cut wings apart through center section
    - Intermittent connection
    - No B_4C Dispersal
    - Can use Electro-spark
  - Stack wings and place in cask if cask is long enough
  - Otherwise cut into sections
    - Only cut through 1 or 2 holes - very slight B_4C dispersal

WESTINGHOUSE BWR CONTROL ROD DELIVERIES

Deliveries 1999

Deliveries 2000 (Through October)

Deliveries 1970 - Oct 2000

Year

Deliveries By Country

Deliveries USA

WESTINGHOUSE BWR CONTROL ROD EXPERIENCE

General

- Atom has delivered over 4000 BWR control rods. All have fulfilled their safety duty.
- Westinghouse has an extensive control rod database

Pool-side Neutron Radiography

- During the 80´s, performed an extensive study regarding boron carbide wash-out in case of cracks in control rods.

Hafnium Hydriding

Hafnium Hydriding

Japan (Bulge) Update

- **Discovered at start after unplanned outage (Oct. 1997) in middle of cycle. Rod could not be withdrawn from core.**
  - Control rod CR 85M design (Never delivered to US)
  - Entirely operated as CCC rod

Japan (Bulge) Update

Japan (Bulge) Update

Hope Creek (Blister) Update

- **Scenario:**
  - Control rod operated in CCC position. 18 month cycles (planned 9 month fully inserted 9 month withdrawn). 4 cycles of operation.
  - During the 4th cycle the indication of the control rod position was lost. The control rod was fully inserted for remainder of cycle.
  - In November 1998 the reactor was shut down due to a scram. When returned to full power a tritium peak was detected.
  - During next refuel outage control rods were inspected, and a blister was found on the most exposed CR 82 rod. Locally at the blister the blade thickness was 16 mm.
  - Reactor water tritium level showed that the control rod had initial crack in the middle of the 4th cycle, between 2.5 and 3.0 snvt in top quarter segment (March 1998). It was then operated fully inserted with cracks.

Hope Creek (Blister) Update

Recent U.S. Inspections

Recent U.S. Inspections

- **Inspection of CR 82M-2 rods in Hope Creek - 1999**
  - All cracked blades replaced
  - Conclusions:

Recent U.S. Inspections

- **Inspection of CR 82M Rods at River Bend - 1999**
  - Exposure below 2 snvt
  - Control rods looked good. No crack indication.
- **Inspection of CR 82M-1 Rod at Dresden 3 - 2000**
  - Inspection at exposure 1.7 snvt
  - Control rod looked good. No crack indication.

Generic Inspection Results / Guidelines

- **All Westinghouse BWR Control Rod Designs are Easily Inspected**
  - Simple visual inspection
  - Low cost inspection
  - No special tools needed
  - Inspection verifies the condition of the control rods
- **Being Able to Easily Inspect a Control Rod is a Clear Advantage**
  - Lowers risk of costly future inspection programs

Inspections Of CR 82

Inspections Of CR 82M

Inspections of CR 82M-1

Inspection Guidelines - CR 82 and CR 82M

CR 82: Inspection when reaching > 3 snvt most exposed quarter segment

CR 82M: Inspection when reaching > 3 snvt most exposed quarter segment

Inspection Guidelines for CR 82M -1

BWR CONTROL ROD CRACKING

Mechanism

- **Irradiation Assisted Stress Corrosion Cracking (IASCC). Intergranular crack mode.**
- **IASCC dependent on the following factors:**
  - Material sensitization - Cr depletion in grain boundaries. At higher fluence other mechanism(s)
  - Stresses - in control rods by boron carbide swelling
  - Oxidizing environment – Normal BWR water chemistry.

Mechanism

- **Material Sensitization of Stainless Steel**
  - Material properties are changed by irradiation with fast neutrons
    - Increased hardness
    - Increased yield and ultimate strength
    - Segregation of elements to and from the grain boundaries e.g. Cr
- **Stresses Due to Swelling of Boron Carbide**
  - $^{10}B + n \rightarrow {}^{7}Li + {}^{4}He + 2{,}8$ MeV
  - Helium is trapped in the boron carbide (well above 90%). Results in volume swelling and stresses on hard contact.
  - Helium release leads to pressure build-up in the control rod

Mechanism

- **Stresses Due to Irradiation of Hafnium**
  - No swelling due to irradiation
  - No hydriding within an intact BWR control rod
  - Hafnium not a factor in control rod cracking
  - Weight is limiting the use of Hafnium in BWR control rods

Remedies for IASCC

WESTINGHOUSE BWR CONTROL ROD DEVELOPMENT - CR 99

CR 99 Design Expectations

Concept With Dense B_4C Pins

Concept With Dense B_4C Pins

B_4C Pin Placement

B_4C Pin Placement

CR 99 Concept Demonstration

- **Oskarshamn 2**
  - Two demo control rods was operated in Oskarshamn 2 between 1991 and 1997

CR 99 Concept Demonstration

- **Forsmark 1**

CR 99 Concept Demonstration

CR 99 Concept Demonstration

CR 99 Design Summary

- CR 99 Design Summary

CR 99 Lead Rod Program

Oskarshamn 3

2 CR 99's planned to be operated on 12 month cycles. Rods inspected after each cycle.

CR 99 Lead Rod Program

Olkiluoto 1/2

2 CR 99's planned to be operated on 12 month cycles.

Introduction of CR 99

1999 2 Rods to Olkiluoto (Finland)
2 Rods to Oskarshamn (Sweden)

2000 4 Rods to Gundremmingen (Germany)

CR 99 Inspections

LICENSING OF WESTINGHOUSE BWR CONTROL RODS

General History

- Licensing done on a specific model type (also reactor type for Westinghouse Atom)
- Changes in a design require new licensing or a 50.59 approach
- NRC management is, in general, satisfied with 50.59 approach, but many utilities are not.
- This approach does not easily allow for product improvements nor flexibility to meet customer specific needs

U.S. Licensing History

- TR UR 85-225, CR-82 use in D-Lattice, approved 1986
- Supplement 1, CR-82 use in C-Lattice, approved 1988
- Supplement 2, CR-82 use in S-Lattice, approved 1989
- Supplement 3, CR-82 use of High Worth rods, submitted in 1988

Generic Licensing Approach

- **Topical Report sent to NRC Feb. 94**
  - Generic methodology, based on past experience
  - Only small changes, relative to Base Design, are allowed
  - Comprehensive set of Design Requirements and specific Acceptance Criteria
  - Appendices for specific applications
  - Annual NRC updates
  - Withdrawn in 1999

Proposed Approach for CR 99

CONTROL ROD SUMMARY

Summary of Presentations

- Westinghouse BWR control rods have always fulfilled their safety duty. (Experience from over 4000 BWR control rods)
- Design changes evolutionary
- Control rod management based on inspections, PIEs and neutron radiography

Deliveries By Country

Deliveries USA

Current / Near Term Designs Offered

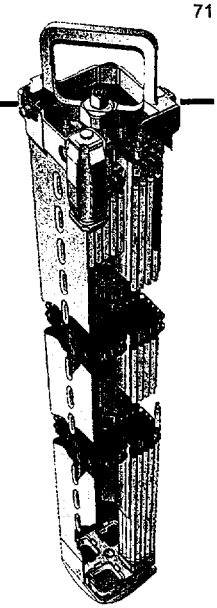
CR 99 Use in U.S.

Westinghouse BWR Fuel Update

Design and Production Update

- Current BWR Fuel Contracts
  - Columbia Generating Station - In fourth cycle, SVEA-96
  - Hope Creek - In first cycle, SVEA-96+
- Continuing Fuel Reliability and Performance Improvement Programs
  - Introducing SVEA-96 Optima2 Fuel Design
  - Developing Fuel Reliability Features
  - Continuing Fuel Inspection Program

SVEA-96 Optima2



- Introduced to NRC Staff in Feb. 17, 2000 Presentation
- Next Evolutionary SVEA Design
  - Based on 14 years SVEA 10x10 Experience

SVEA-96 Optima2

SVEA Fuel Delivered or on Order

Fuel Reliability - Achieving Failure Free Fuel

- Some Current Programs
- Continuing measurement program to prudently extend burnup experience

Fuel Burnup Distribution

Fuel Performance - Rod Growth

Fuel Performance - Oxide Thickness

Fuel Performance - Channel Growth

10x10 Fuel Failure Distribution

Licensing Plans - Background

BWR Initiatives

- SVEA-96 Optima2 US Implementation
- Enhance Current Reload Licensed Methodology

BWR Licensing Submittal Plans

Summary

- No Failures Related to Manufacturing Defects, Primary Hydriding, or CILC
- Over 9,000 SVEA 10x10 Assemblies Delivered
  - 14 years of Experience
- Reload quantities of SVEA-96 at 50 MWd/kgU
  - Lead Assemblies at 55 MWd/kgU
  - Generally excellent performance
  - Zero-failure fuel - within near reach
- SVEA-96 Optima2 Next Evolutionary SVEA Design
- Westinghouse seeks proactive involvement with NRC to facilitate submittal and review consistent with our customers' needs