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NORTHEAST NUCLEAR ENERGY COMPANY

General Offices • Selden Street, Berlin, Connecticut

P.O. BOX 270
HARTFORD, CONNECTICUT 06141-0270
(203) 665-5000

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Docket No. 50-245
B11802

Director of Nuclear Reactor Regulation
Attn: Mr. John A. Zwolinski, Chief
Operating Reactors Branch #5
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Gentlemen:

Millstone Nuclear Power Station, Unit No. 1
ASEA-ATOM Control Blade Operating Experience

In recent conversations with the Staff, an interest was expressed by the NRC in information concerning the operating experience for ASEA-ATOM control blades. In 1984, the NRC licensed the use of ASEA-ATOM hafnium tipped control blades for use in the Dresden Unit No. 3 reactor (Docket No. 50-249).(1) Under an EPRI sponsored demonstration program, four hafnium tipped blades were installed.

The Millstone Unit No. 1 ASEA-ATOM control blade design uses B_4C powder (vibration compacted to 70% theoretical density) filled in horizontal holes drilled in the blade wings as the primary neutron absorber. The uppermost nineteen (19) absorber holes in each blade wing are filled with solid hafnium metal pins (See Figure 1 attached). The basic blade design is identical to that of the blades licensed for use in Dresden Unit No. 3.

The NRC review of the Dresden blades showed mechanical and hydraulic compatibility with the Standard General Electric control blades. Therefore, responses to NRC questions in 1983 concerning the ASEA-ATOM blade design are applicable to the Millstone Unit No. 1 blades.

The hafnium tipped blade design for Millstone Unit No. 1 is identical to the design for Dresden Unit No. 3 except for:

- a shorter absorber hole depth to achieve a reactivity match with standard GE blades,
- the control blade intermittent centerline weld joint cutouts were increased to compensate for the additional weight of the hafnium poison.

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(1) Safety Evaluation by the Office of Nuclear Reactor Regulation Supporting Amendment No. 74 to Facility Operating License No. DPR-25, dated March 9, 1984.

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The shorter absorber hole depth was designed to achieve a closer reactivity match with the existing GE blades in use in the Millstone Unit No. 1 reactor. The overall blade reactivity worth is slightly higher than that of the GE design due to a higher B4C loading.

The mechanical design of the ASEA-ATOM blade is considered to be compatible with the Millstone Unit No. 1 reactor internals and drive mechanism. The control blade has been adapted to the geometry of the existing standard blades. The ASEA-ATOM blades are equipped with a velocity limiter and coupling device identical to that being used currently. The total weight of the ASEA-ATOM control blades is essentially the same as the existing GE standard and hybrid blades. Acceptable stresses on the control rod handle and the transition section to the velocity limiters under normal operation have been shown in Report KUA 82-115 "EPRI Control Rod - Stress Analysis". Report KUA 85-113 "Millstone 1 - Control Rod Welds Between Absorber Blades and Filling Pieces" shows acceptable stresses in the welds when the control rod is subjected to bending.

In order to minimize the potential for stress corrosion attack, special low carbon steel with reduced silicon and phosphorous content is used in the blade design. The use of hafnium as an absorber in the top 6-inch section (a region highly susceptible to intergranular stress corrosion cracking, IGSCC) reduces the potential for IGSCC since hafnium does not swell during irradiation. Furthermore, its rate of decrease in reactivity worth as a function of neutron exposure is significantly lower than B4C.

By the end of 1983, the operating experience of the AA blade design (all B4C type) extends to about 1200 control blades used in nine ASEA-ATOM's BWR's where the longest operating time is more than 12 years. In 1984, 20 blades were found to have cracks. Those failed blades are of the original all-B4C design. Failures occurred after 8 cycles, without any blade shuffling in the Oskarshamn 2 and Barsebeck 1 and after 11 cycles in the Oskarshamn 1 reactor. Based on this experience, the average life time of AA blades without hafnium-tip is about 15 years in AA BWR's.

The AA blade failure statistics based upon visual inspection of 364 blade wings showed a total of 36 wings with visible cracks (usually a single crack on one or two wings of a control blade). The cracks are located close to the blade tips, run horizontally along a hole, and have a variable length. No blade geometry or blade surface deformation has been observed. The cracks have therefore no influence on blade wear and friction or scram insertion time. Since the cracks occur only on one side of a blade wing and are always shorter than the wing span, the control rod retains its mechanical integrity and function during all operating and accident conditions.

Hot cell examinations of the failed rods were carried out in Studsvik. Results and conclusions are summarized as follows:

1. Visual inspection with up to 72 times magnification using a stereo-periscope and liquid penetrant examinations have verified that a simple visual in-pool inspection can detect almost all cracks.

2. Neutronradiography showed that B4C washout occurs in the hole with a crack and to a limited extent in neighboring holes due to gas pressure equalization passages.

3. Examination of absorber hole geometry showed that wall thickness variations were within manufacturing tolerances.

4. Metallographical and SEM-examinations confirmed that the cracks are caused by intergranular stress corrosion (IGSCC). The material showed a normal micro-structure.

5. Measurements of B-10 depletion using mass-spectrometry were carried out on one blade segment both radially along a hole and axially. Results indicate that the threshold for crack initiation is about 60% measured local B-10 depletion (average along B4C hole). The highest measured local B-10 depletion was 81%.

Operating experience accumulated with AA control blades indicates that the crack initiation threshold corresponds to 60% local B-10 depletion averaged along a B4C hole. This value is based on measured B-10 depletion. Only about 5% of the blade wings, which have reached this exposure level, show any visible cracks near the wing tips. The use of hafnium tips in the high exposure region is aimed to circumvent this problem and to extend service life limited by IGSCC. The recommended visual inspection limit for AA Hafnium-tip blades in BWR 2/3/4 is defined as 83% average B-10 depletion in the uppermost (1/4) segment (approximately 5 cycles burnup) which accounts for axial exposure peaking and P3 process computer correction (due to higher B4C content in AA blades). Control blade lifetime can be easily assessed by visual in-pool inspection whenever deemed necessary.

Control rods requiring replacement during the upcoming Millstone Unit No. 1 refueling outage will be replaced with ASEA-ATOM control rods. This work is being done under the provisions of 10 CFR 50.59(a). A description of the replacements including the actual number of rods changed out during the outage will be reported to the Staff in accordance with the provisions of 10 CFR 50.59(b). We trust this information is responsive to your request and remain available to answer any questions you might have.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

J. F. Opeka

J. F. Opeka
Senior Vice President

E. J. Mroczka

By: E. J. Mroczka
Vice President

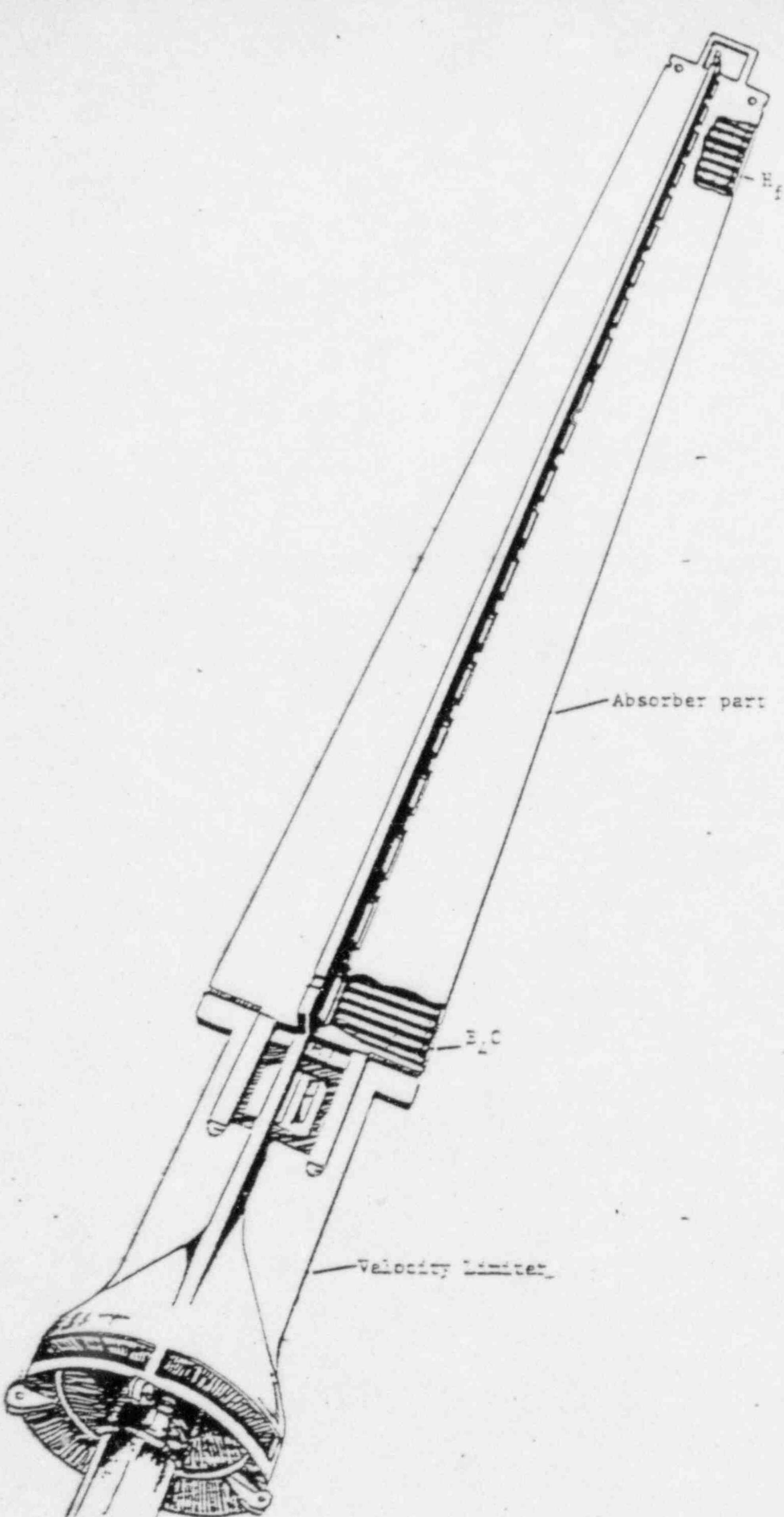

Figure 1: ASEA-ATOM HAFNIUM-TIP BLADE