B&W NUCLEAR TECHNOLOGIES

ENGINEERING INFORMATION RECORD

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Title Interim Engineering Evaluation: ONS-2 CRDM Nozzle Inspection

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Technical Manager Statement: Initials JFS for KEM

Reviewer is Independent.

Remarks:

This document contains an interim engineering evaluation of the NDE results obtained during the CRDM nozzle inspection performed at Oconee Unit 2. It has been determined that the indications detected are acceptable based on the NRC-approved acceptance criteria developed for CRDM nozzle flaws.

This revision contains the following changes:

Addition of Section 5.0, with References renumbered as Section 6.0.
Proprietary level changed to Non-Proprietary.

*** BWNT NON-PROPRIETARY ***

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1.0 Purpose

The purpose of this document is to evaluate the indications detected during the ONS-2 CRDM nozzle inspection in October 1994 with respect to the NRC-approved acceptance criteria.

2.0 Background

An inspection of the control rod drive mechanism (CRDM) nozzles at Oconee Nuclear Station (ONS) Unit 2 was completed during the End-Of-Cycle 14 (EOC-14) refueling outage in October 1994. The inspection was performed by B&W Nuclear Technologies (BWNT) and consisted of blade probe eddy current inspection of all sixty-nine nozzles, motorized rotating pancake coil (MRPC) inspection of three nozzles, and dye penetrant (PT) and ultrasonic (UT) inspection of two nozzles. Linear indications were detected during the inspection; these indications have been evaluated to determine whether they are acceptable based on the acceptance criteria approved by the United States Nuclear Regulatory Commission (U.S.NRC).

2.1 Acceptance Criteria

Prior to inspections within the U.S., the nuclear industry developed acceptance criteria to be implemented during an inspection to identify which cracks are acceptable (i.e., not requiring immediate repair) based on size and location. Initially, the Nuclear Management and Resources Council (NUMARC), now the Nuclear Energy Institute (NEI), submitted the following acceptance criteria, for cracks above the J-groove weld, to the U.S.NRC for review:

ACCEPTANCE CRITERIA SUBMITTED BY NUMARC/NEI IN 1993

Crack Orientation	Allowable Length	Allowable Depth
Axial	any length	75% through-wall
Circumferential	50% around circumference	75% through-wall

Axial cracks below the J-groove weld would be acceptable for any length, at a depth of up to 100% through-wall.

The acceptance criterion for axial cracks identified above was accepted by the NRC as identified above; however, the acceptance criterion for circumferentially-oriented cracks was rejected. Based on a discussion with the NRC, DPCo identified acceptance criteria for circumferential cracks which was implemented at ONS Unit 2 during the inspection; this information had been submitted to the NRC[1] prior to the inspection. The acceptance criterion implemented by DPCo for circumferential cracks is as follows:

ACCEPTANCE CRITERIA SUBMITTED BY DUKE POWER COMPANY

Crack Orientation	Allowable Length	Allowable Depth
Circumferential	2" on outside surface (~16% around circ.)	75% through-wall

Cracks exceeding the acceptance criteria would require engineering analyses and/or repair.

2.2 Indications Detected at ONS-2 BBZ 11/1/94

The following subsections describe the non-destructive examination (NDE) inspections performed at ONS-2 and the results obtained from the inspections.

2.2.1 Eddy Current Results

The blade probe eddy current (BPEC) inspection was performed in accordance with BWNT Procedure ISI 490-2 (Multifrequency Eddy Current Examination and Evaluation of Vessel Head Adapters Using a Blade Probe). The MRPC ET inspection was performed in accordance with BWNT Procedure ISI 491-2 (Multifrequency Eddy Current Examination of CRDM Nozzles Using a Motorized Rotating Pancake Coil [MRPC]).

A 100% inspection (360° of circumference from bottom of nozzle to 2" minimum above weld) of all sixty-nine nozzles was completed during the blade probe inspection. A 100% inspection of three nozzles was completed during the MRPC inspection.

The BPEC inspection found nozzle 23 to contain numerous small, shallow axial indications near the top of the weld at the 180° orientation occurring along the circumference at approximately the same elevation. The MRPC inspection confirmed the blade probe results.

The BPEC inspection found nozzle 28 to contain a small, shallow indication below the weld at the 15° orientation. The MRPC inspection did not confirm the blade probe results. The indication that was detected with MRPC exhibited non-flaw-like characteristics, including improper phase rotation, and was dispositioned as No Detectable Degradation (NDD) per ISI 491-2.

The BPEC inspection found nozzles 60, 62, 63, and 65 to contain small, shallow axial indications throughout the weld signature area, at locations above and below the weld. These indications occur near the phase threshold of the indication criteria per BWNT procedure ISI 490-2. Nozzle 63 was identified to contain the most serious indications. An MRPC inspection of nozzle 63 confirmed the blade probe results. Although these nozzles were dispositioned as NDD per ISI 490-2, further NDE analysis was recommended.

The BPEC inspection found nozzles 16, 45, 46, 50, 52, 56, and 57 to contain indications similar to those detected in nozzles 60, 62, 63, and 65, except that the indications occurred near the threshold of eddy current test detection and have been dispositioned as NDD per ISI 490-2.

All other nozzles have been dispositioned as NDD per ISI 490-2.

2.2.2 Liquid Penetrant Results

Based on the eddy current examination results, a water-washable penetrant test (PT) was performed on nozzles 23 and 63.

For nozzle 23, the PT results showed 21 individual indications, illustrated in Figure 1, ranging in length from 0.08" to 0.33" between the 135 and 246° angular positions in the nozzle circumference. All indications are axial in relation to the nozzle except for two indications; one indication turns in the circumferential direction at the upper end and the second indication is 0.10" in length and lies completely in the circumferential direction.

For nozzle 63, no indications were detected.

2.2.3 Ultrasonic Results

An ultrasonic test (UT) was performed on nozzle 23 in order to quantify the indications detected with eddy current examination and to verify the non-detectable results for nozzle 63. The UT method used is qualified to size axially-oriented CRDM nozzle flaws having depths of 0.079" (2 mm) and greater.

For nozzles 23 and 63, the scanning bounded the indication area identified with the eddy current examination. Review of the UT data showed that there was no evidence of indications of measurable size within the limits of the UT qualification. Therefore, it was determined that there are no axial flaws in the region of the eddy current indications with depths greater than 0.079" (2 mm).

2.2.4 Summary of NDE Inspection Results

In summary, indications were confirmed in nozzle 23 only. As illustrated in Figure 1, there were 21 indications identified by EC and

further evaluated by PT and UT. Two of the indications have been characterized as circumferential indications. The ultrasonic inspection, which can size indications having depths of 2 mm (0.079") and greater, did not detect any indications. Thus, all indications identified in nozzle 23 have depths of less than 0.079". The following section describes the evaluations completed by BWNT to reconcile the results obtained from the inspection to the acceptance criteria identified above.

3.0 Evaluation of Individual Flaws

11/1/94

Each of the 21 indications was evaluated relative to the acceptance criteria and acceptable flaw sizes allowed. The allowable flaw sizes are included in Table 1 and illustrated in Figures 2 and 3. It has been determined that all 21 flaws, 19 axially-oriented and 2 circumferentially-oriented, are within the allowable flaw sizes for one operating cycle (18 months) based on the acceptance criteria.

It should be noted that the allowable flaw sizes identified above were initially calculated for flaws at 0 to 2 inches above the nozzle weld; the stress profiles generated from the finite element analysis for the CRDM nozzles indicated that cracks (if any) should be located in that region. However, the indications detected during the NDE inspection are located at the level of the weld. The stresses at the weld location were evaluated and it has been determined that the allowable flaw sizes for flaws above the weld are conservative (i.e., bounding) for flaws located at the weld.

The longest flaw detected has a length of 0.33" and an assumed depth of 0.079" (2 mm). The 2 mm depth is based on the minimum (qualified) detectable depth of UT, where no indications were detected during the actual inspection. Based on the stresses at this location, it was calculated that the longest flaw may grow to 75% through-wall (and exceed the ASME Code required fracture toughness margin[2]) in 2.89 years of steady-state operation.

This calculation is made based on stresses taken from the finite element model developed for B&W-design CRDM nozzles. However, the stresses obtained from the finite element model are based on a material yield strength of 64.4 ksi and a peripheral nozzle location. Nozzle 23 has a yield strength of 55.2 ksi (from the Certified Material Test Report [CMTR]) and is not located on the periphery of the RV head. Thus, there are additional conservatisms in this calculation.

4.0 Conclusion

It is concluded, based on the evaluations and results described above, that the indications detected at ONS-2 during the CRDM nozzle inspection are acceptable based on the acceptance criteria for detected cracks.

5.0 Recommendations

It is recommended, as a minimum, that NDE inspection of nozzles 23 and 63 be performed during the next refueling outage [EOC-15]. Based on the results of that inspection, future actions will be determined.

TABLE 1

ALLOWABLE CRACK LENGTHS FOR ORIGINAL CRDM NOZZLE FOR ONE FUEL CYCLE

Length /Depth Ratio	Crack Length (Inches) Hillside Nozzle Downhill Side (0°)	Hillside Nozzle Uphill Side (180°)	Center Nozzle
Axial Flaw			
1	0.3285	0.2896	0.3674
2	0.5400	0.4790	0.6460
3	0.6873	0.6220	0.8820
4	0.8028	0.6669	1.0843
5	0.8672	0.6947	1.2500
6	0.9110	0.7110	1.4080
7	0.9466	0.7175	1.4913
8	0.9732	0.7212	1.5610
9	0.9892	0.7169	1.6395
10	0.9942	0.7101	1.6796
Circumferential Flaw			
1	0.4625	0.4607	0.4625
2	0.9090	0.9016	0.9250
3	1.3449	1.3171	1.3829
4	1.3829	1.3829	1.3829
5	1.3829	1.3829	1.3829
6	1.3829	1.3829	1.3829
7	1.3829	1.3829	1.3829
8	1.3829	1.3829	1.3829
9	1.3829	1.3829	1.3829
10	1.3829	1.3829	1.3829

FIGURE 1

LOCATION OF INDICATIONS AT ONS-2 NOZZLE 23

[Note: The weld profile is based on nominal drawing dimensions.]

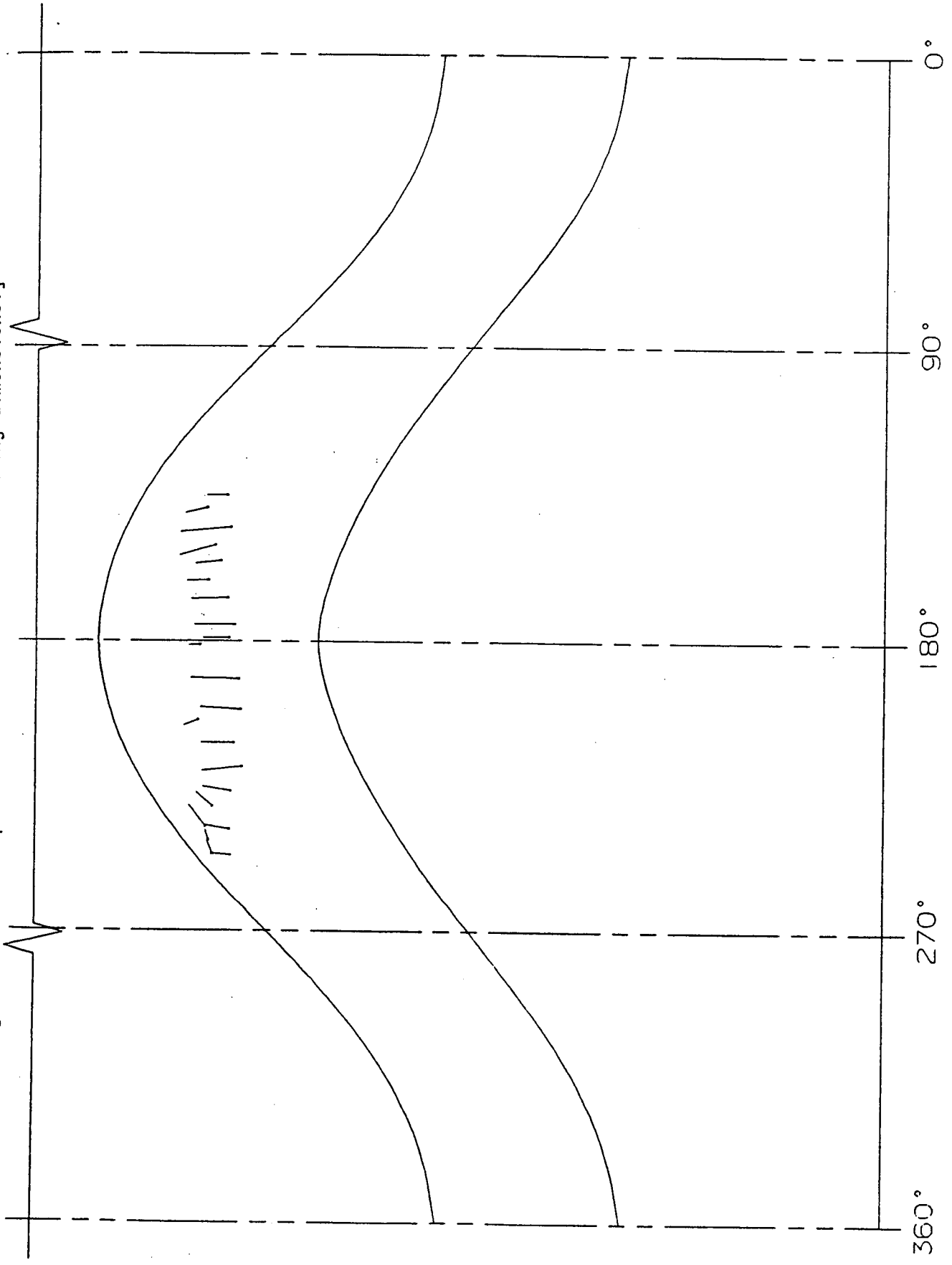


FIGURE 2

ALLOWABLE FLAW SIZE FOR AN INTERNAL SEMI-ELLIPTICAL AXIAL FLAW

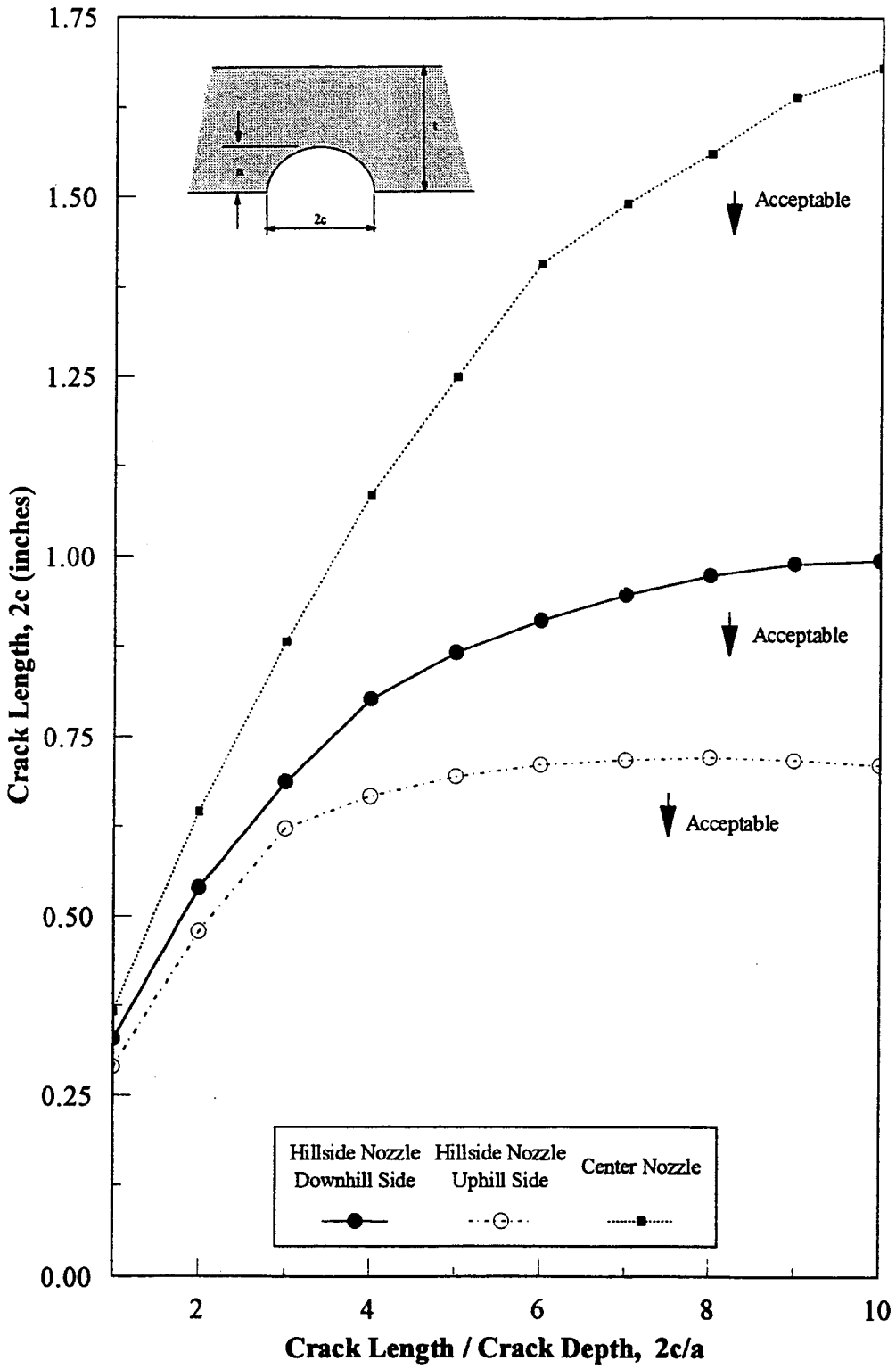
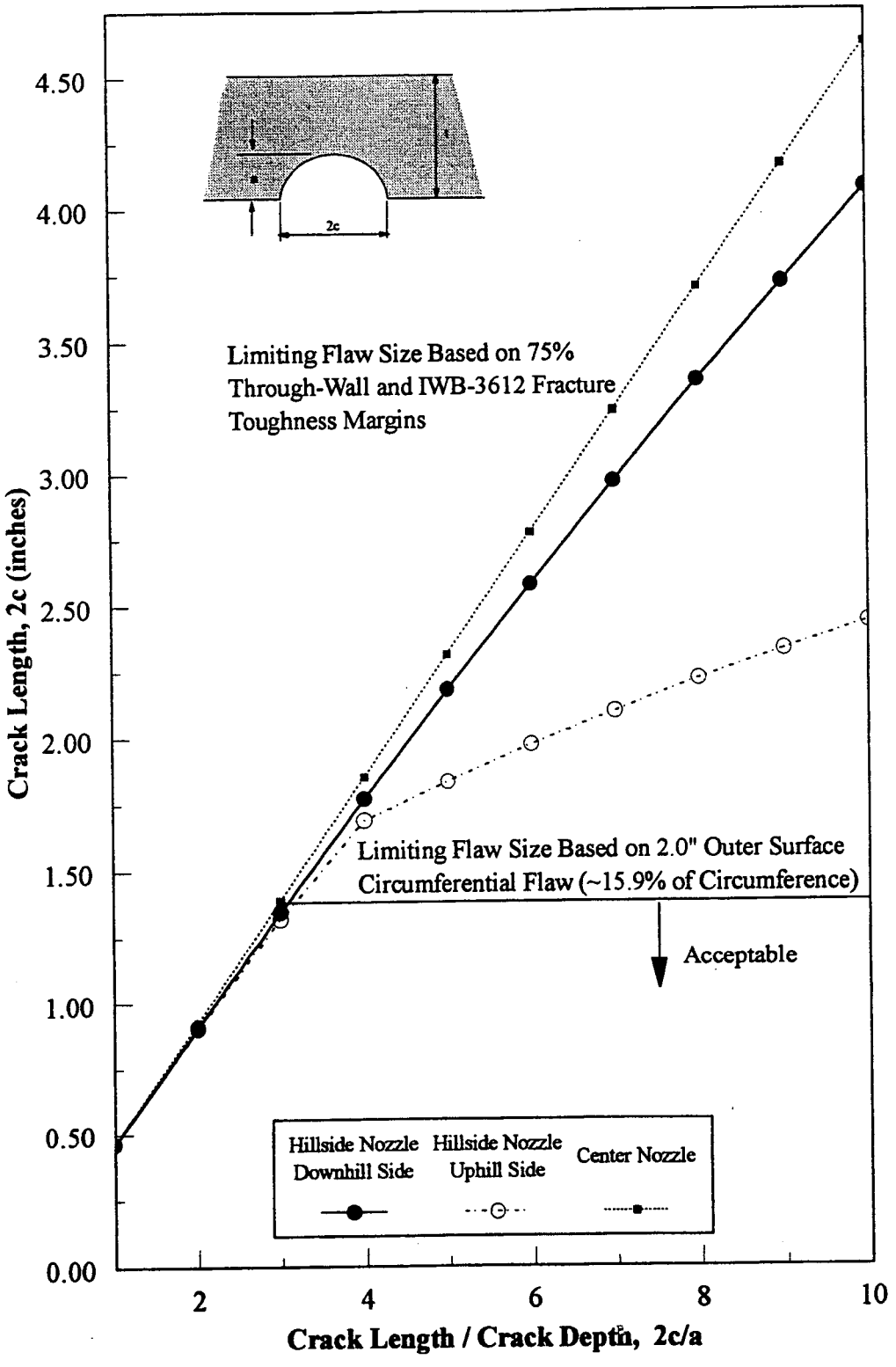


FIGURE 3

ALLOWABLE FLAW SIZE FOR AN INTERNAL, SEMI-ELLIPTICAL CIRCUMFERENTIAL FLAW



6.0 References

1. Letter and attachments to letter from J. Peele for J.W. Hampton, Site Vice President (ONS), to U.S. Nuclear Regulatory Commission, Subject: Acceptance Criteria for Control Rode Drive Mechanism Penetration Inspection, Docket Nos. 50-269, 50-270, 50-287, dated September 22, 1994.

2. ASME Boiler and Pressure Vessel Code, Section XI, 1986 (without Addenda).