IES UTILITIES INC.

NG-94-2637
July 15, 1994

Mr. William T. Russell, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-137
Washington, DC 20555

Subject:	Duane Arnold Energy Center Docket No: 50-331 Op. License No. DPR-49 Response to Request for Additional Information on Hydrogen Water Chemistry Relief Request
References:	1) NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping (Generic Letter 88-01), dated January 25, 1988 2) NG-93-2162, J. Franz (IES) to Dr. T. Murley (NRC), dated May 28, 1993 3) Meeting Summary, R. Pulsifer (NRC), dated May 18, 1994 4) Letter, R. Pulsifer (NRC) to L. Liu (IES), dated June 22, 1994
File:	A-101b, A-286a, B-31c, B-31f

Dear Mr. Russell:

Generic Letter 88-01 (Reference 1) communicated the staff's position on Intergranular Stress Corrosion Cracking (IGSCC) and included provisions for reductions in certain piping inspection frequencies based on the use of Hydrogen Water Chemistry (HWC). IES Utilities Inc. (IES) submitted a request for relief from certain piping inspection frequencies, consistent with the technical conclusions of General Electric Licensing Topical Report NEDC-31951P, per Reference 2 for your staff's review.

During review of the request, IES met with members of your staff to present details of our ongoing HWC program and to address questions regarding our relief request. The contents of that meeting is summarized in Reference 3. In order to complete the review of our submittal, the staff recently requested additional information per Reference 4. Attachments 1 and 2 to this letter provide our response.

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There are no new commitments contained in this letter.

We request your timely review of this response so that we can incorporate appropriate piping inspection plans into the schedule for our next refueling outage. If you have any further questions or require additional information regarding this matter, please contact this office.

Sincerely,

Keith D. Young

Keith D. Young
Manager, Nuclear Licensing

JJF/JCK/pjv~

Attachments: 1) Response to NRC Request for Additional Information
2) Plot of ECP versus Time

cc: J. Kinsey
J. Franz
L. Liu
L. Root
R. Pulsifer (NRC-NRR)
J. Martin (Region III)
NRC Resident Office
DCRC

Response to NRC Request for Additional Information

Question 1:

Were the ECP and conductivity measurements, obtained by external autoclaves, calibrated against the in situ measurements for each individual cycle? If yes, provide the calibration results. If no, discuss what assurance do you have that the sample in the autoclaves is representative of the coolant condition in the recirculation piping.

Response:

ECP measurements at the "B" recirculation piping decontamination flange as well as in-core locations were made at Duane Arnold Energy Center (DAEC) during cycle 10, the second operating cycle after beginning the HWC program. These measurements were a part of an EPRI/GE/IES study (Reference 7) which, in this letter, will be referred to as the EPRI DAEC In-Core Report. This study did not include an in-situ conductivity measurement. No other in-situ studies have been performed since implementing HWC. Comparisons showed the recirculation piping ECP to be in good agreement with the existing external autoclave ECP, as is discussed in more detail below. This provided a verification that samples in the autoclave are representative of the coolant condition in the recirculation piping and that significant sampling errors do not exist at DAEC.

Comparison of the recirculation piping ECP measurements with the external autoclave ECP, during both normal water chemistry (NWC) and HWC conditions, has been documented on page 4-3 of the EPRI DAEC In-Core Report. That discussion is repeated below. A similar discussion was included in the IES presentation to the NRC, as summarized in Reference 3.

"The test configuration at Duane Arnold allowed the direct comparison of ECP measurements made within the recirculation system to those made in an external ECP autoclave. As shown in Figure 3-3, in normal water chemistry the recirculation stainless steel potential was 0.180 V_{SHE}. Introduction of HWC caused a rapid decrease in potential to <-0.500 V_{SHE}. No further decrease occurred with increasing hydrogen.

"The HWC ECPs measured in the external autoclave (Figure 3-5) were quite similar to the in-situ pipe measurements. This vital finding was the first of its kind and indicates that potentials obtained in an external autoclave can be relevant to the in-situ pipe measurements as long as a proper water sample can be delivered to the autoclave.

"The major difference between the ECPs from the in-pipe and the external autoclave was in NWC rather than in HWC. The in-pipe ECPs were about 0.180 V_{SHE}, as compared to 0.115 V_{SHE} from the external autoclave in NWC. The higher ECPs from the in-pipe sensors may be the result of a higher concentration of hydrogen peroxide which could have decomposed in the sample line to the autoclave. In HWC, ECPs from both the in-pipe and external autoclave were about -0.560 V_{SHE}."

The comparison of ECPs at DAEC was also discussed in the EPRI ECP Sourcebook (Reference 6), page 3-3, as follows:

"... the in-situ recirculation piping and autoclave ECPs were essentially identical (and well below the protection potential with 30 ppb dissolved hydrogen in the reactor water) at Duane Arnold...the mechanism driving HWC and establishing oxidant concentrations is radiation-induced recombinations of hydrogen and oxygen in the downcomer region of the reactor pressure vessel. When recombination in the downcomer is extremely efficient, which is the case at Duane Arnold, there is negligible dissolved oxygen and peroxide in the recirculation piping. Therefore, oxidant loss in the sample line due to corrosion, or other time-dependent phenomena obviously would be negligible. Thus, the in-situ ECP and that of the autoclave at the end of the sample line would be low and in close agreement (the Duane Arnold experience)."

Ongoing monitoring of ECP and verification with previous in-situ measurements provide assurance that autoclave measurements are representative of the coolant condition in the recirculation piping.

<u>Question 2a</u>:

a. Estimate the total hours in each fuel cycle when DAEC was operated with HWC and meeting the following conditions:

   i) ECP lower than -230 mV

   ii) Conductivity below 0.3 μS/cm

   iii) Excluding all conductivity transients (>0.3 μS/cm) and hydrogen interruption transients

Response:

There have been no conductivity transients greater than 0.3 μS/cm during hydrogen injection. If at any time ECP was above -230 mV, those hours were subtracted from the numerator when calculating availability. In other words, no credit was taken for the "memory effect" of hydrogen.

An example of how hydrogen interruption transients and availability calculations are done is shown below. It can be seen from the graph (Attachment 2) that HWC was >-230 mV for 7.1 hours during the month of January. Therefore, 7 hours is subtracted from the numerator and availability calculated.

System Performance

Total Hrs in Month	= 744 Hrs
H_2 Req'd to be on (>20% Pwr)	= 744 Hrs
Rx Recirc temp >200°F	= 744 Hrs
ECP Above -230mV (Bad)	= 7 Hrs
ECP Below -230mV (Good)	= 737 Hrs

$$\text{Availability BWROG} = \frac{\text{Hrs} < -230\text{mV}}{\text{Hrs} > 20\%\ \text{power}} = \frac{737\ \text{Hrs}}{744\ \text{Hrs}} = 99\%$$

Beginning in 1994, two separate availabilities for HWC have been calculated. The first will be calculated per the BWROG guidelines. The second is based on discussion with the NRC that indicate hours when reactor recirculation temperatures are greater than 200°F should be included in the calculation, namely to add in the hours. This percentage has been defined as "Total Protection Factor" since 200°F is deemed as the threshold for IGSCC initiation.

$$\text{Total Protection Factor} = \frac{\text{Hrs} < -230\text{mV}}{\text{Hrs Recirc temp} > 200°\text{F}} = \frac{737\ \text{Hrs}}{744\ \text{Hrs}} = 99\%$$

Finally to answer part a(iii):

Cycle 9 = 6,902 hours
Cycle 10 = 9,974 hours
Cycle 11 = 11,089 hours
Cycle 12 = 10,372 hours.

<u>Question 2b</u>:

b. Calculate the percentage of component service time with temperature above 200° F that meets the conditions specified in a. above.

<u>Response</u>:

Currently system design allows for injection of hydrogen at greater than or equal to 20% power. Subsequently there are periods when the plant is above 200°F and hydrogen is not being injected. Therefore, total protection (<-230mV) whenever the plant is greater than 200°F is not achievable and results in a value less than 100%. This is because at lower power levels there is not enough gamma flux to drive the recombination reaction to reduce the oxygen concentration.

$$\text{Total Protection Factor} = \frac{\text{Hrs} < -230\text{mV}}{\text{Hrs Recirc temp} > 200^\circ\text{F}}$$

Total Protection Factor for previous operating cycles is as follows:

Cycle 9 $\frac{\text{6, 902 hours}}{\text{8,064 hours}} = 85.6\%$

Cycle 10 $\frac{\text{9,974 hours}}{\text{12,600 hours}} = 79.2\%$

Cycle 11 $\frac{\text{11,089 hours}}{\text{12,000 hours}} = 92.4\%$

Cycle 12 $\frac{\text{10,372 hours}}{\text{10,700 hours}} = 96.9\%$

Question 3a:

a. How was the ECP evaluated from the indications of individual electrodes in each cycle? Was this method conservative?

Response:

a. At Duane Arnold, ECP measurements are taken when the recirculation sample is available, regardless of plant status. The ECPs of several working (304 SS) electrode/reference electrode combinations are recorded daily. Our response to NRC question 5, in Reference 3 describes the configuration of DAEC ECP instrumentation. All values are reported in units of mV_{SHE}. If system operation is stable and all electrodes are functioning properly, all working electrode/reference electrode combinations should be reporting approximately the same value, e.g., 304 SS (Cu) = - 550 mV_{SHE}. If ECP is increasing from a typically low value under HWC conditions, or has gone above - 230 mV_{SHE}, actions are initiated to determine and correct the cause. ECP measurements are also compared against each other and against other plant measurements which are impacted by HWC operation. These include reactor water dissolved oxygen, dissolved hydrogen, conductivity, and crack growth measurements, as well as hydrogen flow. If any measurement is not consistent with typical values for the current operating conditions, that instrument is considered suspect. ECP values of the reference electrodes alone can also be compared with Figure 2-2 of Reference 6 to diagnose electrode problems. The EPRI ECP Sourcebook (Reference 6), chapters 2 & 6, provides a thorough discussion of the various electrodes, conversion to standard hydrogen electrode, measurement verification, and electrode quality assurance. When an infrequent failure has occurred, the electrode has been replaced at the external autoclave with the plant on-line.

The use of multiple working electrodes and several different reference electrodes provides consistent and repeatable ECP data. Such quality control of DAEC ECP data, in combination with verification against in-situ measurements, provides confidence that this data is consistent with the conditions within the recirculation piping.

...tion 3b:

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Question 3a:

a. How was the ECP evaluated from the indications of individual electrodes in each cycle? Was this method conservative?

Response:

a. At Duane Arnold, ECP measurements are taken when the recirculation sample is available, regardless of plant status. The ECPs of several working (304 SS) electrode/reference electrode combinations are recorded daily. Our response to NRC question 5, in Reference 3 describes the configuration of DAEC ECP instrumentation. All values are reported in units of mV_{SHE}. If system operation is stable and all electrodes are functioning properly, all working electrode/reference electrode combinations should be reporting approximately the same value, e.g., 304 SS (Cu) = - 550 mV_{SHE}. If ECP is increasing from a typically low value under HWC conditions, or has gone above - 230 mV_{SHE}, actions are initiated to determine and correct the cause. ECP measurements are also compared against each other and against other plant measurements which are impacted by HWC operation. These include reactor water dissolved oxygen, dissolved hydrogen, conductivity, and crack growth measurements, as well as hydrogen flow. If any measurement is not consistent with typical values for the current operating conditions, that instrument is considered suspect. ECP values of the reference electrodes alone can also be compared with Figure 2-2 of Reference 6 to diagnose electrode problems. The EPRI ECP Sourcebook (Reference 6), chapters 2 & 6, provides a thorough discussion of the various electrodes, conversion to standard hydrogen electrode, measurement verification, and electrode quality assurance. When an infrequent failure has occurred, the electrode has been replaced at the external autoclave with the plant on-line.

The use of multiple working electrodes and several different reference electrodes provides consistent and repeatable ECP data. Such quality control of DAEC ECP data, in combination with verification against in-situ measurements, provides confidence that this data is consistent with the conditions within the recirculation piping.

Question 3b:

b. Please explain why there is a significant range in the magnitude of the ECP measured by different electrodes and discuss the reliability and conservatism of these ECP measurements.

Response

b. Reference 3, Attachment 5-1 presented a graph of DAEC ECP data during April, 1994. ECP data from seven working electrode/reference electrode combinations are shown. Each ECP is designated as follows: the first letter, a or b, indicates in which external ECP autoclave the electrodes are located; the next three characters indicate the working electrode, 304 or GND (ground, i.e., the autoclave); the characters in parentheses indicate the reference electrode. For example, the uppermost ECP plot on the graph is a304(Ag). During this period, the plant operated under HWC conditions with the exception of isolations of the recirculation piping sample valves for valve surveillance on April 5, 26, and 27. (Note: The excursion on April 5 shown on Attachment 5-1 was not the result of a HWC system trip. The graph is mislabeled.)

The bottom four ECP plots are b304(Pt), a304(Pt), b304(Cu), and a304(Cu). ECP values vary from -495 to -555 mV_{SHE}, or a total variance of 60 mV_{SHE}. This is close to the ± 25 mV_{SHE} variance between electrodes discussed in the response to NRC question 5 in Reference 3. This is typical of 304 SS referenced to Pt or Cu, which provide the most consistent data. The next curve up is bGND(Cu). The ground values are slow to respond to changes. However, they do approach the previous four curves over time, as can be seen on the graph. The next plot, bGND(Ag), is reading roughly 100 mV_{SHE} high for most of the month. After the sample isolation of April 27, the value rises to about +100 mV_{SHE}. This is an indication that the bAg/AgCl electrode has failed. The uppermost curve, a304(Ag), is at a very high value, relative to the other curves, throughout the month. This is an indication that the aAg/AgCl electrode had previously failed.

The a304(CU) ECP electrode combination is used as a primary indication to monitor whether recirculation piping is protected (<-230 mV_{SHE}). The remaining electrode combinations provide additional diagnostic indication.

In summary, the 304 SS working electrode in combination with either the Cu or Pt reference electrodes provide consistent indication of recirculation piping ECP. DAEC uses the a304(Cu) ECP for evaluation purposes. The ground (autoclave) values provide a good point of comparison to the 304 working electrode during stable monitoring periods. Although the additional diagnostic Ag reference electrodes have, in the past, given proper indication of ECP, both had failed during this period.

Question 4:

Was the implementation of HWC in compliance with the EPRI Guidelines provided in EPRI Report NEDC-4947-SR?

Response:

HWC was implemented at DAEC in July, 1987. This was prior to issuance of the EPRI BWR Hydrogen Water Chemistry Guidelines: 1987 Revision, EPRI NP-4947-SR (Reference 5). A recent update of this document is EPRI BWR Water Chemistry Guidelines - 1993 Revision: Normal and Hydrogen Water Chemistry, EPRI TR-103515 (Reference 8). Additional guidance is provided in the EPRI ECP Sourcebook, EPRI NP-7142 (Reference 6). Because of its superior performance, DAEC HWC was used as a reference in developing the recommendations in these documents. DAEC meets or exceeds the HWC recommendations contained in these EPRI Guidelines.

References

1. NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping (Generic Letter 88-01), dated January 25, 1988.

2. NG-93-2162, J. Franz (IES) to Dr. T. Murley (NRC) dated May 28, 1993

3. Meeting Summary, R. Pulsifer (NRC), dated May 18, 1994

4. Letter, R. Pulsifer (NRC) to L. Liu (IES), dated June 22, 1994

5. *BWR Hydrogen Water Chemistry Guidelines: 1987 Revision*, Electric Power Research Institute, Palo Alto, CA, December 1988 (EPRI NP-4947-SR).

6. *Corrosion Potential (ECP) Measurement Sourcebook, Electric Power Research Institute*, Palo Alto, CA, January 1991 (EPRI NP-7142).

7. W. D. Miller, R. A. Head, M. E. Indig, *Measurement of In-Core and Recirculation System Response to Hydrogen Water Chemistry at the Duane Arnold Energy Center*, Electric Power Research Institute, Palo Alto, CA, April 1993 (EPRI TR-102310).

8. *BWR Water Chemistry Guidelines - 1993 Revision: Normal and Hydrogen Water Chemistry*, Electric Power Research Institute, Palo Alto, CA, February 1994 (EPRI TR-103515)

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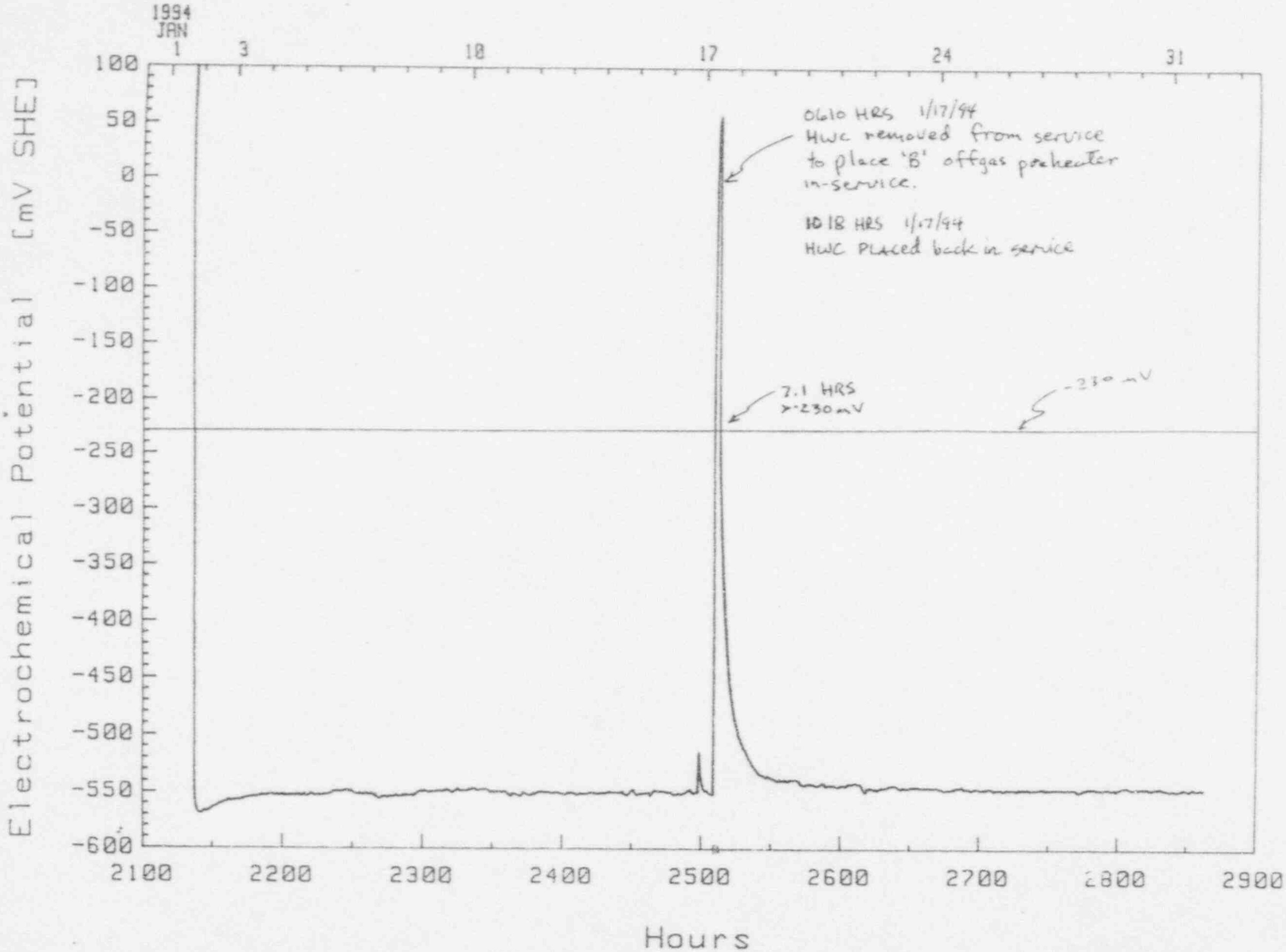

Plot of ECP versus Time

Attachment 2 to
NG-94-2637
Page 1 of 1