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GAS EVOLUTION IN REACTOR COOLANT

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DATE April 21, 1966

**TO D. M. Diediker
Supervisor, Plant Design**

**FROM P. J. Zimmerman
Engineer, Test Engineering**

SUBJECT GAS EVOLUTION IN REACTOR COOLANT

This document consists of 2 Pages

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In Testing and Irradiation Service Request #021, you asked that we sample the reactor coolant in an attempt to determine the amount of air evolution in the vicinity of the K downcomer. This letter includes the data which were obtained and conclusions drawn from analysis of the data.

It was concluded that data obtained could be used to infer the maximum gas evolution (19.7 ppm $O_2 + N_2$ at stated conditions); however, the uncertainty associated with the proximity to equilibrium of the gas evolution reaction prohibits placing a minimum on this quantity. Unless the transient approach to equilibrium can be determined, further sampling of the nature described herein would not be expected to yield positive results. Resolving the problem should probably best be accomplished by one or more of the following approaches:

1. Conduct a complete literature search on determining gas evolution rates theoretically and experimentally (consider radiation effects on these).
2. Use a specifically designed out-of-reactor test to obtain the basic reaction rate information necessary to predict the conditions of concern.
3. Obviously the best, but likely unfeasible, is an in-situ measurement of the gas to water void fraction.

Table I is a composite of the data taken. RI-REA-2679 describes in detail the sample locations identified generally in this letter. Samples were taken from: (1) the inlet water at 165 KE; (2) top of the near riser; (3) the approach box to the downcomer (OA and OB); and (4) just above the orifice plates in the downcomer (3D, 7D). Figure 1 shows the typical sampling set-ups; Set-up A for samples 1-4 and Set-up B for 6 through 13.

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C A Bauman

D. M. Diediker

-2-

April 21, 1966

The samples were chemically analyzed for oxygen, and nitrogen concentrations were calculated from the oxygen data. Samples 6-13 were analyzed immediately as the sample was taken to eliminate the potential for drawing air into the sample as it cooled. This procedure, along with the more efficient separator shown in Set-up B, combined to reduce the apparent oxygen concentration compared to samples 1-4. Figure 2 shows the data plotted on a curve of oxygen solubility in water for various temperatures. The temperature of the effluent water was constant at 84°C while the temperature of the water at the sample location could be controlled between 39°C and about 75°C by regulating the flow rate and taking advantage of the heat losses in the sample line. By noting on Figure 2 that lines connecting data points obtained at different temperatures but with all other conditions remaining the same have slopes considerably different from the standard solubility curve, we may conclude that the oxygen gas is not redissolving in the water as rapidly as the temperature effect is changing. This might also be expected since the large pockets of gas observed through the sample lines would tend to reduce the effective available contact area between gas and liquid phase. If we assume the slope of these lines remains constant and project to the temperature of the effluent, we may infer the concentrations at the desired locations (about 4.5 ppm O_2 at 84°C). The difference between this value and that at inlet conditions should give the oxygen in the gas phase (12 ppm -- 4.5 = 7.5 ppm). The difference between 4.5 ppm and the standard solubility value 2.5 ppm gives the oxygen in a super-saturated state in the liquid. If we assume nitrogen gas reacts similarly and use standard solubility values, we predict 7.4 ppm N_2 at the downcomer location OA and OB at 84°C with the same percent super-saturation. We calculate:

(a) 11.8 ppm N_2 + 7.5 ppm O_2 in gas phase

(b) 13.2 ppm N_2 + 2.0 ppm O_2 in super-saturated liquid

(c) 4.2 ppm N_2 + 2.5 ppm O_2 in saturated liquid

or 72.5 cc O_2 + N_2 per gallon of water at 84°C would be in the gas phase at the downcomer approach box location.

As emphasized, we assumed the slope of the lines on Figure 2 remains constant. This implies that the evolution of gases from the effluent water was at equilibrium before it was sampled such that there was no tendency for gas to come out of solution in the sample line. After discussing this phenomena with R. G. Geier, W. B. Silker and others, it appears that this assumption may not be 100 percent correct. Depending on how close this reaction was to equilibrium, the amount of gas evolved could vary from close to zero to 19.3 ppm O_2 + N_2 .

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DUE-970

D. M. Dieder

April 21, 1966

I have been unable to find further information concerning the reaction in question; however, an experiment could be designed to yield this information.

In order to minimize cost and time requirements, you may want to raise this question with appropriate Washington State University authorities in the field, who may be able to locate further information on it. If you wish to pursue the experimental approach further or have any questions on the data, please feel free to call on me.

P. J. Zimmerman, Engineer
Test Engineering
RESEARCH AND ENGINEERING

PJZ:jk

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April 21, 1966

TABLE I
OXYGEN IN WATER SAMPLES

No.	Date	Location	Temp	Cond	O ₂	Pressure	Remarks
1	3-18-66	OA	64°C	HI Flow	5.6 ppm	19.7 cm Hg	Used Set-up A
2	"	OA	44°C	Lo Flow	6.0 ppm	"	"
3	"	OA	67°C	HI Flow	5.2 ppm	"	"
4	"	Near River	75°C	HI Flow	6.4 ppm	37.5 cm Hg	"
5	"	Lo Lift Pump Disch	67°C	"	12 ppm	"	"
6	3-23-66	OB	67°C	HI Flow	4.0 ppm	"	Used Set-up B & Immediate Analysis
7	"	OB	67°C	HI Flow	4.0 ppm	"	"
8	"	OB	40°C	Lo Flow	4.2 ppm	"	"
9	"	Near River	72°C	HI Flow	4.6 ppm	"	"
10	3-23-66	3D	69°C	HI Flow	5.04 ppm	15 psig	Used Set-up B Flank Separator & Immediate Analysis
11	"	3D	44°C	Lo Flow	5.6 ppm	"	"
12	"	7D	66°C	HI Flow	4.6 ppm	10 psig	"
13	"	7D	39°C	Lo Flow	5.6 ppm	"	"

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SET-UP A

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SET-UP B

FIGURE 1

FIGURE 2

MEASURED OXYGEN CONCENTRATION

REACTOR COOLANT

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Gas Concentration (ppm)

3.0	0.0	105
3.0	0.1	105
3.0	0.5	105
3.0	0.8	105
3.0	1.0	105
3.0	1.5	105
3.0	2.0	105

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