Washington Public Power Supply System
A JOINT OPERATING AGENCY

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April 17, 1979
G02-79-70

Docket No. 50-397

Director, Office of Nuclear Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Mr. S. A. Varga

Subject: WPPSS NUCLEAR PROJECT NO. 2
SUBMITTAL OF LEGIBLE COPIES
OF NRC QUESTIONS 312.16 AND 331.20

Reference: Letter, D.L. Renberger to S.A. Varga, "Responses to Round One Questions - MTEB, CPB, AAB, ETSB, RAB, GSB, HMB," 3/21/79, G02-79-45.

Dear Mr. Varga:

It has been noted that two of the responses contained in the referenced letter were not reproduced in a clearly legible form. Attached please find 60 more readable copies of the responses to NRC questions 312.16 (22.048) and 331.20.

Very truly yours,

D L Renberger

D. L. RENBERGER
Assistant Director
Technology

DLR:SAG:sg

REGULATORY DOCKET FILE COPY

Attachment

cc: I. Littman - WPPSS, N.Y. - wo/att
JJ Verderber - B&R, N.Y. - "
JJ Byrnes - B&R, N.Y. - "
RC Root - B&R, Site - "
HR Canter - B&R, N.Y. - "
C. Bryant - BPA "
E. Chang - GE, San Jose - w/att (4)
FA MacLean - San Jose - w/att (1)
J. Ellwanger - B&R, N.Y. - w/att (5)
NS Reynolds - Debevoise & Liberman - w/att (1)
WNP-2 Files - w/att (1)

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Subject: WPPSS NUCLEAR PROJECT NO. 2
SUBMITTAL OF LEGIBLE COPIES
OF NRC QUESTIONS 312.16 AND
331.20

STATE OF WASHINGTON)
) ss
COUNTY OF BENTON)

D. L. RENBERGER, Being first duly sworn, deposes and says: That he is the Assistant Director, Technology, for the WASHINGTON PUBLIC POWER SUPPLY SYSTEM, the applicant herein; that he is authorized to submit the foregoing and knows the contents thereof; and believes the same to be true to the best of his knowledge.

DATED April 11, 1979

D L Renberger
D. L. RENBERGER

On this day personally appeared before me D. L. RENBERGER to me known to be the individual who executed the foregoing instrument and acknowledged that he signed the same as his free act and deed for the uses and purposes therein menthioned.

GIVEN under my hand and seal this 11th day of April, 1979.

Reba B. Helgesen
Notary Public in and for the
State of Washington
Residing at Richland

Q 312.16

Provide an estimate, including your basis, of the total amount of hydrogen and methane gases that can be generated by the radiolytic and chemical decomposition of organic materials and protective coatings under the conditions which would exist following a design base accident (i.e., a postulated loss-of-coolant accident). Your estimate should be limited to those materials and coatings that would be directly exposed to the containment atmosphere.

Response:

The estimate of the total amount of hydrogen and methane gas that can be generated by the radiolytic and chemical decomposition of organic materials and protective coatings under the conditions of a postulated loss-of-coolant accident is discussed in the answers to Question 022.048.

Q 022.048

You state in Section 6.2.5.3.1.3 of the FSAR that the corrosion of aluminum, zinc, and zinc base paints located either in the drywell or in the suppression chamber were determined to be insignificant. However, we have determined that a potential hydrogen release from the corrosion of zinc following a postulated loss-of-coolant accideat should be considered in the analysis of the total hydrogen production and accumulation within the containment. Accordingly, provide the following information:

a. Provide the corrosion rate as a function of temperature for all materials in the containment that could become a source of hydrogen due to corrosion.

b. Describe how the corrosion rates assumed for the materials identified in Item (a) were established: Identify the experimental data base, including the appropriate references, and discuss the conservatism in the applicability of the data in view of the calculated environmental conditions following a postulated loss of coolant accident.

c. Provide the mass and surface area of zinc paint and galvanized steel and other corrodible materials in both the drywell and the wetwell.

d. Provide a graphic representation of the total hydrogen concentration inside the containment as a function of time with (1) no hydrogen recombiners operating; (2) one recombiner operating; and (3) both recombiners operating.

e. Provide a graphic representation of the contribution of each source of hydrogen as a function of time.

f. Describe the periodic surveillance that will be done to demonstrate the operability of the hydrogen recombiners and the backup purge system.

g. Identify the location of (1) the hydrogen sample points in the drywell and the suppression chamber; and (2) the suction and discharge points of the combustible gas control system with respect to nearby structures and equipment.

RESPONSE:

A review of tests conducted to date on Aluminum, Zinc or Zinc coatings, indicates that several factors which would tend to mitigate the evolution of hydrogen following a postulated loss-of-coolant accident have not been reported or have not been investigated. A brief explanation, therefore, is required to substantiate the rationale for the conclusions drawn in this response.

Question 022.048 asks a question with respect to the corrosion of aluminum and the subsequent evolution of hydrogen. The water chemistry of WNP-2 is such that the water is free from additives and is neutral, i.e., a pH of 6.5-7.5.

With reference to Aluminum, Uhlig [1] states: - "Aluminum base alloys are not appreciably affected by distilled water even at elevated temperatures (up to 180°C (350°F) at least). Furthermore, distilled water is not contaminated by contact with most aluminum base alloys."

Uhlig [2] states: - "Condensate from steam boilers, if free from carryovers of water from the boiler, is similarly inert to aluminum base alloys. Thus, either wrought or cast aluminum alloys are used successfully for steam radiators as unit heaters. Where aluminum alloys are used it is desirable to install suitable traps in the steam lines, since entrapped boiler water, especially if alkaline water treating compounds are employed, may be corrosive."

Uhlig [3] states: - "Steam causes a definite protective white film to form ~~as~~ on aluminum alloys. This film is highly protective at temperatures up to 180° to 350°C (350° to 500°F). At temperatures above this range, under some conditions at least, the steam reacts with aluminum with the formation of aluminum oxide and hydrogen."

Experimental data from the aforementioned references indicate that aluminum and aluminum alloys are nonreactive with pure water and/or steam at temperatures up to and including 500°F. Aluminum rapidly forms a protective oxide film, in oxygen containing atmospheres, which is insoluble in neutral water or steam. Since the containment ~~area in the BWR under discussion~~ is noninerted, there is ~~a~~ free access to oxygen during operation, and has been throughout ~~the~~ construction. ~~phases.~~ The oxygen has reacted with the aluminum to form the protective tight adherent water insoluble and nonreacting film, which eliminates the case of hydrogen evolution at the temperature and/or environment present during or following a postulated loss-of-coolant accident. ~~in a BWR.~~

Question 022.048 also addresses the corrosion of zinc and zinc base paints and the evolution of hydrogen following a loss-of-coolant accident.

Hubbell and Finkeldy [4] stated: "Like several other metals which exhibit marked resistance to corrosion in the atmosphere bright zinc rapidly tarnishes when first exposed, forming a smooth tightly adherent protective film. The film is apparently a combination of zinc oxide, zinc carbonate and zinc hydroxide. It is not readily soluble in ordinary atmospheric waters nor easily destroyed by other atmospheric agencies.

The film varies in thickness depending upon the exposure conditions, probably reaching a maximum thickness of .0003 in. If removed or worn thin by abrasion, it is renewed in a few days to its original thickness."

McKay and Worthington [5] state in their chapter on Defining Non-Corrosive Neutral Range of Aqueous Solutions: "Zinc has useful resistance only in a relatively narrow, neutral range of solution; this resistance being due in the simplest case to a protective film of hydrate, abetted in the case of impure solutions by other precipitated corrosion products and compounds deposited from solution. The hydrate is soluble on both the acid and alkaline sides of this neutral zone.

Work by Roetheli, Cox and Litteral has very effectively drawn the limits of the neutral, hydrate-forming zone in tests in distilled water with hydrochloric used to throw the solution acid and/ sodium hydroxide alkaline. The solutions were kept rather strongly agitated." Figure ~~1~~ 022.048-1 depicts the results.

McKay and Worthington [6] explain that: "The hydrate is seen to have been most protective between the neutral point of pH 7 and pH 12.5. The fact is brought out that the exact shape and location of this curve is typical probably only of the particular set of conditions under which the tests were made. Factors such as agitation, aeration, salts in the solution, and temperature, in conjunction with hydrogen-ion concentration, affect the characteristics of film formation. The investigators conclude in a universal sense the condition of low or negligible corrosion probably lies between pH values of 6 and 8 as a minimum and 11 as a maximum."

Cox [7] in a paper titled "Effect of Temperature on the Corrosion of Zinc", established the effect of temperature on the behavior of zinc in distilled water. The specimens were constantly in motion in the solution, and the solution was aerated with a stream of unwashed air bubbles. The duration of the test was 15 days.

The results of their investigation are shown in Figure 022.048-2.

Examination of the zinc hydrate film showed that the strong increase in corrosion coincided with a change in the nature of the film from an adherent gelateneous state to a non-adherent granular state.

Table 022.048-1 gives the results of the change in the film structure of zinc with respect to temperature.

TABLE 022.048-1

EFFECT OF TEMPERATURE ON THE CORROSION OF ZINC IN DISTILLED WATER *

Temp. °F	Temp. °C	Corrosion Rate mg/dm²/day	mil/yr	Appearance of Corrosion Film
68	20	3.9	.78	Gelatenous, very adherent
122	50	13.7	2.74	Less gelatenous, adherent
131	55	76.2	15.2	Mostly granular, nonadherent
149	65	577.0	115.4	Granular to flaky, nonadherent
167	75	460	92.0	Granular flaky, nonadherent
203	95	58.7	11.7	Compact dense, nonadherent
212	100	23.5	4.7	Very dense and adherent

* Rolled high-grade zinc, immersed for 15 days in water aerated by air bubbles. Specimens rotated at 56 RPM.

McKay and Worthington,[8] site work by Bengaugh and Hudson which says: "Of the neutral solutions, distilled water is relatively high in its action on zinc. An idea of rates may be gained by the following data, from 24 hour tests at room temperature on cast 99.97% zinc."

Distilled water	mg. per sq. dm. per day
Quite suspension	53; 76
Air-agitated	167; 199
Agitated with carbon dioxide	143
Agitated with air	33

The authors state that a fair average range of rates in distilled water would be 30 to 200 mg./sq. dm. per day.

~~Section 1.2 Question 312.16 requests that we provide~~ An estimate of the total amount of hydrogen and methane gases that can be generated by the radiolytic and chemical decomposition of organic materials and protective coatings under conditions which would exist following a postulated loss-of-coolant accident is considered below.

~~The answer to this question is extremly difficult to even evaluate.~~ There is, to our knowledge, no published experimental data which states the amount of hydrogen attributable to the effects of a LOCA on specific coatings or organic materials. There is also no published data which gives the amount of methane produced from the decomposition of organic materials in a noninerted environment at the temperature and radiation levels resulting from a loss-of-coolant accident. All of the organic coating materials used within the containment have been subjected to the test requirements stipulated in ANSI N-101.2 and ANSI N-512 and to an accumulative dose of 1×10^9 rads, at the Oak Ridge National Laboratory. Test results show the coatings were intact with no defects.

Mattson[9] states:

"Decomposition of Organics: A substantial amount of organic materials is used in protective coating systems, including those over zinc-based primer paints inside PWR and BWR containments. When exposed to the LOCA environment (high temperature, chemical, and radiation fields), these organic materials undergo a process of decomposition to form hydrogen and hydrocarbons. The Accident Analysis Branch (DSE) has estimated the resultant hydrogen and hydrocarbon concentrations resulting from the radiolytic decomposition of organics and the thermal and chemical reaction of organic coatings on concrete surfaces. Assuming a conservatively integrated radiation exposure of 10^{8} rads, the Accident Analysis Branch (AAB) estimates the hydrogen concentration due to radiolytic decomposition of organic coatings to be less than 0.4% for PWR's and less than 0.2% for BWR's. For hydrogen generation due to thermal and chemical reaction of organic coatings on painted concrete surfaces the AAB estimates the resultant hydrogen concentration to be less than 0.3% for PWR's and less than 0.2% for BWR's. If we sum these hydrogen contributions from organic materials which were heretofore not included in our analysis, the additional hydrogen represents roughly a 10% increase in the hydrogen generated from all sources previously considered, i.e., Zirconium water reaction, radiolysis of water, and oxidation of zinc with its organic top coat during the post-LOCA period.

Since there will be a large amount of water, relative to the amount of organic materials, it can be concluded that the hydrogen gas generated from radiolysis of water should dominate that from decomposition of the organic materials."

The following paragraphs address Question 022.048 item by item.

a. The corrosion rates as a function of temperature for all materials in the containment that could become a source of hydrogen due to corrosion are:

1. Zinc - applies to galvanize and zinc base paints

Temp. °F	Corrosion mg/dm²/day	Corrosion oz/sq.ft./day
68	3.9	.0013
122	13.7	.0045
131	76.2	.0250
149	577	.1892
167	460	.1508
203	58.7	.0192
212	23.5	.0077

2. Aluminum - applies to reflective insulation around the RPV and piping

Temp. 70°F to 340°F - Nonreactive, will not produce hydrogen at temperature indicated.

3. Organic Materials - Consists of all organic coating materials on steel and concrete in drywell and wetwell. No specific reaction rates have been published wherein the function of temperature on the corrosion rates of organic materials has been addressed. Most data addressed the loss in or deterioration of physical properties such as strength, durometer and the like. All of the materials used for coating of concrete or steel have been subjected to the required tests stipulated in ANSI N-101.2 and ANSI N-512 in accordance with Bechtel Corporation's specifications CP-951 and CP-956, by the Analytical Chemistry Division of Oak Ridge National Laboratory. The test reports indicate that there were no defects in the coating materials, i.e., there were no signs of chaulking, flaking, cracking, delamination or blistering beyond the requirements of the acceptance criteria of the ANSI Standards. Reference 9 states that "The Accident Analysis Branch (DSE) has estimated the resultant hydrogen and hydrocarbon concentration resulting from radiolytic decomposition of organics and the thermal and chemical reaction of organic coatings on concrete surfaces. Assuming a conservatively integrated radiation exposure of 10 rads, the Accident Analysis Branch (AAB) estimates the hydrogen concentration due to radiolytic decomposition of organic coatings to be less than 0.4% for PWR's and less than 0.2% for BWR's. For hydrogen generation due to thermal and chemical reaction of organic coatings on painted concrete surfaces the AAB estimates the resultant hydrogen concentration to be less than 0.3% for PWR's and less than 0.2% for BWR's."

For the specific BWR in question, we are speaking of a possible 0.4% total hydrogen and hydrocarbon concentration.

4. Metal water reactions and radiolytic decomposition of water are addressed in ~~the FSAR Chapter~~ 6.2.5.

b. The corrosion rates for the materials identified in item (a) of the question were established as follows:

1. Zinc - Since no definitive data with respect to the corrosion rate of zinc in a BWR environment, containing neutral water without additives, has been reported in the test conducted by Oak Ridge National Laboratory, Franklin Institute Research Laboratories or Brookhaven National Laboratory, it was necessary to refer to the investigations conducted by other recognized corrosion experts and institutions. Figure 022.048-2 [11] and the accompanying Table 022.048-1 [12] explains the investigations conducted to determine the corrosion rate of zinc (rolled high grade) immersed for 15 days in distilled water aerated by air bubbles while rotating the specimens at 56 RPM. The table which appears in the referenced publications shows the actual corrosion in milligrams per square decimeter per day and mils per year at the various temperatures. The data which was used as a basis for calculating the evolution of hydrogen is actual measured data.

The premise that all of the metal which corrodes will react to produce a stoichiometric quantity of hydrogen is ultra conservative, since there are other competing reactions which will produce zinc carbonate and zinc oxide. In our evaluation we determined the highest corrosion rate of zinc occurred at 149°F and resulted in a rate of 577 mg/dm^2/day or .189 oz/sq.ft./day [13]. In our analysis we used this maximum amount as the corrosion rate, at temperature, in the containment. It can be determined from the published data that this is conservative by a factor of more than 27, if we consider that at 212°F the corrosion rate is 23.5 mg/dm^2/day or .0077 oz/sq.ft./day and that at 68°F it is 3.9 mg/dm^2/day or .0013 oz/sq.ft./day. The data of Figure 022.048-2 and Table 022.048-1 show that at the temperature of 149°F the maximum rate occurs and that the rate falls sharply with temperature increase so that at a temperature of 340°F it would be below that shown at 212°F.

022.048

2. Aluminum - Our search of the literature (1), (2), (3) clearly indicates that aluminum will not corrode or produce hydrogen since the pH of the water is in the neutral range and the temperature is below that required to produce hydrogen.

3. Organic Coatings and Materials - ~~We searched the~~ The literature was searched in an effort to determine if there was any firm data which showed that the organic coatings and materials used would produce hydrogen as a result of a postulated loss-of-coolant accident. ~~We found that~~ It has been postulated that organics do form hydrocarbons as a result of radiation, but this theory is based on the fact that there is a loss of physical properties as radiation exposure increases. We have stated ~~in the FSAR~~ that the organic top coats and coatings used within containment were subjected to the test requirements of ANSI N-101.2 and ANSI N-512 to an accumulative dose of 1×10^9 rads, with a resulting no defects.

Mattson [9] states that "The Accident Analysis Branch (DSE) has estimated the resultant hydrogen and hydrocarbon concentration resulting from the radiolytic decomposition of organics and the thermal and chemical reactions of organic coatings on concrete surfaces. Assuming a conservatively integrated radiation exposure of 10^8 rads", the resultant concentration is considered to be less than 0.2% for BWR's. He further states that ~~it is estimated that~~ thermal and chemical reactions are estimated to produce less than 0.2% of hydrogen for BWR's.

c. The mass and surface area of zinc paint, galvanized steel, aluminum and organic coatings is as follows:

1. Zinc Paint

   280,853 sq. ft. - 18,367.8 lbs. of zinc in drywell and wetwell above the water level

2. Galvanize

   67,483 sq. ft. - 3018.3 lbs. of galvanize in drywell and wetwell above the water level

3. Aluminum

   460,700 sq. ft. - 32,374 lbs. around reactor pressure vessel and piping

4. Organic Topcoats

On steel 400,000 sq. ft. - approx. 187,500 lbs.

On concrete 33,000 sq. ft. - approx. 24,750 lbs.

~~Question 0322040, Part d~~

d. The graphic representation of the total hydrogen concentration inside containment as a function of time is shown in Figure 4.

~~Question 0322040, Part e~~

e. The graphic representation of the contribution of each source of hydrogen ~~on~~ as a function of time is shown in Figures 3 and 4.

~~Question 03240, Part f~~

f. The periodic surveillance that will be done to demonstrate the operability of the hydrogen recombiner and the backup purge system is ~~explained~~ discussed in ~~Chapter 6 of the FSAR~~ 6.2.1.1.8 and 6.2.5.4.

~~Question 03240, Part g~~

g. The location of the hydrogen sample points in the drywell and the suppression chamber and the suction and discharge points of the combustible gas control system with respect to nearby structures and equipment has been answered ~~in the FSAR~~ in response to Question ~~022.025~~ 022.25.

See, in addition, revised Section 6.2.5 pages of the FSAR.*

* draft revised pages attached.

BIBLIOGRAPHY TO 022.048

1. The Corrosion Handbook - H.H. Uhlig p. 42, Pub. J. Weley & Sons

2. The Corrosion Handbook - H.H. Uhlig p. 43, Pub. J. Weley & Sons

3. The Corrosion Handbook - H.H. Uhlig p. 617, Pub. J. Weley & Sons

4. Corrosion Resistance of Metals and Alloys - R. McKay & R. Worthington p. 168, Pub. Reinhold Pub. Corp.

5. Corrosion Resistance of Metals and Alloys - R. McKay & R. Worthington p. 159, Pub. Reinhold Pub. Corp.

6. Corrosion Resistance of Metals and Alloys - R. McKay & R. Worthington p. 169, Pub. Reinhold Pub. Corp.

7. Corrosion Resistance of Metals and Alloys - R. McKay & R. Worthington p. 159, Pub. Reinhold Pub. Corp.

8. Corrosion Resistance of Metals and Alloys - R. McKay & R. Worthington p. 163, Pub. Reinhold Pub. Corp.

9. U.S.N.R.C., Memorandum 10/17/78, R.J. Mattson, Director, Division of Systems Safety to R.S. Boyd, Director, Division of Project Managment (Available NRC Public Document Room)

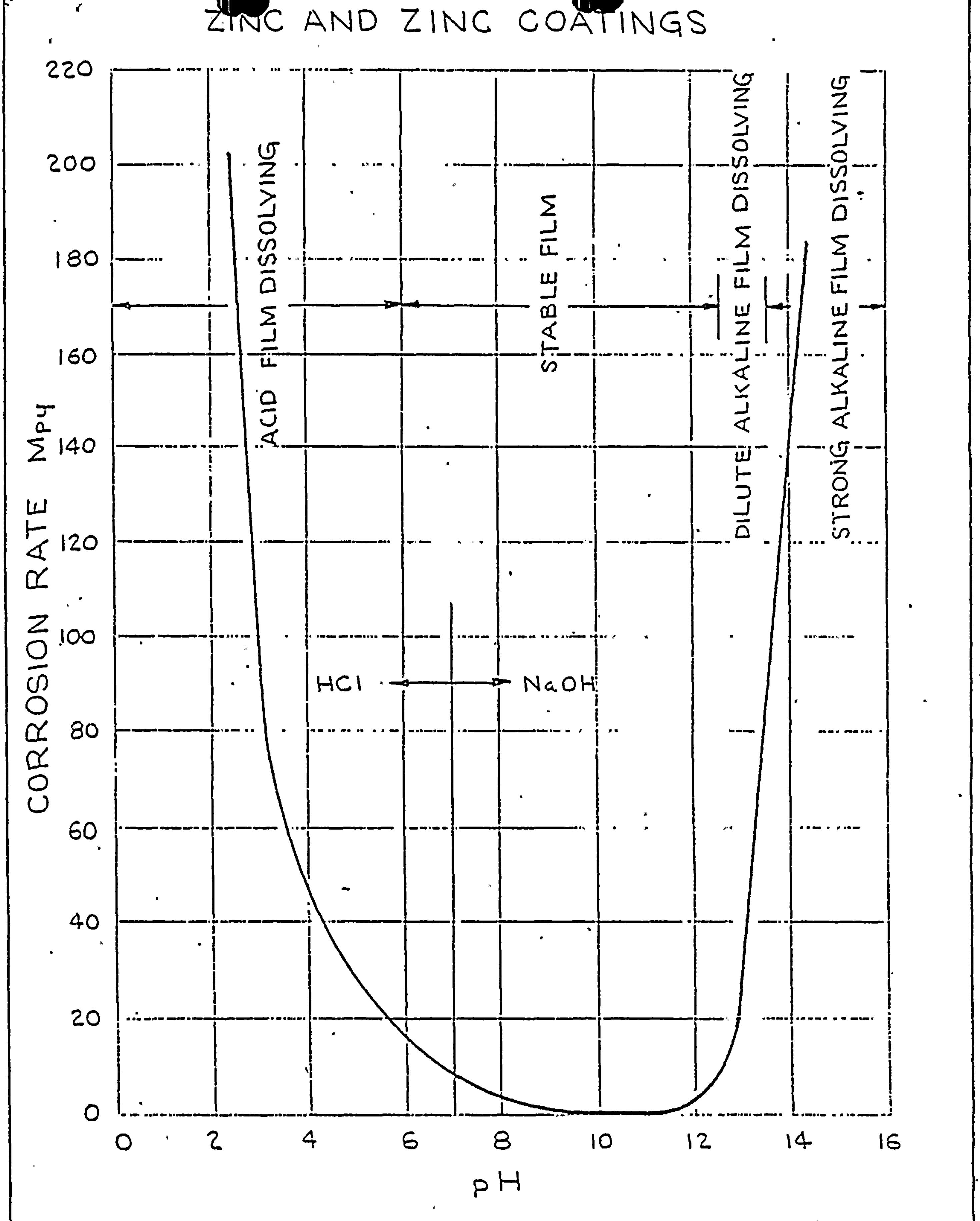
10. Fig. 022.048-1 p. 160 McKay & Worthington
    p. 13 Zinc: Its Corrosion Resistance Pub. Zinc Institute

11. Fig. 022.048-2 p. 161 McKay & Worthington
    p. 104 Zinc: Its Corrosion Resistance, Pub. Zinc Institute
    p. 232 LaQue & Copson - Corrosion Resistance of Metals and Alloys

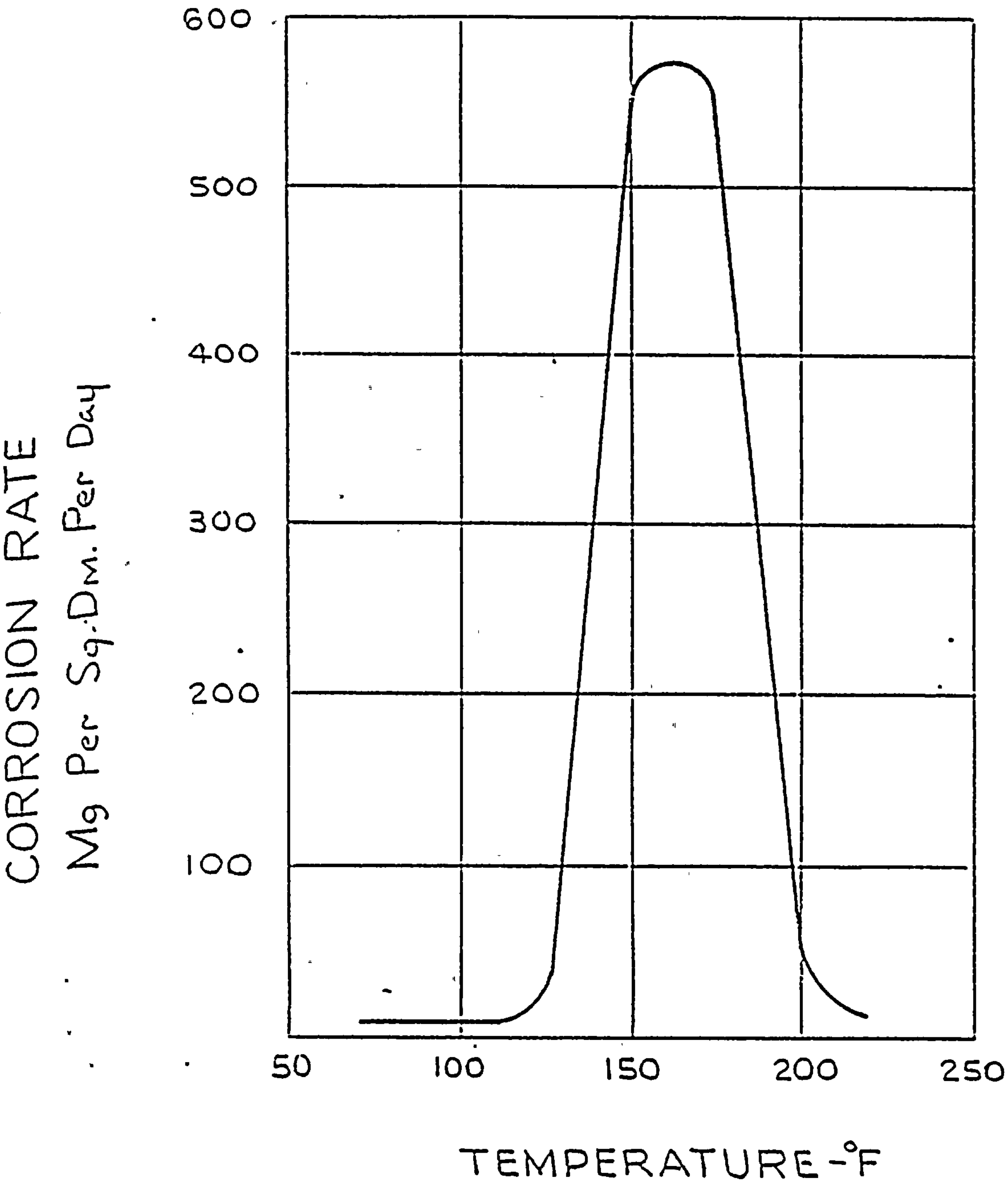
12. Table 022.048-1 p. 160 McKay & Worthington
    p. 233 LaQue & Copson - Corrosion Resistance of Metals and Alloys
    p. 103 Zinc: Its Corrosion Resistance, Pub. Zinc Institute

13. Conversion Factor H. H. Uhlig The Corrosion Handbook p. 1160 Table 19

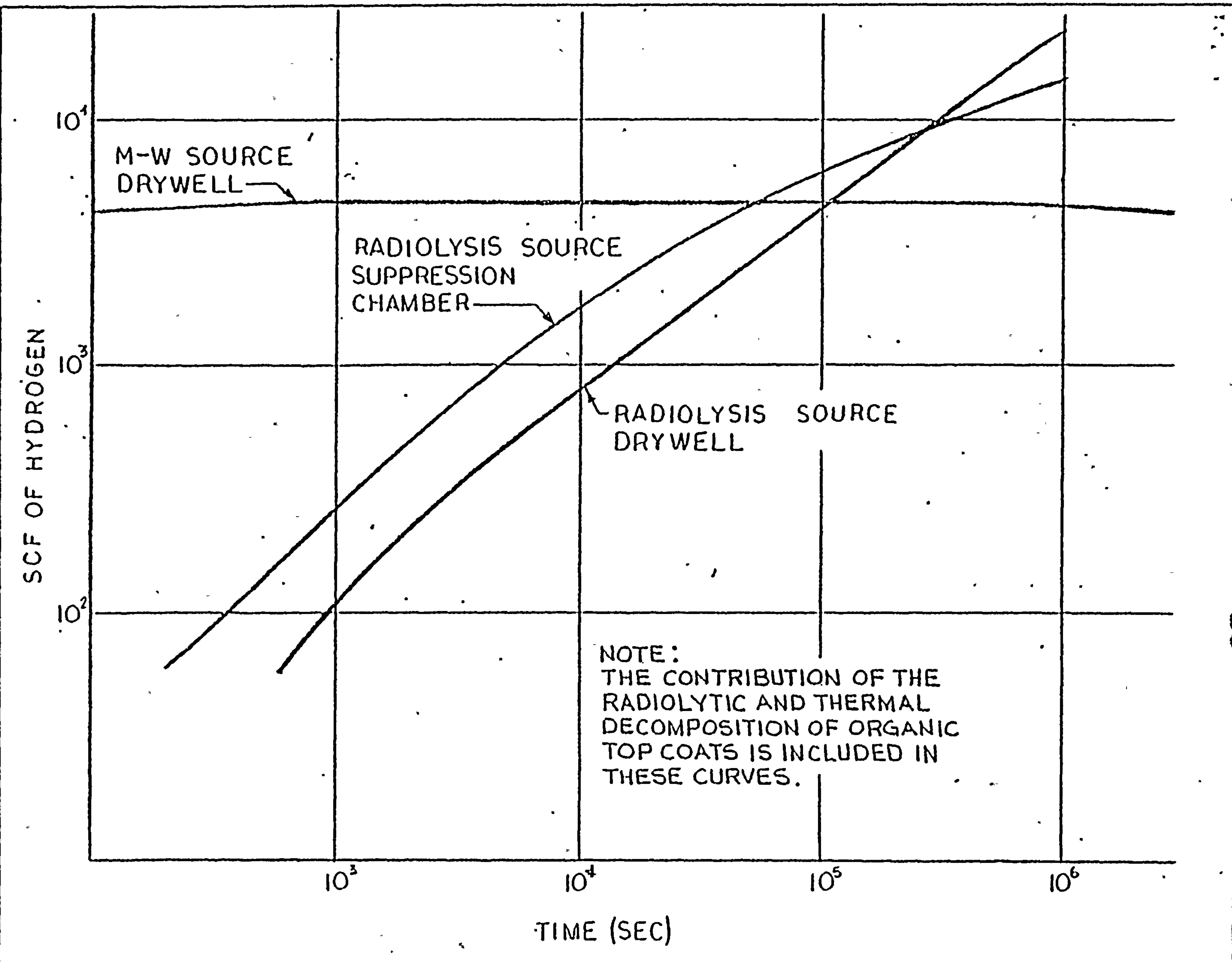
14. Final Report F-C4290, Hydrogen Evaluation From Zinc Corrosion Under Simulated Loss-Of-Coolant Accident Conditions - Franklin Institute Research Laboratories 8/76



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	EFFECT OF pH ON CORROSION RATE OF PURE ZINC IN OXYGENATED SOLUTIONS	FIGURE 022.048-1



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	ZINC v.s DISTILLED WATER EFFECT OF TEMPERATURE	FIGURE 022.048- 2

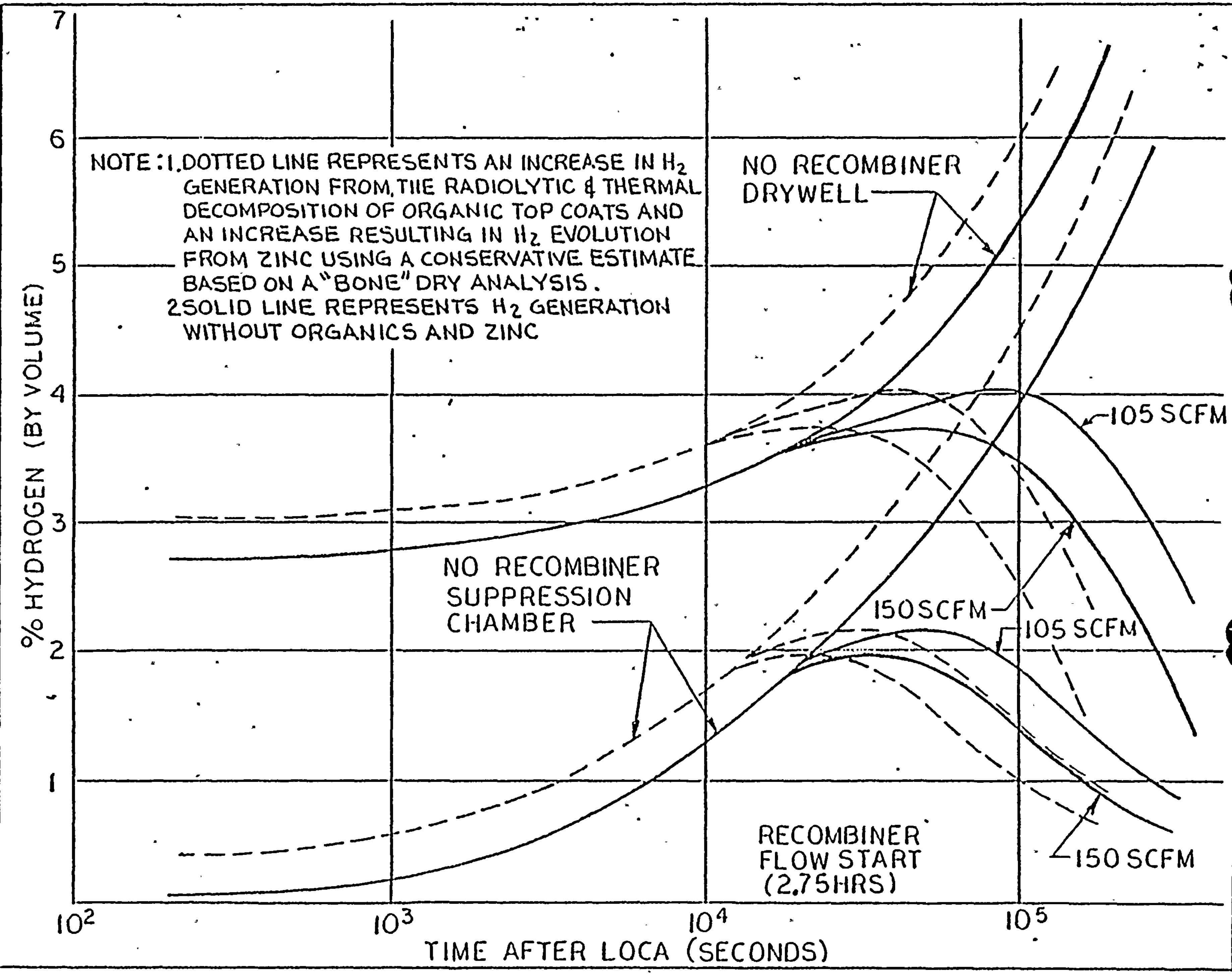


WASHINGTON PUBLIC POWER SUPPLY SYSTEM
NUCLEAR PROJECT NO. 2

INTERGRATED HYDROGEN PRODUCTION AS A FUNCTION OF TIME (WITHOUT HYDROGEN RECOMBINING)

FIGURE 022.046-3

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
NUCLEAR PROJECT NO. 2



DRYWELL & SUPPRESSION CHAMBER HYDROGEN CONCENTRATION AFTER LOCA AS A FUNCTION OF TIME

FIGURE 022.048

k. The system is designed to meet quality assurance, redundancy, power supply and instrumentation requirements for an engineered safety feature system.

l. Since the system is redundant and is not shared with other nuclear units, transportation of the hydrogen recombiners is not required.

m. Since all components of the system are redundant, a containment purge system as a backup is not required. A containment purge system used for other environmental controls is discussed in 6.2.1.1.8.

6.2.5.2 System Design

The containment atmosphere control system provides effective control of the hydrogen generated following a postulated LOCA. Piping and instrumentation for the system is shown in Figures 3.2-17, 3.2-15 and 3.2-6. Equipment details are given in Table 6.2-17.
The system consists of the following:

1. A hydrogen mixing system which operates to assure a well mixed atmosphere in both the drywell and suppression chamber. This system is the containment spray system and can be actuated approximately 10 minutes after the postulated LOCA.

2. A hydrogen concentration monitoring system measures the amount of hydrogen in the drywell and suppression chamber atmosphere.

3. Two 100 percent capacity hydrogen recombiners, one of which is manually initiated approximately 2.75 hours after the accident to preclude the hydrogen concentration from exceeding four percent by volume. The recombiners are catalytic type hydrogen oxygen recombiners.

6.2.5.2.1 Hydrogen Mixing System

The function of the hydrogen mixing system is to provide a well mixed atmosphere in the drywell and suppression chamber.

The cooling water supplied to the aftercooler is returned to the standby service water system. The cooling water supplied to the scrubber is discharged to the suppression pool.

All components of the containment atmosphere control system are redundant. Controls include the control panel located in the main control room and the local control panel for each recombiner located in environmentally suitable rooms in the reactor building. All of the functions necessary to control the system are located in the main control room.

6.2.5.2.4 Containment Purge

Since active and passive components of the containment atmosphere control system are redundant, containment purge as a backup system is not required.

6.2.5.3 Design Evaluation

Based on the assumptions of the model described below, it is calculated that the hydrogen concentration in the drywell eventually reaches 4% by volume approximately 10.0 hours after the postulated LOCA if the hydrogen recombiner is not in operation. The recombiner is started, however, when the hydrogen concentration reaches approximately 3.5% by volume (2.75 hours after the postulated LOCA) to limit the hydrogen concentration below 4% by volume. Figure 6.2-26 shows the drywell and suppression chamber hydrogen concentration as a function of time, with and without operation of the hydrogen recombiner system at design capacity of 150 scfm and at 105 scfm, minimum flow required to maintain the hydrogen concentration below 4% by volume.

The determination of the time dependent hydrogen concentration in the drywell and suppression chamber atmospheres is based on a two-region model of the primary containment, a drywell and a suppression chamber atmosphere.

The drywell and suppression chamber free volumes contain air and water vapor at atmospheric pressure just prior to the postulated LOCA. Gases considered available for hydrogen dilution are the non-condensibles and water vapor present during normal operating conditions. Water vapor generated from blowdown is not considered. The radiolytic generation of free oxygen is added to the total inventory of gases. The pressure in containment is assumed to remain at atmospheric pressure and the temperature history of Figure 6.2-7 curve a, is used. The hydrogen contribution from zinc and organics took no credit for dilution.

and Decomposition

6.2.5.3.1.3 Corrosion of Containment Materials

and decomposition

The corrosion of containment materials was considered as a potential source of hydrogen. The corrosion of aluminum, zinc, ~~and~~ zinc base paints, located either in the drywell or suppression chamber was evaluated as a potential source of hydrogen. ~~It was determined that these potential sources were insignificant for the following reasons:~~

and the radiolytic and chemical decomposition of organic materials

~~a. The containment spray does not contain any chemical additives. The pH of the spray solution is 6.5 - 7.0.~~

~~b. Aluminum corrosion is negligible at a pH of 6.5 - 7.5.~~

~~c. The corrosion of both zinc and aluminum is highly temperature dependent. The duration of elevated post-LOCA temperature in the drywell and suppression chamber is short (See Figures 6.2-3, 6.2-12 and 6.2-15) and the magnitude is not sufficient to produce significant corrosion.~~

replace

The evaluation is included in the response to NRC question 022.048. The results are taken into account in Figures 6.2-26 and 6.2-30.

6.2.5.4 Testing and Inspections

The hydrogen recombiners and the associated instrumentation are periodically inspected and tested to ensure reliable operation.

Each hydrogen recombiner system has been shop tested. Written test procedures and acceptance criteria were established for all tests. Test results were recorded in performance records. The full scale performance tests were accomplished by placing each unit in operation, starting the hydrogen recombiner and allowing atmospheric air, hydrogen and steam to flow through the unit. A flow of at least 155 SCFM was maintained throughout all tests. The simulated environmental conditions (temperature, pressure and hydrogen at 0.5 to 4% by volume) following a postulated LOCA (Figures 6.2-6 and 6.2-7, curve c) were used during these tests.

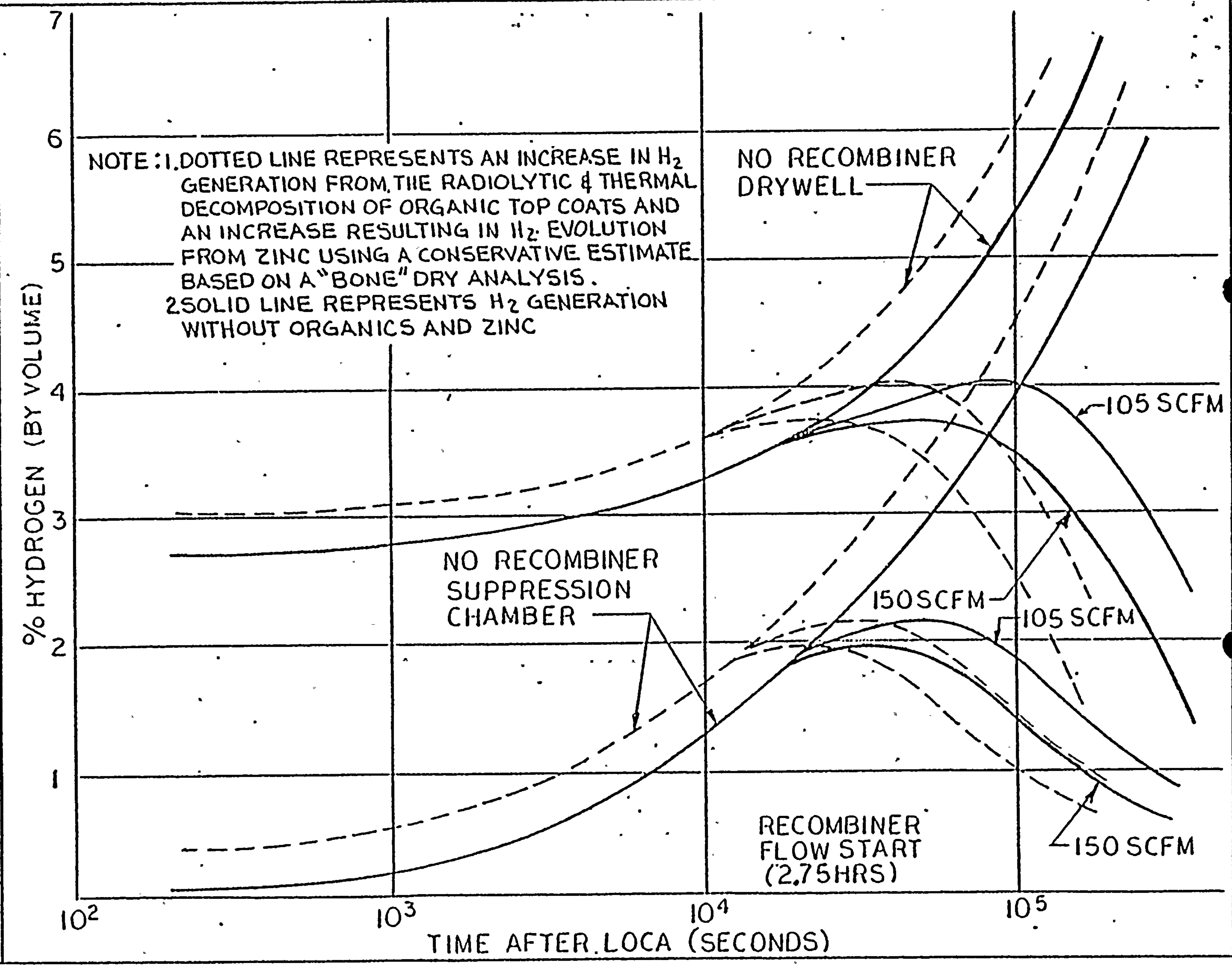
The manufacturer has also conducted a series of catalyst performance tests including the effect of iodine and methyl iodide.

[illegible]

[illegible]

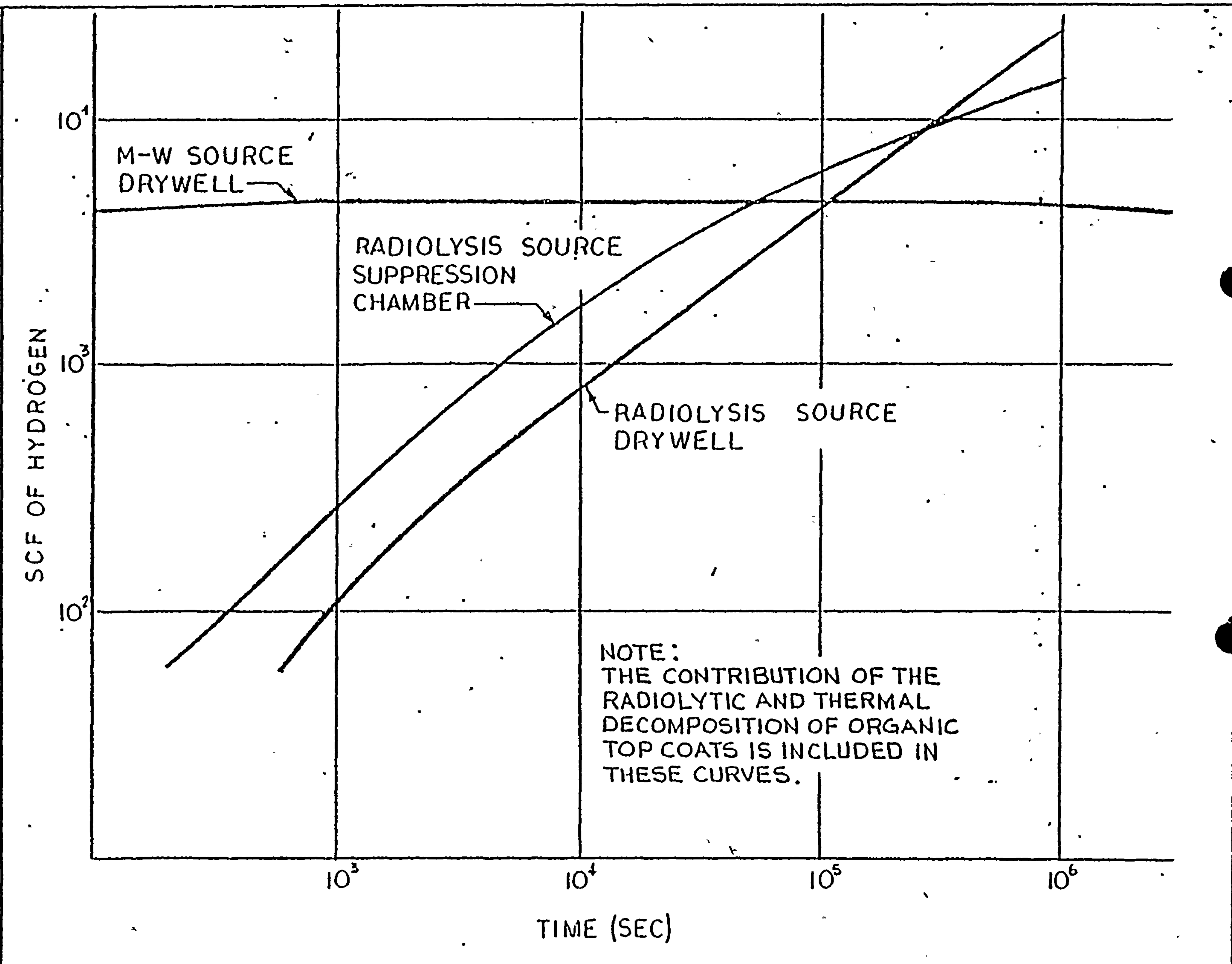
[illegible]

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
NUCLEAR PROJECT NO. 2



DRYWELL & SUPPRESSION CHAMBER HYDROGEN CONCENTRATION AFTER LOCA AS A FUNCTION OF TIME

FIGURE 6.2-26



WASHINGTON PUBLIC POWER SUPPLY SYSTEM
NUCLEAR PROJECT NO. 2

INTERGRATED HYDROGEN PRODUCTION AS A FUNCTION OF TIME (WITHOUT HYDROGEN RECOMBINING)

FIGURE 6.2-3C

Q 331.20
(12.4.1)

In addition to the job group exposure breakdown in Section 12.4 of the FSAR, provide a profile of the estimated annual man-rem doses at the WNP-2 facility broken down by major functions such as operations, maintenance, radwaste handling, and inservice inspection. Using experience from operating boiling water reactors, provide estimates of doses resulting from non-routine or special maintenance activities. Indicate the estimated dose rates, the expected required number of workers and the occupancy times required for performing such maintenance work which you used in evaluating the estimated annual can-rem doses. Regulatory Guide 8.19 provides guidance in making such an assessment.

Response:

See revised Section 12.4.* The tables in revised Section 12.4 provide a profile of the estimated annual man-rem doses at the WNP-2 facility. The tables are based on operating BWR experience and are formulated in accordance with Regulatory Guide 8.19.

*Draft changes attached.

12.4 DOSE ASSESSMENT

replace with new section 12.4.1 attached

12.4.1 DESIGN CRITERIA, OCCUPANCY FACTORS AND PERSONNEL DOSE

The criteria for the dose to plant personnel during normal operation and anticipated operational occurrences, including refueling, are based on the requirements discussed in 10CFR Part 20. The design radiation levels during normal operation and refueling are shown on Figures 12.3-1 to 12.3-6. In areas such as the control room and offices, the maximum dose rate does not exceed 1.0 mrem/hr (Zone I radiation level). For personnel who work in controlled radiation areas, radiation Zone II through V on Figures 12.3-1 to 12.3-6, administrative controls ensure that doses do not exceed the requirements of 10CFR Part 20.

The occupancy factors used in estimating plant personnel radiation exposure are listed on Table 12.4-1 for the six personnel groups.

a. Group 1 - includes maintenance personnel such as mechanical, electrical instrument craftsmen and foremen. There are approximately 46 people in this group.

b. Group 2 - includes control and equipment operators. There are approximately 29 people in this group.

c. Group 3 - includes technicians such as health physics and chemistry technicians and engineering assistants. There are approximately 8 people in this group.

d. Group 4 - includes engineers and technical supervisors. There are approximately 9 people in this group.

e. Group 5 - includes inplant supervisors such as health physics-chemistry supervisor, shift supervisor, etc. There are approximately 14 people in this group.

f. Group 6 - includes administrative and management personnel. There are approximately 11 people in this group.

These occupancy factors are determined by estimating the amounts of time spent by personnel in controlled radiation areas while performing the following functions:

g. Routine patrol

h. Periodic tests and operations

i. Control room operations

j. Refueling

k. Maintenance

l. In-service inspection

Table 12.4-1 also lists the estimated annual dose that will apply to a particular group in a particular area. To find the dose that will apply to a particular group, the dose rate is multiplied by the occupancy factors and the number of people in each group. The results, listed in Table 12.4-1, represent whole body exposure.

Data on personnel exposure from operating BWR plants show that the operation and maintenance requirements of all BWR plants are similar. It is anticipated that the operation and maintenance requirements of WNP-2 will be similar to other BWR plants and therefore the personnel exposure data will be similar. 12.4.2 discusses personnel exposure based on BWR operating experience.

replace with new 12.4.1
attached

12.4 DOSE ASSESSMENT

12.4.1 DESIGN CRITERIA

The criteria for the dose to plant personnel during normal operation and anticipated operational occurrences, including refueling, are based on the requirements discussed in 10CFR part 20. The design radiation levels during normal operation and refueling are shown on Figures 12.3-1 to 12.3-6. In areas such as the control room and offices, the maximum dose rate does not exceed 1.0 mrem/hr. (Zone I radiation level). For personnel who work in controlled radiation areas, radiation Zone II through V on Figures 12.3-1 to 12.3-6 administrative controls ensure that doses do not exceed the requirements of 10CFR part 20.

12.4.2 PERSONNEL DOSE ASSESSMENT BASED ON BWR OPERATING DATA

12.4.2.1 General

In general, recent data[1] from operating BWR's have shown that the man-rem exposures to plant personnel are primarily due to the corrosion product isotopes. Of the corrosion product isotopes, Co-60 is believed to be the single most important radionuclide.

The variables that have been found to affect plant personnel exposure include the following:

a. BWR plants show an increase in total personnel exposure during the first few years of operation.

b. The need to minimize plant downtime requires that inspection and repair tasks must be started immediately after plant shutdown when the dose rates from short-lived radionuclides can be significant.

c. Plant design and equipment layout has a significant effect on personnel dose. 12.3.1 discussed the design features used to minimize plant personnel exposure.

d. Training and experience of plant workers.

e. The extent of maintenance operations required for a specific year.

f. The extent that a utility uses non-regular or contractor personnel.

12.4.2.2 Personnel Dose From Operating BWR Data

References 1 and 2 provide a tabulation of personnel exposures for operating BWR's. Table 12.4-9 tabulates the average personnel exposure for several plants operating for a period of several years based on these references. References 4 through 7 provide more recent information. The assesment summarized in section 12.4.2.3 includes this more recent information.

Replace with 12.4.2.2 updated

delete

A tabulation of the average fraction (in percent) of the annual plant exposure is listed on Table 12.4-3. This table shows that the jobs listed account for 47% of the total dose received by plant personnel on the average. The remaining exposure can be largely accounted for after considering miscellaneous routine operations and maintenance. Each of the tasks in this category are insignificant as far as radiation dose is concerned. However, the cumulative dose received by plant personnel after performing many of these tasks becomes significant. Data show that the exposure from routine operations is approximately 33% of the total annual exposure. The remaining 20% of the total annual exposure is accounted for after considering miscellaneous work during outages, bias in accounting for exposure, and differences in dosimetry results.

It is concluded that no single source of exposure is dominant at operating BWR's. The largest single sources were the recirculation pumps including clean-up system and work on valves, particularly relief and safety valves. Each of these sources contributed 8% to the total annual exposure. Inservice inspection, liquid waste treatment systems and fuel handling contributed the next highest exposures, 4.9%, 5.6% and 5.5% of the annual exposure, respectively.

None of the above discussion includes the dose received by contractor personnel. Looking at Table 12.4-2, subtracting the column labeled "regular-man-rem" from "total-man-rem" yields the dose received by contractor personnel. In general, a significant fraction (between 25% and 60%) of the total man-rem is received by contractor personnel.

12.4.2.3 Results and Conclusions

As discussed previously, a precise estimate of occupational exposure of specific individuals is not attainable. A gross assessment is provided in the following paragraphs for the six job group classifications defined in 12.4.1.

a. Group 1 - Maintenance personnel would receive the largest dose of any of the six groups. Based on the data discussed in the preceding sections, the average annual personnel dose for all plants with a thermal output greater than 50,000 MWD is 140 man-rem per year per plant. The plants considered are listed on Table 12.4-2.

replace with new 12.4.2.3 attached

From Table 12.4-3, it is seen that maintenance operations, which include control rod drive, recirculation pump, valve, turbine, fuel pool and condensate demineralizer maintenance operations), would account for 21% of the average annual personnel dose. If one-half of the dose from routine operations (33%) and miscellaneous work during outages (20%) also is received by plant maintenance personnel, approximately 50% of the total annual average personnel dose, or 70 man-rem, is received by this group. Assuming 46 people are in this group results in a dose of 1.52 rem per person annually. As discussed in 12.3.1, the equipment design and layout and the shielding design are such that the exposure is as low as reasonably achievable.

b. Group 2 - Plant operation personnel can be divided into three groups - supervisors, control room staff and plant equipment operators. These exposures can be estimated using radiation zone limit values. The values given in Table 12.4-1 show that the total personnel dose for operation and shutdown is approximately 22 man-rem or about 0.7 rem/yr per person. As part of this total, the supervisors and control room staff would be expected to receive an exposure of less than 500 mrem/yr if they remain in the control room and administrative office areas. These people will, however, spend time on inspection of plant systems.

c. Group 3 - If the plant health physics/chemistry personnel spent 1% of their time collecting samples in Zone III sampling stations, they will receive a maximum dose of 300 mrem/yr. Assuming that they spend the remainder of their time in Zone I and Zone II areas, their total dose would be between 1 and 2 rem per person. The plant health physics/chemistry personnel also conduct radiation surveys and support maintenance activities which require monitoring and pre-job radiation surveys. The exposure to the health physics/chemistry staff can range from 1 to 3 rem/yr. This is based on experience from operating plants.

replace with new section 12.4.2.3 attached

with new section 12.4.2.3 attached

Assuming a dose rate per person of 2 rem/yr and considering the 8 people in this group, the total personnel dose is 16 man-rem.

d. Group 4 - The engineering staff and technical supervisors will spend most of their time in Zone I areas where exposures will be less than 500 mrem/yr. They will spend time in higher radiation areas. However, the resulting dose that they will receive is difficult to estimate accurately. The dose received by the 9 people in this group is taken to be 4.5 man-rem.

e. Group 5 - Plant supervisors will spend time supervising Group 1 and Group 3 personnel. Their dose rate would be about the same as that received by personnel in Group 1 and 3. This value is about 1 rem/yr. With 14 people in this group, the total personnel dose is 14 man-rem.

f. Group 6 - The administrative and plant personnel will spend their time in Zone I radiation areas. Thus, it is expected that their dose rate will be less than 500 mrem/yr. With 11 people in this group, the total personnel dose becomes 5.5 man-rem.

The total personnel dose for all groups is approximately 130 man-rem. Assuming that another 130 man-rem will be received by contractor personnel, as discussed in 12.4.2.2, the total personnel exposure is estimated to be 260 man-rem.

12.4.3 INHALATION EXPOSURES

Airborne radionuclide concentrations in normally occupied areas are, as discussed in 12.2.2, well below the limits set by 10 CFR Part 20 and thus inhalation exposures are negligible.

12.4.2.3 OCCUPANCY FACTORS, DOSE RATES, AND ESTIMATED PERSONNEL EXPOSURES

A summary of the total estimated man-rem doses broken down by major function is given in Table 12.4-1. More detailed breakdowns are presented in Tables 12.4-2 through 12.4-8 for each of the seven major functions given on Table 12.4-1. These tables are based on the more recent information obtained from References 4 through 7. The data from Table 12.4-9 is given for comparison purposes only.

The results of the total estimated man-rem doses will be discussed with reference to six occupational groups as follows:

a. Group 1 - This group includes maintenance personnel such as mechanical, electrical, instrument craftsmen and foremen. There are approximately 46 people in this group. Tables 12.4-4 and 12.4-8 provide the functional breakdown of exposure for this occupational group. As can be seen from the Tables, 373 total man-rem may be expected.

   Routine and special maintenance operations which include control rod drive repairs, Residual Heat Removal (RHR) repairs, snubber maintenance, etc. account for approximately 62% of the average annual personnel dose. One to three rem per year per person is projected for the station maintenance personnel for a maximum total of 138 man-rem per year. Accordingly, the remaining 235 man-rem per year would be expected to be received by nonstation maintenance personnel. As discussed in 12.3.1, the equipment layout and design and shielding design are such that the exposures are as low as reasonably achievable (ALARA).

b. Group 2 - This group includes plant operations personnel composed of supervisors, control room staff and plant equipment operators. There are approximately 29 people in this group. Tables 12.4-2, 12.4-3, 12.4-5 and 12.4-6 show the total estimated man-rem for this group. As can be seen, the total is approximately 111 man-rem per year or approximately 3.8 rem per year per man. Personnel in this group will be performing routine and non-routine operation and surveillance, waste processing and refueling operations. In plant operations personnel are expected to receive approx. one to two rem per year per man for a maximum total of 58 man-rem per year. The remaining 51 man-rem per year may be expected to be received by nonstation personnnel. As part of this total, the supervisors and control room staff are expected to receive an exposure of less than 500 mrem/yr.

c. Group 3 - This group includes health physics/chemistry technician personnel. There are approximately 8 people in this group. If the plant health physics/chemistry personnel spend 1% of their time collecting samples in zone III sampling stations, they will receive a maximum dose of 300 mrem/yr. Assuming the remainder of their time is spent in zone I and II areas the total dose is between 1 and 2 rem per person. The plant health physics/chemistry personnel also conduct radiation surveys and support maintenance activities which require continuous and pre-job radiation surveys. The exposure to these health physics/chemistry personnel ranges from 2 to 4 rem/yr. This is based on experience from operating plants. Assuming a dose of 3 rem per person per year and considering 8 people in the group, the total is 24 man-rem per year. Since this group covers virtually all functions delineated in Tables 2 through 8, this 24 man-rem is considered to be spread out across all the functions.

d. Group 4 - This group includes engineers and technical supervisors. There are approximately 9 people in this group. Personnel in this group will spend most of their time in Zone I areas where exposures are less than 500 mrem/yr. Table 12.4-7 indicates approximately 129 man-rem per year will be experienced for inservice inspection. Plant technical personnel will have a supervising roll in this operation with nonstation personnel performing the inspecting operations. Thus, the projected dose estimate for the 9 people in this group is 4.5 man-rem per year, the balance being accounted for by the nonstation personnel.

e. Group 5 - This group includes station supervisors such as health physics-chemistry supervisors, shift supervisors, etc. There are approximately 14 people in this group. Station personnel will supervise Group 1 and Group 2 personnel. Their dose is approximately the same as personnel in these groups. With a projected dose estimate of 1 rem per year and 14 people in the group the total dose is 14 man-rem per year.

f. Group 6 - This group includes administrative and management personnel. There are approximately 11 people in this group. Personnel in this group spend their time in Zone 1 radiation areas. The projected dose estimates will be less than 500 mrem/yr. With 11 people in this group and a 500 mrem per man per year the total dose is 5.5 man-rem per year.

As seen from Table 12.4-1, the total estimated man-rem exposure is 613 man-rem. Groups 3, 5, and 6 are considered to be spread over all the functions. These groups constitute only 7% of the total exposure in any case.

12.4.4 SITE BOUNDARY DOSE

Steam-handling equipment on the turbine operating floor can contribute to the site boundary dose in two ways: through a direct component and through an air-scattered "skyshine" component. Since the N-16 bearing equipment is known, it can be shielded to reduce the direct component. The "skyshine" component reaches the site boundary as a result of those gamma rays which are directed such that they bypass any intercepting shield walls and are scattered by the air to the site boundary.

The calculated results show that the skyshine dose will have its greatest effect on a dose point 1950 meters north of the turbine building. The skyshine dose at this point will be approximately 3.6 mrem/yr. This result is based on a plant capacity factor of 80% at full power operation.

The main contributors to this dose and their contribution (in percent) are the south moisture-separator reheater (MSR) which contribute 60%, the north MSR which contributes 20%, the cross over lines which contribute 10% and the turbines and feedwater heaters which contribute 10%.

The dose estimate was computed from a model that represents the N-16 gamma leakage by point isotopic sources. This model uses the output from the COHORT Code[3] which gives the air-scattered dose as a function of distance and source ray angle.

The site boundary dose from liquid and gaseous effluents are discussed in 11.2.3 and 11.3.3.

12.4.5 REFERENCES

~~12.4-1~~ 124-1 Atomic Industrial Forum, Compilation and Analysis of Data on Occupational Radiation Exposure Experienced at Operating Nuclear Power Plants, September 1974.

~~12.4-2~~ 124-2 USAEC, A Compilation of Occupational Radiation Exposure From Light Water Cooled Nuclear Power Plant 1969-1973, WASH-1311.

~~12.4-3~~ 124-3 Wells, J. B., Collins, D. G., and Neuendorf, W. P., Boundary Dose Rates Due to Gamma Rays at Power Reactor Sites, Report RRA-7202, Radiation Research Associates (November 12, 1972).

124-4 Vance J, Weaver C. L., Lepper, E. M. A preliminary Assessment of the Potential Impact on operating Nuclear Power Plants of a 500 mRem Occupational Exposure Limit, Atomic Industrial Forum, Washington D. C. April 1978.

124-5 Murphy, T. D., Dayem, N. J., Bland, O. J., Pasciah, W. J., Occupational Radiation Exposure at light water cooled power reactor 1969-1975, VS. NRC, NUREG 0109, Washington D. C., April 1976.

124-6 Dickson, H. W., Cottrell, W. D., Jacobs, D. C., Application of ALAD concept to exposure of workers at light water reactors, 2 RNC, TM-5126, Oak Ridge Tennessee, November 1975.

124-7 Ninth Annual Occupational Radiation Exposure Report, USNRC, NUREG 0322, Washington D. C., October 1977.

TABLE 12.4-1

ESTIMATED ANNUAL DOSE TO PERSONNEL

		PLANT IN OPERATION					
		REACTOR BLDG.		TURBINE BLDG.		RADWASTE BLDG.	
Personnel Group	Number of People in Group	Occupancy Factor (hr/man/yr)	Personnel Dose (man-rem)	Occupancy Factor (hr/man/yr)	Personnel Dose (man-rem)	Occupancy Factor (hr/man/yr)	Personnel Dose (man-rem)
Maintenance Craftsmen (Group 1)	46	20	4.60	20	4.60	60	27.60
Operators (Group 2)	29	50	4.35	50	4.35	50	7.25
Technicians (Group 3)	8	50	1.20	50	1.20	50	2.00
Engineers (Group 4)	9	8	.22	8	.22	4	.18
Plant Supervision (Group 5)	14	35	1.46	35	1.46	30	2.10
Management (Group 6)	11	1	.03	1	.03	1	.05
TOTAL	117		11.86		11.86		39.18

All Table to be replaced with Attached

Table 12.4-1

SUMMARY OF

OCCUPATIONAL DOSE ESTIMATES

AT WNP-2

		Man Rem/Year
1. Routine Operation and Surveillance		38
2. Non-Routine Operation and Surveillance		15
3. Routine Maintenance		275
4. Waste Processing		11
5. Refueling		47
6. Inservice Inspection		129
7. Special Maintenance		98
	Total	613

Table 12.4-2

OCCUPATIONAL DOSE ESTIMATES DURING ROUTINE OPERATIONS AND SURVEILLANCE AT WNP-2

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Year
Walking	.5	.5	2	1/shift	.54
Checking					
a. Railroad Access Change Rooms Relay Room Motor Generator Sets Battery Room Computer Room Switch Gear Room Air Conditioning Equip. Recirc. Motor Gen. SGTS HPCI Turbine & Pump RBCCW Heat Exchangers Emergency Air Comp. RBCCU Pumps RRCCW Expansion Tank	1	1	2	1/shift	2.2
b. CRD Pumps CRD Hydrolic Control Units Refueling Flear CRD Filters RUCV Demmo Resin Tanks RNP Pumps SRMP Pumps Air Coolers IVST Racks CRD Storage & Repair	10	.5	.2	1/shift	11
c. RWCU Heat Exchangers RHR Heat Exchangers Acid Purple & Turbine	50	.1	1	1/shift	5.5

Table 12.4-2 (page 2)

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Year
hecking (cont'd)					
Demin Precoat Tank	0.2	0.5	1	1/shift	0.1
Precoat Pump					
Waste Sample Pump					
Floor Drain Sample Room					
Waste Surge Pump					
Equip. Drain Sump Pump					
Waste Surge Pump					
Equipment Drain Sump Pump					
Waste Precoat Pump					
Waste Sludge Discharge Pump					
Waste Filter Aid Pump					
Chemical Waste Pump					
Floor Drain Collection Pump					
Chemical Waste Tank	50	0.5	1	1/week	1.3
Spent Resin Pump					
Condensate Phase Decant Pump					
Condensate Phase Sludge Discharge Mixing Pump					
Floor Drain Demin.	8	2	1	1/week	0.8
Waste Hopper					
Floor Drain Filter					
Turbine Instruments & Controls	.5	1	2	1/shift	1.1
Gen. Co_2 Units					
Station Air Comp.					
Heater Feed Pumps					
Demineralize Pumps & Valves					
MTG Lubrication System					
Hatch Area above Demin Tanks					
H_2 Seal 2.1 Equip.					
Health Shell Pull Space					
TBCCW Heat Expansion & Pumps					

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Year
2. Checking (Cont.)					
h. TBCCW Expansion Tank Ventilation Equip. Demin. Precoat & Resin Tanks Demin. Precoat Pumps Sump Pumps Reactor Feed Pump Turbine Lub. System MTG Lub Oil Cooler Main Gen. & Exciter MTG Utilizer Activators Stop & Throttle Valves	5	0.3	1	1/shift	1.6
i. Heater Drain Pumps Heater Drain Flash Tanks Condense Water Box Circ. Water Isolation Valves Reactor Feed Pumps & Turbines Drain Coolers Med. Vacs Pumps Feed Water Heaters Reheater Seal Tank Gland Steam Condenser Main Turbine Reheater Separators	2.5	0.5	1	1/shift	13.7
				Total	37.8

Table 12.4-3

OCCUPATIONAL DOSE ESTIMATES DURING NONROUTINE OPERATION AND SURVEILLANCE AT WNP-2

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Year
1. Operation of Equipment:					
a. Traversing In-core Probe System	2	2	2	3/year	0.02
b. Safety Injection Sys	5	1	1	1/month	0.06
c. Feedwater Pumps & Turbine	1	1	1	1/week	0.05
c. Instrument Calibration	2	1	1	1/day	0.73
2. Collection of Radioactive samples:					
a. Liquid System	10	0.5	1	1/day	1.83
b. Gas System	5	0.5	1	1/month	0.03
c. Solid System	10	0.5	1	4/year	0.01
d. Radiochemistry	1	1	2	1/day	0.73
e. Radwaste Operation	3	8	3	1/week	3.75
f. Health Physics	5	2	2	1/day	7.30
				Total	14.5

Table 12.4-4

OCCUPATIONAL DOSE ESTIMATES DURING ROUTINE MAINTENANCE
AT WNP-2

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Numbers Of Workers	Freq.	Dose Man-Rem/Year
1. Minor Repairs Reactor Building	1	20	2	1/week	2.1
2. Ventilation & Air Conditioning	0.5	20	1	1/week	0.5
3. Control Rod Drive Repair*	15	200	6	1/year	18
4. Reactor Water Clean Up Pump*	180	35	3	1/year	19
5. Reactor Water Clean Up Valve & Heat*	110	45	6	1/year	30
6. Exchanger					
7. Residual Heat Removal System*	200	27	8	1/year	43
8. Safety Relief Valves	80	30	5	1/year	12
9. Main Steam Isolation Valves	75	100	6	1/year	45
10. Recirc. Pumps	200	50	3	1/year	30
11. Snubber Inspector & Repair	75	100	5	1/year	37.5
12. Misc. Turbine Bldg. Repairs	2	8	1	1/day	5.8
13. Reactor Feed Pumps & Turbine	2	40	2	6/year	0.96
14. Drain Coolers	2	40	2	1/year	0.16
15. Steam Jet Air Ejectors	2	40	2	2/year	0.32
16. Off Gas System	2	40	2	6/year	0.96
17. MTG Actuator	5	40	1	1/year	.24
18. Heater Drain Flash Tanks	2	40	1	1/year	0.08
19. Condensor Water Box	5	20	1	1/year	0.1
20. Annual Turbine Inspection	3	120	10	1/year	3.6
21. Misc. Radwaste Pump Repairs	5	40	2	6/year	2.4
22. Misc. Radwaste Valve Repairs	5	40	2	6/year	2.4
23. Filter & Demin.	65	30	3	1/year	5.9
24. Centerfuge	5	8	2	4/year	.32

Table 12.4-4 (page 2)

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Year
Mechanical (Cont.)					
5. Evaporation	85	50	3	1/year	12.8
6. Turbine Instr. & Control	2	10	1	1/week	1.0
7. Waste Solidification	2	40	2	2/year	0.32
8. Area Monitors	20	40	2	2/year	0.32
				Total	274.8

Table 12.4-5

OCCUPATIONAL DOSE ESTIMATES DURING WASTE PROCESSING
AT WNP-2

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Year
Radwaste Control Room	.5	8	1	1/shift	4.4
Sampling & Filter Changing	10	4	1	1/week	2.1
Panel Operator Insp. & Testing	1	2	1	1/day	.73
Operation of Waste & Packaging Equip.	2	16	2	1/week	3.3
				Total	10.5

Table 12.4-6

OCCUPATIONAL DOSE ESTIMATE DURING REFUELING AT WNP-2

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Year
Opening/Closing Reactor* Pressure Vessel	60	40	10	1/year	24
Fuel Preparation	10	24	2	1/year	0.48
Refueling *	10	100	15	1/year	15
Fuel Handling	2.5	100	4	1/year	1.0
Fuel Sipping	10	100	6	1/year	6.0
				Total	46.5

Table 12.4-7

OCCUPATIONAL DOSE ESTIMATES DURING INSERVICE INSPECTION AT WNP-2

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Year
1. Removal/Replacement of Insulation	150	40	4	1/year	24
2. Installation/Removal & Ladders	50	40	4	1/year	8
3. Inspecting Inside Dry Well*	150	80	6	1/year	72
4. Recorder Data	50	80	6	1/year	24
5. Inspecting Outside Dry Well*	5	50	2	1/year	.5
				Total	129

Table 12.4-8

OCCUPATIONAL DOSE ESTIMATES DURING SPECIAL MAINTENANCE
AT WNP-2

Activity	Ave. Dose Rate mRem/Hr.	Exposure Time Hrs.	Number Of Workers	Freq.	Dose Man-Rem/Ye
Sparger Replacement	800	60	5	Should not be necessary	—
CRD Replacement	260	35	5	1/year	45.5
Turbine Overhaul	3	250	20	1/5 year	3
Servicing In Detectors	15	50	3	1/year	2.3
Off Gas Charcoal Sys. Overhaul	100	100	2	1/20 year	1
Special Maintenance Reactor	150	100	4	1/10 year	6
Water Clear Up Sys.					
Misc. Piping Repair's	80	100	5	1/year	40
Total					97.8

(see Table 12.4-9)

TABLE 12.4-9

PERSONNEL EXPOSURE FOR SEVERAL BWR PLANTS

PLANT #3 RATED MWe: 640

CAL YEAR	PLANT AGE (YRS)	THERMAL MWD	DOWN HOURS	REGULARS* #	REGULARS MAN-REM	TOTAL MAN-REM
73	5	452,708	2263	142	551	1449
72	4	540,877	1548	108	399	651
71	3	486,380	1567	98	140	249
70	2	441,800	1687	88	48	64
69	1	49,806		69	7	13
68				67	.3	.3

PLANT #5 RATED MWe: 630

CAL YEAR	PLANT AGE (YRS)	THERMAL MWD	DOWN HOURS	REGULARS* #	REGULARS MAN-REM	TOTAL MAN-REM
73	4	457,173	2679	136	310	594
72	3	417,109	2678	130	218	305
71	2	381,082	2798	68	106	206
70	1	247,501	4487	69	26	62

* Regulars - Denotes the number of Regular (Non-Contractor) Plant Employees

TABLE 12.4-9 (Continued) Sheet 4

PLANT #13 RATED MWe: 652

CAL YEAR	PLANT AGE (YRS)	THERMAL MWD	DOWN HOURS	REGULARS* #	REGULARS* MAN-REM	TOTAL MAN-REM
73	3	58,082	8040	176	225	620
72	2	403,650	3960	232	255	595
71	1	463,000	3240	244	31	49
70		11,988				

* Regulars: Denotes the number of Regular (Non-Contractor) Plant Employees

TABLE 12.4-7 (Continued) Sheet 2

Plant #8 RATED MWe: U1 200
U2,3 800

CAL YEAR	PLANT AGE (YRS)	THERMAL MWD	DOWN HOURS	REGULARS* #	REGULARS* MAN-REM (all units)	TOTAL MAN-REM (all units)
73	14	U1 101,353	2332		576	909
73	4	U1 681,174	807			
73	3	U3 495,689	2577			
72	13	U1 156,783	1726	239	368	728
72	3	U2 432,725	3402			
72	2	U3 618,888	1144			
71	12	U1 99,078	3140	225	315	715
71	2	U2 364,023	2669			
71	1	U3 149,510	5944			
70	11	U1 198,835	498	202	127	143
69	10	U1 120,493	3292	182	215	
68	9	133,307	3177	189	303	
67	8	115,362	3855	170	363	
66	7	199,214	368	107	150	
65	6	138,149	1800	103	128	
64	5	138,688	1547	71	90	
63	4	130,757	1992	89	108	

* Regulars - Denotes number of Regular (Non-Contractor) Plant Employees

TABLE 12.4-9. (Continued) Sheet 3

PLANT #8 RATED MWe: U1 200
(Continued) U2,3 800

CAL YEAR	PLANT AGE (YRS)	THERMAL MWD	DOWN HOURS	REGULARS* #	REGULARS* MAN-REM (all units)	TOTAL MAN-REM (all units)
62	2	168,008	1716	182	86	145
61	2	72,403	4500		105	105
60	1	31,707			64	64

PLANT #9[1] RATED MWe: U1 800
U2 800

CAL YEAR	PLANT AGE (YRS)	THERMAL MWD	DOWN HOURS	REGULARS* #	REGULARS* MAN-REM	TOTAL MAN-REM
73	2	U1 646,112	970	259	142	201
73	1	U1 676,909	1074			
72	1	U1 110,733	3502	380	26	64
72		U2 205,080				

PLANT #10 RATED MWe: 548

CAL YEAR	PLANT AGE (YRS)	THERMAL MWD	DOWN HOURS	REGULARS* #	REGULARS* MAN-REM	TOTAL MAN-REM
73	3	405,000	2131**	105	91	156
72	2	445,000	1419	83	63	65
71	1	180,000	4367	82	27	29

**First six months only

* Regulars - Denotes the number of Regular (Non-Contractor) Plant Employees