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PLANT NAMES: H. B. Robinson

ENCLOSURES:
REPORT: Enviro Consequences of a Postulated Steam Line Break & Clad Flattening Analysis for the H. B. Robinson Unit No. 2.

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Carolina Power & Light Company

50-261

March 8, 1973

Mr. D. J. Skovholt
Asst. Director for Operating Reactors
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

H. B. ROBINSON UNIT NO. 2
LICENSE DPR-23
INTEGRITY OF STEAM GENERATORS UNDER ACCIDENT CONDITIONS

Dear Mr. Skovholt:

In response to your request of October 5, 1972, for additional information and analysis concerning the failure of steam generator tubes and fuel rod cladding during transients in the H. B. Robinson Unit No. 2 plant, we are submitting the final portion of the requested information, which will supplement and complete our submittal of October 27, 1972. In our previous submittal, we discussed the various mechanical tests which were performed on samples of steam generator tubing and showed that there would be no catastrophic failure of the tubes during a steam line break accident, thus preventing an increase in the consequences of such an accident. Subsequently, several hydrostatic tests were performed in accordance with Mr. Giambusso's request of November 24, 1972, the results of which were summarized in our submittal of January 29, 1973, and supported our contention that no catastrophic failure of the tubes would result from a pressure transient that would be experienced during a steam break accident and that no serious degradation of the tubes has been experienced since the tube plugging and inspection operations of May-June, 1972.

In the present submittal, the results of an analysis of the environmental consequences due to the steam line break is presented in the attachment assuming concurrently the maximum primary-to-secondary leak rate permitted under the interim operating conditions, which is 0.3 gpm in a steam generator. The number of fuel rods that experience collapse has been determined based on current Westinghouse analytical techniques summarized in WCAP-7984, and it is assumed that all of these rods fail during the transient and release their gap activities to the reactor coolant. Various other assumptions important to the analysis are tabulated, and the results show that the doses from this accident are well within the limits as defined in 10CFR100 (25 rem whole body and 300 rem thyroid site boundary dose).

1624

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The plant is currently operating at reduced power in anticipation of our upcoming refueling outage on March 16, 1973. At the present time, the primary-to-secondary leakage rate is at the lower limits of detection ($\leq$0.01 gpm) which implies no leakage. Also, at reduced power, the pressure transient due to a steam line break accident would not be as severe as at full power since the differential pressure between the primary and secondary systems is reduced. Thus, we conclude that there is no remaining unreviewed safety question with regard to a steam line break accident at Robinson, and that the occurrence of such an accident will not result in an undue risk to the health and safety of the public.

Very truly yours,

E. E. Utley
Vice President
Bulk Power Supply

DBW/za

Attachment

cc: Mr. B. J. Furr
Mr. N. B. Bessac
Mr. C. D. Barham
Mr. D. V. Menscer

Regulatory File Cy. 3/6/73

50-261

ENVIRONMENTAL CONSEQUENCES OF A
POSTULATED STEAM LINE BREAK AND CLAD FLATTENING ANALYSIS
H. B. ROBINSON UNIT NO. 2
CAROLINA POWER & LIGHT COMPANY

1627

ENVIRONMENTAL CONSEQUENCES OF A POSTULATED STEAM LINE BREAK

The consequences of the double ended rupture between the containment and the isolation valves of the largest steam pipe has been re-evaluated for the H. B. Robinson Plant using a suitably conservative analyses. These analyses result in boundary doses which conform to 10CFR100 with margin. The analysis includes the effects of steam generator tube leakage and failure of flattened fuel rods.

The postulated accidents involving release of steam from the secondary system will not result in a release of radioactivity unless there is leakage from the reactor coolant system to the secondary system in the steam generators.

A conservative analysis of the potential off-site doses resulting from this accident is presented with number of failed fuel rods as a parameter. This analysis incorporates assumptions of a range of defective fuel, and a given steam generator leakage prior to the postulated accident for a time sufficient to establish equilibrium specific activity levels in the secondary system.

The assumptions used to determine the equilibrium concentrations of isotopes in the secondary system are as follows:

1. The primary to secondary leakage in steam generators occurs when the reactor starts up, and the leakage remains constant during plant operation.

2. The primary to secondary leakage is evenly distributed in steam generators at 0.3 gpm total.

3. Primary coolant activity is associated with 1 percent defective fuel and is given in Table I.

4. The iodine partition factor is $\frac{\text{amount of iodine/unit mass steam}}{\text{amount of iodine/unit mass liquid}} = 0.1$[1] in steam generators. The iodine partition factor is $\frac{\text{amount of iodine/unit vol. gas}}{\text{amount of iodine/unit vol. liquid}} = 10^{-4}$[1] in the condenser.

5. No noble gas is dissolved or contained in the steam generator water; i.e., all noble gas leaked to the secondary system is continuously released with steam from the steam generators through the condenser off-gas system.

6. The blowdown rate from steam generators is continuous at 12.5 gpm per steam generator.

The following assumptions and parameters are used to calculate the activity releases and off-site doses for the steam line break accident.

1. Prior to the accident, an equilibrium activity of fission products exist in the primary and the secondary systems due to a primary to secondary leakage in steam generators.

2. The threshold for rod failure of flattened fuel rods for the over-power transient is taken to be above 1 kw/ft which corresponds to clad stress levels of approximately 60% of the yield stress. It is conservatively assumed in this analysis that all flattened rods fail.

3. Activity in the fuel rod gaps (Table 1) of those rods damaged as a result of the accident is immediately released to the reactor coolant system. This activity is assumed to be uniformly distributed throughout the coolant at that time.

4. Off-site power is lost for the first two hours following the accident, main steam condensers are not available for steam dump. After two hours, off-site power is restored and the condensers are available for cooling the plant.

5. Eight hours after the accident the residual heat removal system starts operation to cool down the plant.

6. The primary to secondary leakage is evenly distributed in the steam generators.

7. Defective fuel is 1 percent, 0.3 percent and 0.1 percent.

8. After two hours following the accident, no steam and activity are released to the environment through the unaffected steam generators. The steam and activity go to the condenser. After 8 hours following the accident, no steam and activity are released to the environment.

9. No air ejector release and no steam generator blowdown during the accident.

10. No noble gas is dissolved in the steam generator water.

11. The iodine partition factor is $\frac{\text{amount of iodine/unit mass steam}}{\text{amount of iodine/unit mass liquid}} = 0.1$[1] in the good steam generators.

12. The iodine partition factor is $\frac{\text{amount of iodine/unit volume steam}}{\text{amount of iodine/unit volume liquid}} = 10^{-4}$[1] in the condenser.

13. All noble gases leaking to the secondary side during the eight hours following the accident are released directly to the atmosphere.

14. In the affected steam generator, all iodine activity leaking to the secondary side during the eight hours is immediately released to the environment with a decontamination factor of 10.

15. During the postulated accident iodine carryover from the primary side in the two good steam generators is diluted in the incoming feedwater. All iodine activity carried over plus activity present in the steam generator water in the good steam generators is released to the environment via steam dump for the first two hours with a retention factor of 0.1.

16. The 0-8 hour atmospheric diffusion factor of 8.9×10^{-4} sec/m^3 at the site boundary and the 0-8 hour breathing rate of 3.47×10^{-4} m^3/sec are applicable.

17. In the affected steam generator, all the water boils off and releases through the break immediately after the accident. A decontamination factor for iodine releases is assumed to be 10.

18. It is conservatively assumed that the primary pressure remains constant at 2235 psig for 0-2 hours and decreases linearly to atmospheric from 2235 psig during the period of 2-8 hours. However, it has been assumed that the primary to secondary leak rate is constant at 0.3 gpm for the duration of the accident.

The whole body and thyroid doses for the steam line break accident at the site boundary as a function of number of damaged fuel rods are given in Figures 1 and 2. Based on an expected (235)[2] flattened rods at the end of Cycle 1 (see Section on clad flattening), the doses from this accident are well within the limits as defined in 10CFR100 (25 rem whole body and 300 rem thyroid site boundary dose).

CLAD FLATTENING ANALYSIS

MINIMUM TIME FOR CLAD FLATTENING

Using current Westinghouse analytical techniques (3) and operating conditions appropriate for the lead power rods in each region of H. B. Robinson No. 2, the minimum time to clad flattening is predicted for operation with a coolant system pressure of 2250 psia. The predicted times are:

Region 1 -	5,000	EFPH (4)
Region 2 -	10,000	EFPH
Region 3 -	11,000	EFPH

The plant is currently operating at 100% power (2200 MWt). The projected duration of Cycle 1 is 11,300 EFPH. It is predicted that clad flattening will occur in Region 1 during Cycle 1. Clad flattening is not expected in Regions 2 or 3 during Cycle 1 due to the conservation of the model.

The buildup of fission gas pressure with exposure was not included in the predictions above. In actuality this will reduce the pressure differential across the clad and should increase the minimum time to clad flattening. Recent data from Point Beach 1 indicate that the above predictions are conservative since no clad flattening was observed at 13,000 EFPH at Cycle 2 refueling ((12,000) (2) EFPH predicted) in Regions 2 and 3. Further evaluation of this conservatism is underway.

PREDICTIONS OF CREEP FLATTENING FREQUENCY

Creep flattening of fuel clad has been observed in the Ginna, and Point Beach 1 reactors. While there are various ways of correlating the flattening data, the data has been treated as the percentage of rods observed for a given region which contains flattened rods. It is implicit in this form of correlation that all rods observed in an indicated region had the same flux, temperature and axial gap conditions, have the same potential for flattening, and hence, can be treated as a single population.

The predictions of the time to flatten for the lead burnup rod has been used as a basis for scaling or normalization. The data for 94% TD fuel are plotted, in Figure 2.1, using a time scale relative to the predicted time to flatten for the lead burnup rod.

At the end of Cycle 1 a total of (235)[2] flattened rods are predicted.

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(1) M. A. Styrikovich, O. I. Martynova, K. Ya. Katkovska, I. Ya. Dubrovski and I. N. Smirnova, "Transfer of Iodine from Aqueous Solutions to Saturated Vapor", Soviet Atomic Energy, 17, 735-39 (1964).

(2) Westinghouse Proprietary Class 2

(3) G. Eng, et.al., "Fuel Densification Penalty Model", WCAP-7984, October, 1972.

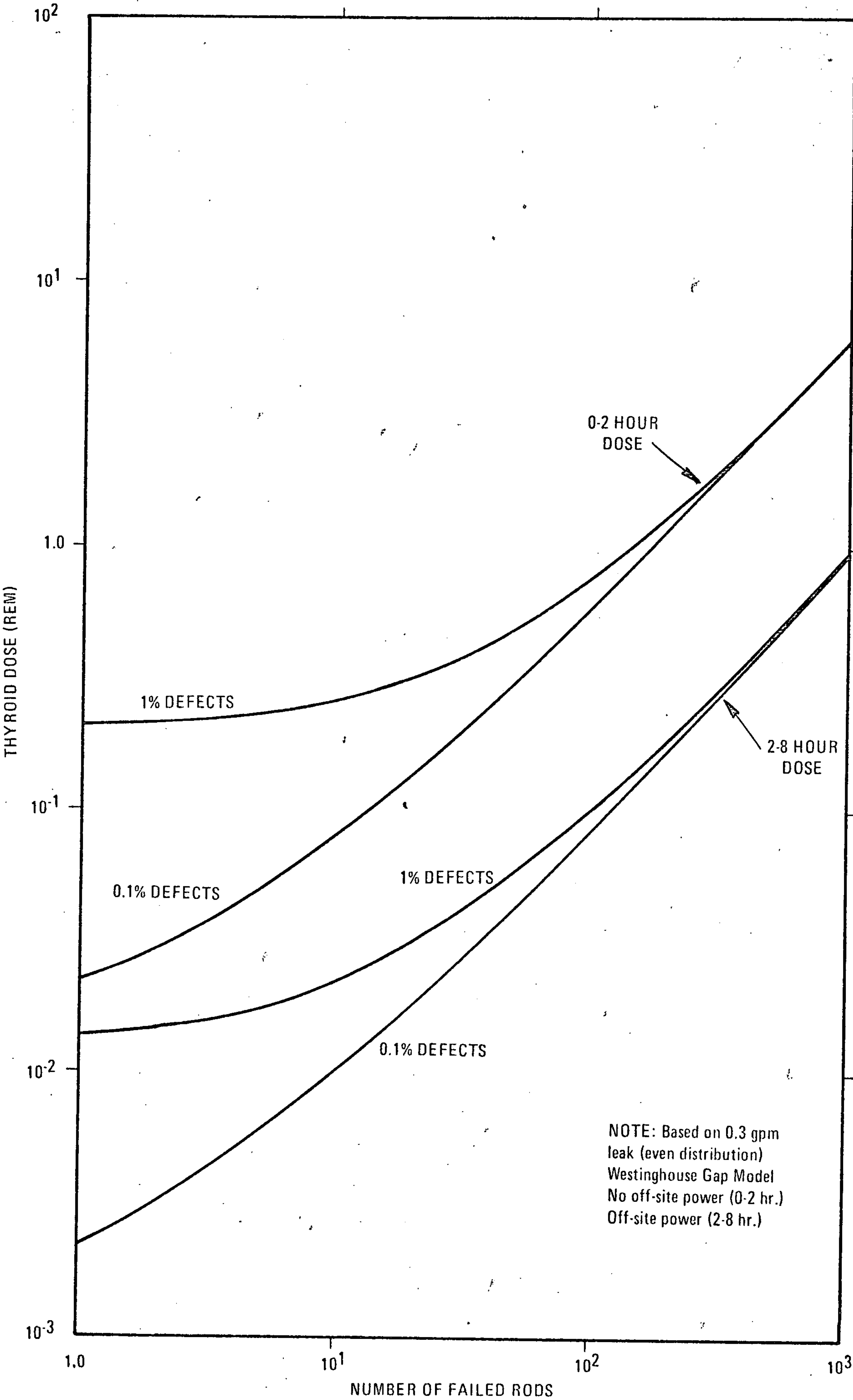
(4) EFPH = Effective full power hours, integrated flux equivalent to operating at 100% power at stated time.

TABLE 1

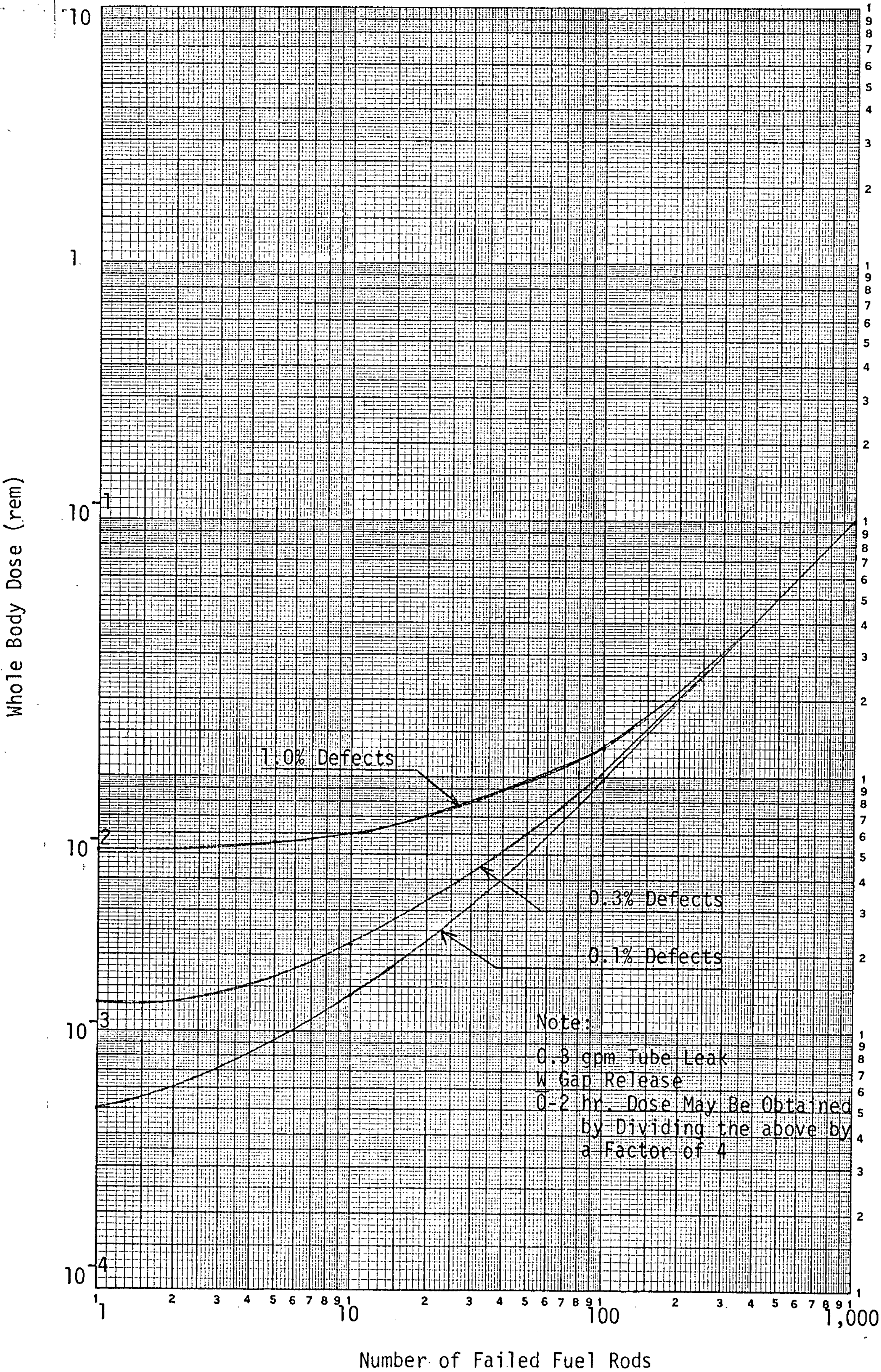
STEAM LINE BREAK WITH FUEL FAILURE - SOURCE TERMS

ISOTOPE	REACTOR COOLANT EQUILIBRIUM ACTIVITY WITH 1% FUEL DEFECTS (CURIES	W TOTAL GAP ACTIVITY (CURIES)	W GAP ACTIVITY PER ROD (CURIES/ROD)
I-131	3.51×10^{2}	1.02×10^{6}	3.18×10^{1}
I-132	1.37×10^{2}	1.73×10^{5}	5.40
I-133	5.91×10^{2}	7.66×10^{5}	2.39×10^{1}
I-134	8.86×10^{1}	1.85×10^{5}	5.78
I-135	3.32×10^{2}	3.98×10^{5}	1.24×10^{1}
Kr-85	8.12×10^{2}	1.55×10^{5}	4.84
Kr-85m	3.32×10^{2}	7.09×10^{4}	2.21
Kr-87	2.03×10^{2}	7.54×10^{4}	2.35
Kr-88	5.91×10^{2}	1.54×10^{5}	4.81
Xe-131m	4.43×10^{2}	9.48×10^{3}	2.96×10^{-1}
Xe-133	4.41×10^{4}	1.93×10^{6}	6.03×10^{1}
Xe-133m	4.98×10^{2}	3.22×10^{4}	1.01
Xe-135	9.60×10^{2}	1.45×10^{5}	4.53
Xe-135m	2.95×10^{1}	2.40×10^{4}	7.49×10^{-1}
Xe-138	1.07×10^{2}	8.19×10^{4}	2.56

H. B. ROBINSON
THYROID DOSE
STEAM LINE BREAK WITH FUEL FAILURE



H.B. Robinson
Whole Body Dose
Steam Line Break with Fuel Failure



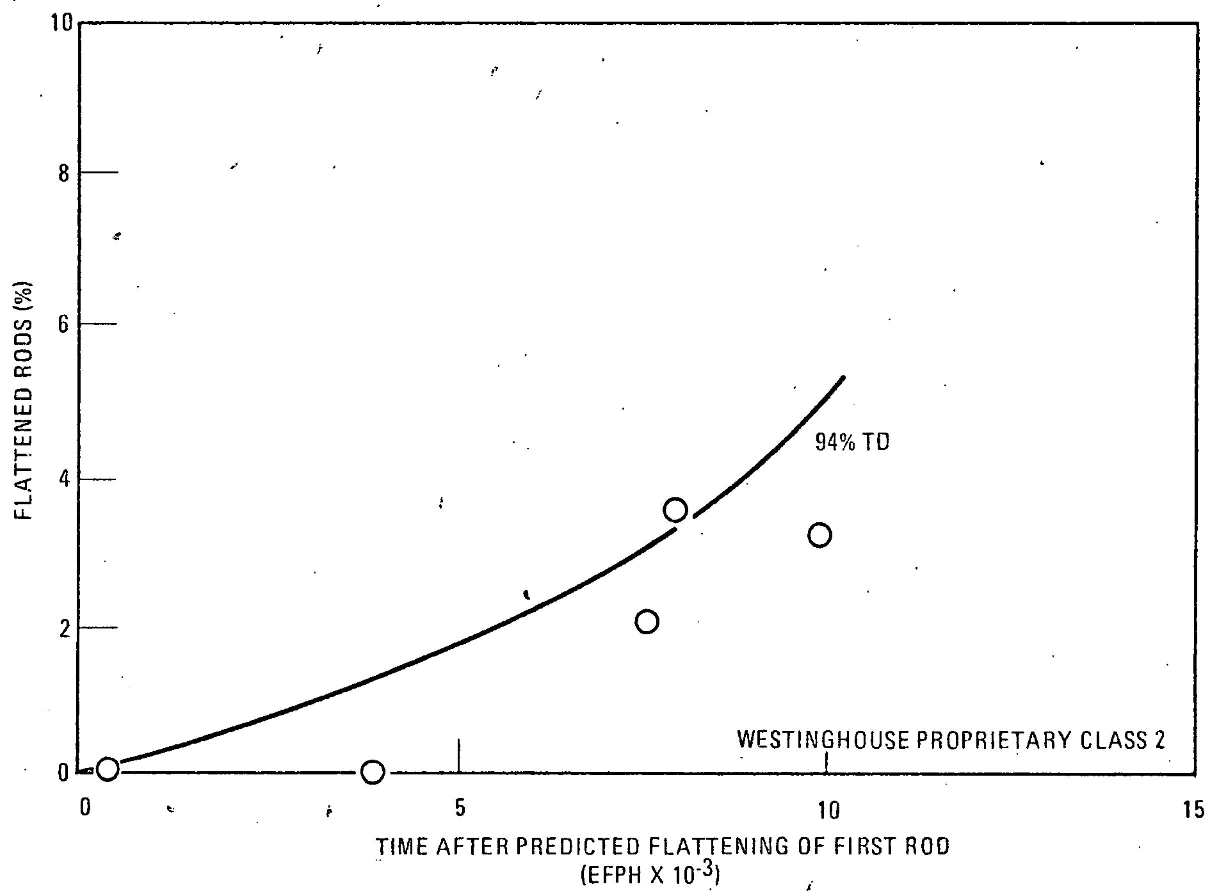


Figure 2.1 Flattening Frequency for Unpressurized Rods