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Memorandum

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THRU: Roger S. Boyd, Chief, Research & Power Reactor Safety Branch, Division of Reactor Licensing

FROM : J. T. Telford, Research & Power Reactor Safety Branch Division of Reactor Licensing J. J. Telford

SUBJECT: THE OFF-SITE CONSEQUENCES FOLLOWING A MCA AT INDIAN POINT #2 AS A FUNCTION OF FILTER EFFICIENCY AND A COMPARISON OF THE VIRTUAL SOURCE METHOD FOR CALCULATING BUILDING DISPERSION

50-247

Introduction

Due to the extreme conditions within the containment following a loss of coolant accident and the uncertainties of applying the experimental data relating to filter operation during these adverse conditions, I have attempted to show how the off-site consequences change with filter efficiency. The calculations that follow show that Part 100 could be met at the exclusion radius with a 30% filter efficiency and at the low population zone with a 45% efficiency.

The method of analyzing the effect of building dispersion was changed in the application for a construction permit from that submitted during the preliminary site review stage. The latest method (virtual source) is not as conservative and apparently has no experimental basis. The attached Figure 3 indicates how the dose vs. distance is calculated to be smaller for the virtual sources method.

Input information and assumptions

Power level - 2758 Mw
Fan - filter capacity 65,000 CFM
Emergency power operation - 4 of 5 fans
Total capacity - 1.56×10^7 $ft^3/hr.$
Recirculation rate - 5.97 containment volumes/hr.
Fraction bypassing filters - 10%
Reduction constant λ_f - (5.97)(.9)(filter efficiency)
Dose reduction factor - DRF = $\frac{h\lambda_f}{i - e^{-h\lambda_f}}$
Time interval under consideration - h hours
Unfilterable fraction - 5%
Fraction available for leakage - 25%

The leak rates, core inventory and other pertinent meteorological data can be found in the safety analysis report (PSAR) Section 12.

Discussion

By combining the above information with the data supplied in the PSAR the following equations can be obtained for the dose over a particular time interval:

$$D_2 = 1.342 \times 10^6 \, (X/Q)_2 \left(\alpha - \frac{1-\alpha}{DRF_2}\right)$$

$$D_{22} = 7.54 \times 10^6 \, (X/Q)_{22} \left(\alpha - \frac{1-\alpha}{DRF_{22}}\right)$$

$$D_{30} = 2.7 \times 10^7 \, (X/Q)_{30} \left(\alpha - \frac{1-\alpha}{DRF_{30}}\right)$$

α = unfilterable fraction

These are the integrated dose equations for 2 hr., 22 hr., and 30 days respectively. Note that X/Q is a function of distance, DRF depends on filter efficiency and they both vary with the time interval under consideration.

The attached Fig. 1 shows how the thyroid dose changes with distance and with filter efficiency for the first two hour period following the MCA.

Fig. 2 presents the accumulated dose received by a person exposed to all three of the time intervals i.e. it is a summation of the 2 hr., 22 hr. and 30 day doses. The X/Q values reported in the application for a preliminary site review were used to calculate these curves.

The three distances of particular interest are indicated on the attached figures 1 and 2. For the Indian Point #2 site the exclusion radius in 520 meters, the population center distance (boundary of town of Peekskill) is 1400 meters and the low population zone radius is1100 meters. The resulting thyroid dose at these distances can be obtained from the figures as a function of filter efficiency.

The Gifford and Fuguay model for determining (X/Q) has previously been used by applicants to account for building dispersion. Con. Ed. used this method for the preliminary site review, but switched to the virtual source method in the PSAR. The equations are written here to highlight their differences.

Gifford

$$X/Q = \frac{2}{u\,(nC_yC_zx^{2-n} + A)} \exp\left(\frac{-y^2}{C_y^2 x}\right) \bar{n}^{-2}$$

Virtual Source

$$X/Q = \frac{2}{u\; nC_yC_z(x + x_o)^{2-n}} \exp\left(\frac{-y^2}{C_y^2 x + x_o}\right)^{n-2}$$

Fig. 3 shows the 30 day integrated thyroid dose as a function of distance from the containment assuming a filter efficiency of 90%. Although the difference between the two calculations is not great (30% or less) there is apparently no experimental basis for using the virtual source model.

Conclusion

The filter efficiency necessary to meet the guidelines set forth in 10 CFR 100 can be obtained from the attached figures 1 and 2. The criteria requiring that the two hour exposure at the site boundary (520 m) not exceed 300 rem can be met with a filter efficiency of 30%. The filter efficiency must be 45% to meet the 30 day exposure of 300 rem at the low population radius (1100 m). Both of these valves change rapidly with containment leak rate and fraction of unfilterable iodine. For example, with a filter efficiency of 90% the 30 day dose increases from 225 rads to 380 rads when the fraction of unfilterable increases from 5 to 10%.

Figure 3 shows how the integrated dose increases with the fraction of unfilterable iodine. Also included is a curve showing the results obtained from the virtual source method compared with the Gifford method. Over the distances of primary interest the virtual source method predicts a lower dose. For example, at the site boundary the calculated dose is 20% lower than the Gifford calculation and at some distances is lower by as much as 30%. This model is more conservative within the exclusion radius however.

It is apparent from these calculations that the doses do not change appreciably with filter efficiencies in the range from 60 to 90%. This is primarily due to the rapid recirculation rate. The more important parameters to consider when calculating off-site doses are the fraction of unfilterable iodine and the containment leakage rate. Table 1 on the following page summarizes the pertinent information obtained from this calculation.

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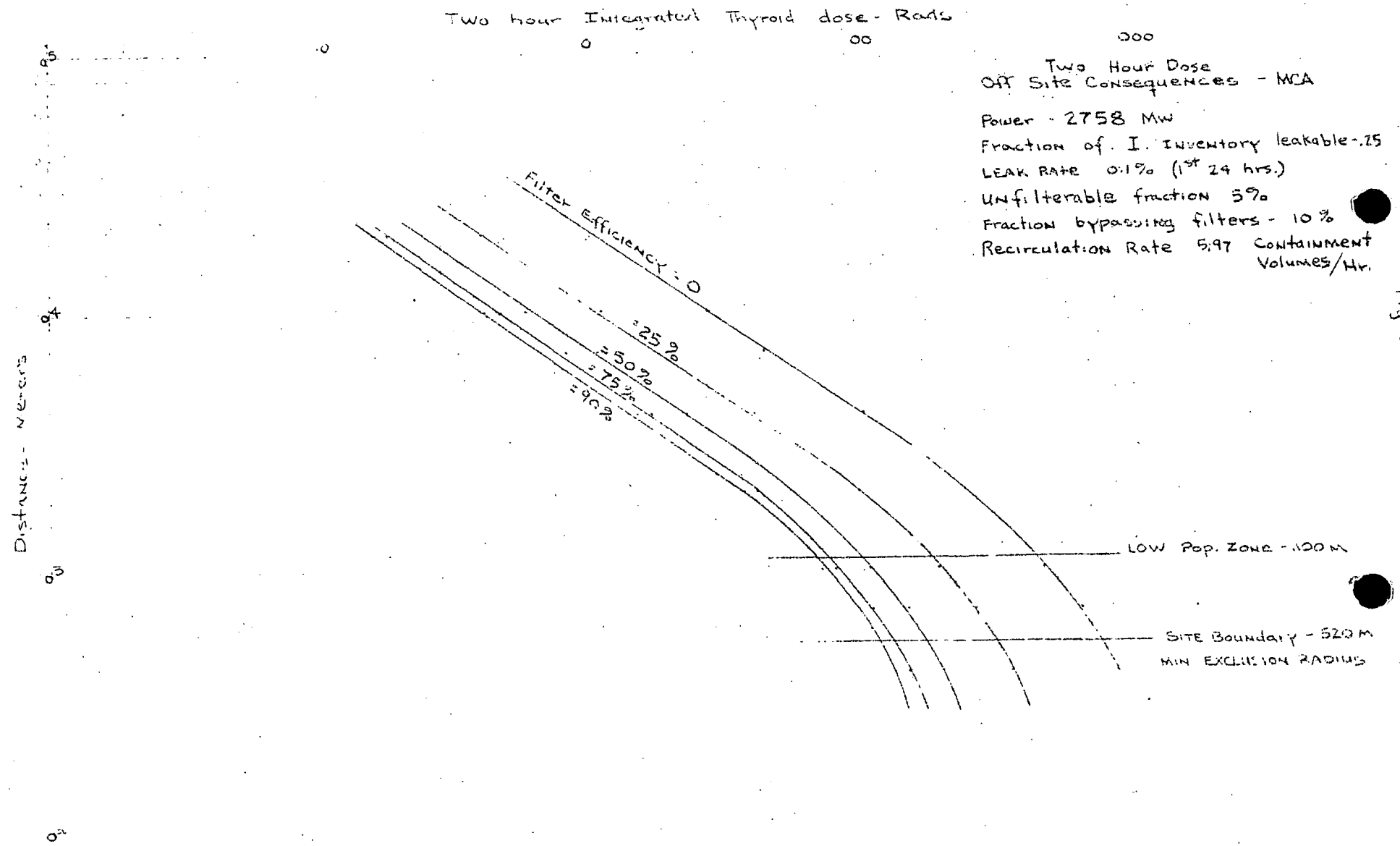
Table 1.

LOCATION	Calculational Model	Filter Efficiency	DOSE Rem to Thyroid 2 Hr.	DOSE Rem to Thyroid 30 day
Minimum Exclusion Radius 520 M.	Gifford & Fuquay	30	300	660
	" "	90	130	430
	Virtual Source	90	140	420
Low Population Zone 1100 M	Gifford & Fuquay	45	130	300
	" "	90	75	230
	Virtual Source	90	70	180

			Integrated Thyroid Dose Man-Rem
Population Center Distance 1400 M	Gifford & Fuquay	45	6×10^6
	" "	90	4.5×10^6
	Virtual Source	90	3.5×10^6



Two Hour Dose
Off Site Consequences - MCA

Power - 2758 MW
Fraction of I. Inventory leakable - .25
Leak Rate 0.1% (1st 24 hrs.)
Unfilterable fraction 5%
Fraction bypassing filters - 10%
Recirculation Rate 5.97 Containment Volumes/Hr.

Fig 1

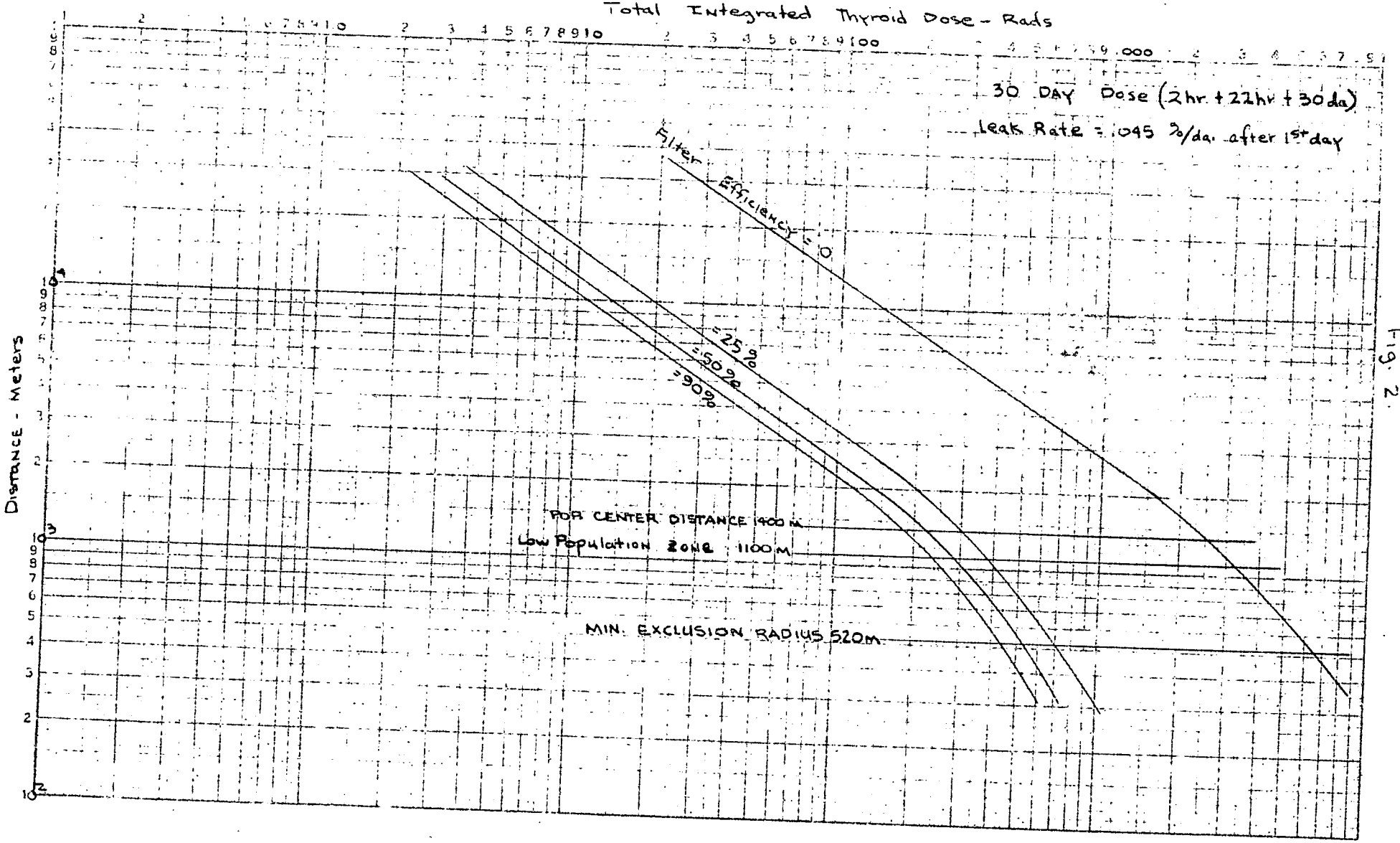
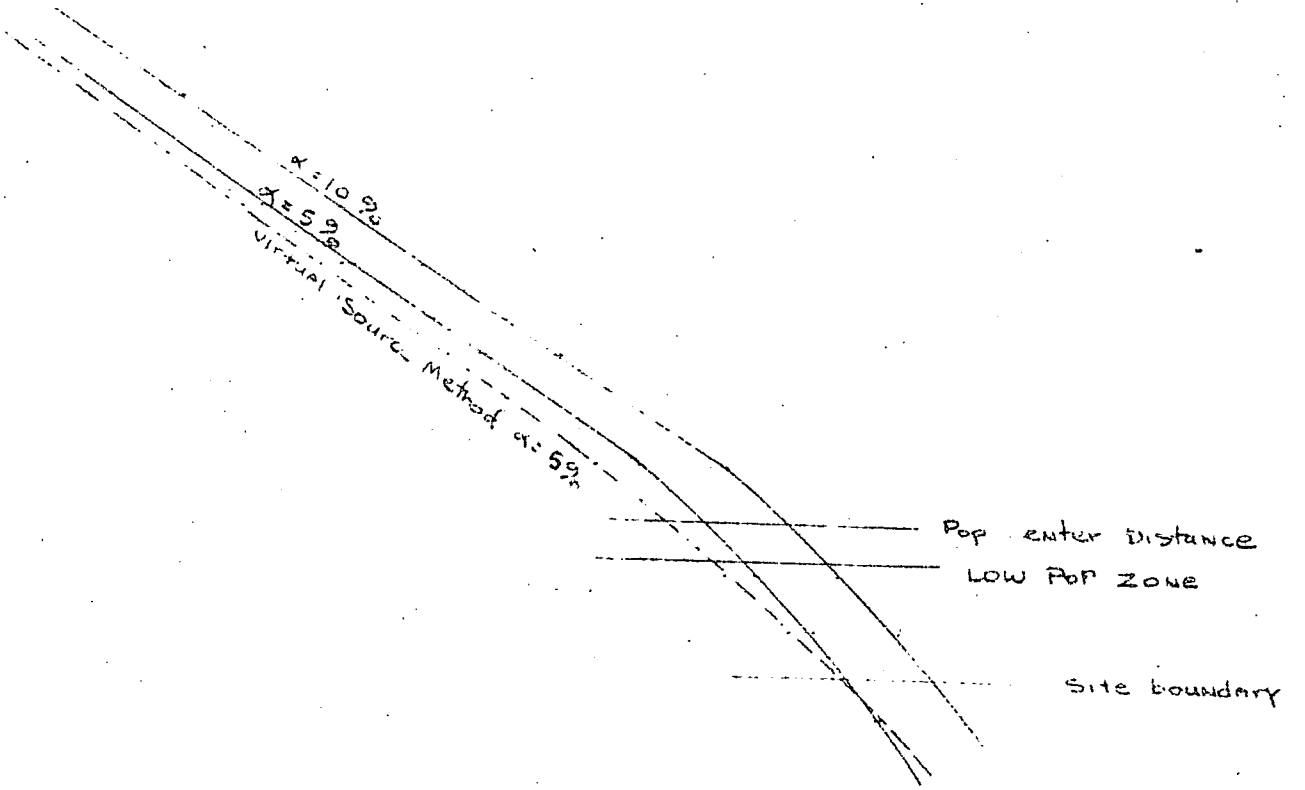

Total Integrated Thyroid Dose - Rads
30 DAY Dose (2hr + 22hr + 30da)
Leak Rate = .045 %/da. after 1st day
Filter Efficiency = 0
= 25%
= 50%
= 90%
FOR CENTER DISTANCE 1400 M
Low Population Zone 1100 M
MIN. EXCLUSION RADIUS 520M
Distance - Meters

Fig. 2


χ/Q 10 %
χ/Q 5 %
Virtual Source Method χ/Q 5%
Pop enter Distance
LOW POP ZONE
Site boundary