COST-BENEFIT ANALYSIS FOR IODINE FILTER INSTALLATION IN THE AUXILIARY BUILDING IN AN OPERATING PWR

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BACKGROUND

Following the TMI2 accident the installation of an iodine filter in the Ringhals unit 2 auxiliary building was considered by the Swedish State Power Board. Such a filter should as far as practically possible meet the requirements in Reg. Guide 1.52. Later on a filter was also demanded by the Swedish National Institute of Radiation Protection.

The preliminary design of a filter system was based on a reactor coolant activity level equal to the one obtained at TMI2. The leakage in the auxiliary building was assumed to be in accordance with the Technical Specifications for largest permissible leakage in isolation valves. Calculations indicated a cost of about 15 MSEK which raised the question whether an iodine filter would be cost-effective or not from a safety point of view.

At present the air from the auxiliary building is vented during normal operation and accidents through absolute filters out to the environment. These filters do not prevent the release of elemental iodine or organic iodide. Four alternatives were therefore considered:

1. Accept the present state of no iodine filter
2. Exchange existing absolut filters to iodine filter, which the ventilation air would by-pass during normal operation
3. Add a simplified iodine filter for accident conditions
4. Add an iodine filter largely according to R.G. 1.52 for accident conditions.

In alternative 2 the prevention of aerosol release (like caesium) is probably negligible. These four alternatives were investigated regarding cost and consequences of an accident of TMI-type. The methods and results are given in this paper.

ACTIVITY RELEASES OF A LARGE ACCIDENT

The conditions and assumptions of the TMI-type accident are as follows. The activity level in the reactor coolant is, according to TMI2 experience, for the important nuclides in this context:

Noble gases	100 % of core inventory
Iodine and caesium	50 % of core inventory

The largest permissable leakage flow according to Technical Specification is 45 cm^3/s. The time before isolation of the leakage is achieved is assumed to be 60 minutes. The activity leaked in this way to the auxiliary building is vented to the filters. However, due to steam condensation and deposition on walls, ventilation drums, etc. it is assumed that only 10 % of the iodine resp. 1 % of the caesium will reach the filter(s).

With these assumptions the activity to the filter(s) will be:

Noble gases:	4700 TBq (13000 Ci)	Kr-87 equivalents
Iodine:	109 TBq (2900 Ci)	I-131 equivalents
Caesium:	10 TBq (270 Ci)	of which 1.5 TBq from the isotopes Cs-134 and Cs-137

The dose calculations based on above releases (without regard to filter attenuation) showed that no acute effects were obtained. The dominating individual dose was as expected the thyroid dose to children, which was 1.5 Sv at 0.5 km distance. The results of the collective dose calculations (ref 1) are shown in Table 1. The thyroid dose from iodine is transformed to a weighted whole-body dose by multiplying the thyroid dose by a factor of 0.03 according to ICRP 26.

Table 1

Collective weighted whole-body doses from iodine (no iodine filter) and caesium (no absolute filter) with an accident of TMI-type and a simultaneous reactor coolant water leakage. 0-150 km.

	5% cumulative frequency (weather conditions)		50% cumulative frequency (weather conditions)	
	iodine	caesium	iodine	caesium
External gamma radiation and inhalation dose, mmanSv	9.3	0.17	1.1	0.020
Ground dose (30 years), mmanSv	1.2	3.2	0.14	0.39
Dose from foodstuffs (30 years), mmanSv	-	1.7	-	1.1
Total, mmanSv	10.5	5.1	1.2	1.5

At 5% cumulative frequency, there is a small gain if the absolute filter is exchanged for an iodine filter. This gain is uncertain, since it depends on a comparison between two nuclides which behaviour in the auxiliary building is different and uncertain. At 50% cumulative frequency, the caesium gives greater concequences.

IS THE IODINE FILTER COST-EFFECTIVE FROM A SAFETY POINT OF VIEW?

To estimate the cost-effectiveness of "back-fitting" an iodine filter the method recommended in NUREG-0880 (ref 2) was used. The collective dose due to the event is first calculated, and then multiplied by the probability of the event in order to obtain an expected value for the collective dose. The recommended cost is $ 100 000/manSv saved.

In this case, an accident of the TMI-type is assumed to occur once in every 1500 reactor years and the probability of an on-shore wind is c. 0.5. It is assumed that a leakage of 45 cm^3/sec exists from the beginning. Over 30 reactor years this gives a probability that the event will occur of 0.01 (=0.5 · 30/1500). Since this study a PRA of Ringhals unit 2 has indicated a much lower probability for an accident of TMI-type. Table 2 gives information on costs and consequences for the different alternatives.

DISCUSSION OF UNCERTAINTIES AND CONSERVATISM

The most important uncertainties are as follows:

- The assumptions that 10% of the iodine and 1% of the caesium activity leaking out into the auxiliary building will reach the filters are probably conservative.

- For the weather type, 5% cumulative frequency has been assumed. This means that the collective dose is normally lower.

- As regards collective dose calculations, the greatest uncertainties are in food intake and ground dose. As regards iodine, it is assumed that the milk in the contaminated area has been dumped.

- The probability of an accident of TMI-type is overestimated.

CONCLUSIONS

The conclusions can be summarized as follows:

- Alternative no 2 is excluded since in most cases this exchange gives a higher collective dose (see Table 1, 50% cumulative frequency).

- Alternative 4 involves a very large marginal cost by comparison with a simplified iodine filter according to the note in Table 2.

From a cost-benefit point of view, alternative no 1, no iodine filter is acceptable.

REFERENCES

1. The Collective Dose from an Accident of TMI-type at Ringhals 2. Investigation of the Importance of Different Filter Types (in Swedish). Studsvik Energiteknik AB NW-81/153 (1982)

2. NUREG-0880. Safety Goals for Nuclear Plants: A Discussion Paper, NRC (1982).

Table 2. Cost-benefit analysis of iodine filter plant from a safety point of view for different alternatives

	Cost Million SEK	Collective weighted whole-body dose (manSv)	Probability /30 years	Cost per saved manSv x probability (Million SEK/manSv)
Value recommended by NRC	-	-	-	0.8
1 No change		10.5	0.01	-
2 Exchange existing absolute filter for coal filter; by-pass during normal operation	2.5	5.1	0.01	46
3 Simplified iodine filter. No redundance	10	0.01	0.01	95
4 Complete iodine filter, largely according to NRC standards	15	0.01	0.01	140

<u>Note</u> Cost-benefit for alternative 4 by comparison with alternative 3 has also been investigated. Since there is no redundance in alternative 3, the probability of a loss of filter functions is $5 \cdot 10^{-3}$. The marginal cost/manSv saved will then be

$$\frac{15-10}{(10.5 - 0.01) \times 5 \cdot 10^{-3} \times 0.01} = 9500 \text{ million SEK}$$