THE RADIATION RISKS OF THE ACCIDENT SPECTRUM OF THE GREEK RESEARCH REACTOR

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ABSTRACT

The Greek Research Reactor is a 5MW swimming pool type reactor located within the Athens area, a large population center of 3081000 inhabitants. The consequence analysis of the reactor focuses on the risks stemming from reactivity, coolant flow blockage, and loss of coolant accidents. Individual doses are estimated to a distance of 20km from the reactor site. Collective exposure and latent health effects for the inhabitants of the region are also calculated.

INTRODUCTION

The Greek Research Reactor (GRR) is an open pool type, light water moderated and cooled reactor with MTR type fuel elements, currently fueled with enriched uranium, that contains about 93% of U-235. GRR is located on the edge of the Athens larger area, about 10km from the city center, an area that concentrates more than three millions inhabitants.

The safety analysis(1) of GRR is based on the study of its response to postulated disturbances in process variables, and to postulated malfunctions, equipment failures, and operator errors. Four general groups of accidents are considered in the safety analysis report, namely loss of flow accidents, reactivity accidents, loss of coolant accidents, and minor accidents. The accident consequence estimations were performed using a PC version of CRAC.IPTA, a code that is based on the CRAC2 code(2).

THE ACCIDENT SPECTRUM OF GRR

The first category of accidents considered in the safety analysis of GRR, includes accidents that cause a decrease of the removal rate of the heat produced in the reactor, such as primary pump failures, valve failures, partial flow blockage to fuel assemblies, loss of flow in the secondary cooling system, etc. Of all the accidents in this group the one with the potentially worst consequences is a coolant flow blockage accident (CFBA), that would cause a 50% failure of six fuel elements(3). The assumptions concerning the releases into the environment from this accident are the following(3): (a) 100% of the noble gases, 50% of iodines, and 1% of all other fission products of the melted fuel are released into the pool water, (b) 100% of the noble gases, and 10% of the remaining fission products in the pool water are released into the reactor building, (c) 100% of the noble gases, 10% of iodines, and 5% of the particulates in the reactor building are released into the environment through the system of absolute and activated charcoal filters, (d) the release to the environment occurs through the reactor stack with an effective height of 50m, and lasts for ten hours. Such an accident has already occurred in similar reactors, and it is considered as the most serious realistic accident that could potentially affect GRR.

The second group of accidents includes accidents that involve a sudden increase in reactivity, such as maximum startup accidents, reactivity insertion accidents, excursions following the decay of a Xe-135 transient, loading accidents, control rod failures, etc. The most serious accident in this category is the maximum reactivity insertion accident (MRIA), that would cause the melting of less than 2% of the reactor core. The assumptions concerning the associated release of radioactive substances into the environment are similar to those of the CFBA.

The third group includes accidents that cause a loss of coolant, that might occur after such events as the rupture of the pool wall, the failure of an experimental beam tube or the thermal column, and most importantly the rupture of the primary cooling system. This last case involving the guillotine break of the largest pipe of the primary system defines the design basis accident (DBA) of GRR, a postulated loss of coolant accident that limits the potential risk to the public from any credible accident and for which the engineered safety features of the reactor are designed. The following assumptions apply to the DBA(4): (a) 20% of the reactor core melts, (b) 100% of the noble gases, 50% of iodines, and 1% of all other fission products of the melted core are released into the environment, (c) the release into the environment occurs through leaks in the reactor building at ground level.

The fourth category includes accidents that have a minor impact, and do not lead to substantial releases that would affect adversely the general public. Such accidents are a fuel element cladding failure, the loss of ventilation in beam tubes and thermal column, the loss of primary electric power, etc. Since the consequences of such accidents are trivial they are not considered in the analyses performed.

RADIATION RISKS

The spectrum of accidents of GRR is delineated, as far as the consequences to the Athens population are concerned, by the three accidents CFBA, MRIA, and DBA, that are representative of the first three categories described previously. These consequences stem from both early exposure, i.e. direct irradiation by the passing cloud, exposure from inhaled radionuclides, and exposure to radioactive material deposited onto the ground, and chronic exposure, i.e. long-term groundshine from contaminated ground and inhalation of resuspended particles. Individual doses and cancer risks are estimated to a distance of 20km from the reactor site. Collective exposure and latent health effects for the inhabitants of the region are also calculated. The results are presented as dose curves for exposed individuals vs. distance from the reactor, or as complementary cumulative

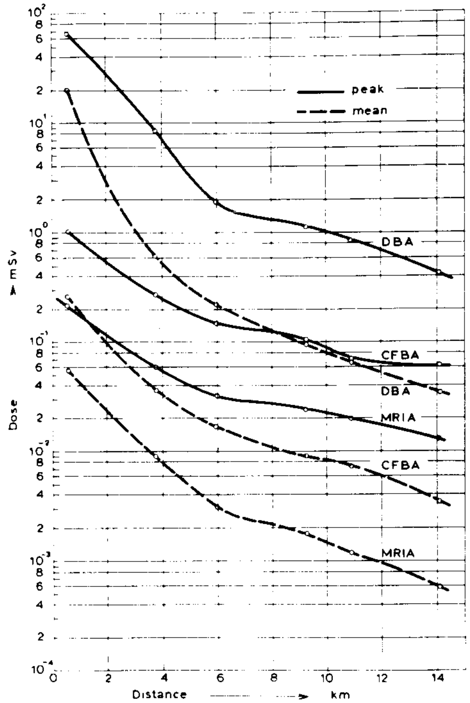

Fig 1 Acute Bone Marrow Dose vs Distance from Reactor

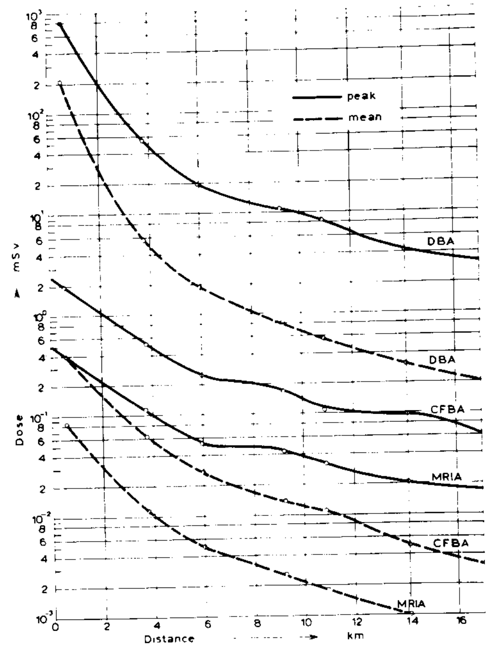

Fig 2 Acute Thyroid Dose VS Distance from Reactor

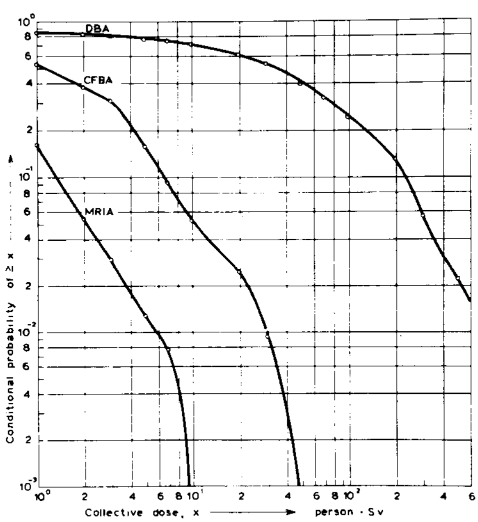

Fig 3 Whole Body Collective Dose CCDF

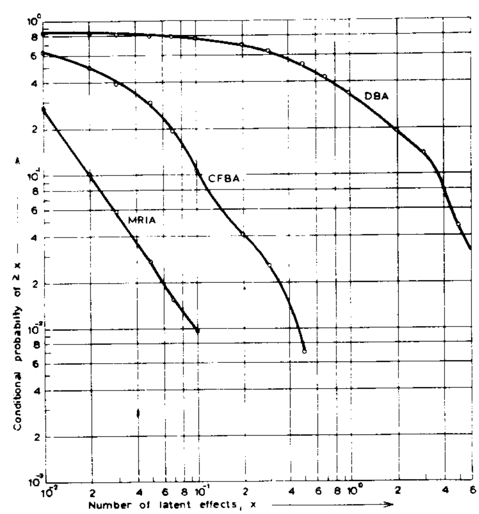

Fig 4 Whole Body Latent Effects CCDF

Table 1. Summary of number of latent effects - Total exposure

Effect	Mean Values			Peak Values		
	DBA	CFBA	MRIA	DBA	CFBA	MRIA
Whole body	1.28	0.0461	0.0092	20.5	0.864	0.180
Thyroid	37.2	0.289	0.0568	672	5.85	1.21
Leukemia	0.27	0.0093	0.0019	4.33	0.177	0.037
Lung	0.45	0.0084	0.0017	7.59	0.158	0.033
Breast	0.30	0.0112	0.0022	4.80	0.209	0.044
Bone	0.12	0.0037	0.0007	1.90	0.071	0.015
GI tract	0.10	0.0038	0.0008	1.63	0.070	0.015
Other	0.31	0.0113	0.0023	4.88	0.213	0.044
WB collective exposure (Sv)	81.1	2.92	0.582	1300	54.7	11.4

distribution functions (CCDFs) for collective exposure and health effects. The consequences of these accidents for the 3081000 inhabitants of the larger Athens area are presented in Figs. 1-4. Furthermore Table 1 presents a summary of the latent health effects that result from the total exposure of the Athens population.

CONCLUSIONS

The results presented in the previous section indicate that the consequences of the CFBA and the MRIA are negligible in comparison to the consequences of the DBA, being on the average about two orders of magnitude smaller.

It is important to note in Table 1 the small magnitude of the health effects associated with the realistic CFBA and MRIA, which amounts on the average to a very small fraction of an event , while even their peak values do not constitute any significant impact.

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