External Events and Probabilistic Safety Analyses of Bulgarian Nuclear Power Plant 'KOZLODUI'

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ABSTRACT

The paper discusses some problems in the probabilistic safety analyses - level 1 in case of external events for Bulgarian Nuclear Power Plant "Kozlodui".

1 INTRODUCTION

Bulgaria is one of the countries, using atomic energy for electrical production. About 30% from all electrical production is from the Nuclear Power Plant "Kozlodui". It's first unit was commissioned in 1974 and now four units with VVER-440 type reactors and one unit with VVER-1000 type reactor are in operation. The sixth unit with VVER-1000 is still under construction and will be commissioned in 1991.

2 EXTERNAL EVENTS FOR NPP "KOZLODUI"

The performance of probabilistic risk analysis for NPP "Kozlodui" started some years ago, but it is embarrassed by lack of data base about equipment failures, lack of experience in this area of analyses and also by lack of experience and possibility to use the modern PRA computer codes, wide-spread in the other countries.

Till now a list of so-called Initiating Events, which could trigger an accident has been compiled. Those events which are judged to have a similar effect on the plant are grouped into one of seventeen categories. The frequency of occurrence of each Initiating Event is evaluated, based on the available operational experience data (for example this frequency for loss of off-site power is 1,3 10^{-1}ev./year; for 4 out of 4 Main Coolant Pumps is 2,8 10^{-2} ev./year; for main steam collector break is 3,1 10^{-3} ev./year etc.). For some of the events categories, probabilistic analyses have been already performed and quantitative results such as probability of reactor core melting are obtained.

The external events are determined as once of the most significant initiating events for NPP "Kozlodui". In these analyses earthquakes, external fires and floods, chemical accidents and events when the river Danube iz frozen up (the service water for NPP "Kozlodui" is from Danube) are

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considered.

Bulgaria is a country with relatively high seismic activity. 165 earthquakes with magnitude M $\geq$ 4 and intensity $I_0 \geq$ IX (scale MSK) are registered in the period between 1900 and 1970 years {1}. The NPP "Kozlodui" is situated in a seismic area with intensity I_0 = VII. The expected frequency of occurrence of an earthquake with M $\geq$ 7 is evaluated as 5.10^{-3} ev./year.

The service water for NPP "Kozlodui" cooling is provided by the river Danube. The reliable work of the service water system is needed for the normal operation of the NPP. It is analysed that in case of long - term freezing of the river there may be difficulties in service water system operation, even the service water may be lost. The frequency of this external event is $1{,}34\ 10^{-1}$ ev./year (the statistical data are for 52 years, and only the freezings with more than 10 days duration are considered {2}).

In case of loss of service water the time delay due to the existent service water pools is also taken into account.

The analysis of the statistical data for the other external events shows that their frequencies of occurrence are negligible (Table 1.).

Table 1. Frequency of occurrence of external events for Bulgarian NPP "Kozlodui"

Event	Frequency, ev./year
River freezing	$1{,}34 \times 10^{-1}$
Earthquake	$5{,}0 \times 10^{-3}$
Floods	$1{,}0 \times 10^{-5}$
Fire	$1{,}0 \times 10^{-7}$
Aircraft accident	1.0×10^{-9}
Chemical accident	-

In further analyses of the potential consequences which result from the earthquakes and freezings events some difficulties are found in accounting the common cause equipment failures. In order to deal with these problems a combination of two probabilistic methods is proposed - fault tree method and Markov models.

Each of them may be used at differnt levels of the probabilistic safety analyses and thus the whole estimation process may be improved. For fault tree analyses available PSA computer codes as FTAP and TREE MASTER are used{3} and an attempt to computerize some Markovian evaluations is performed.

The obtained results for the reactor core melting probability, in case of external events for NPP "Kozlodui" will be published soon, after necessary verification and analyses.

The world practice shows that the Probabilistic Safety Assessment is used in many countries, when NPP safety problems are discussed. This approach for safety analyses will be wide used in Bulgaria too, especially for the planned forthcoming reconstruction of the first four units of the NPP "Kozlodui".

Full probabilistic risk analyses for all selected Initiating Events is the aim of the further investigations.

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