Probabilistic safety assessment applied to research reactors

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This report presents a Probabilistic Safety Assessment (PSA) and an uncertainty modeling review of a fuzzy approach applied to the Greek Research Reactor (GRR - 1) of the National Center for Scientific Research ''Demokritos'' [1]. The work was performed as part of the Probabilistic Safety Analysis (PSA) for the Research Reactor [2] in view of the development of new research reactors for radioisotopes production. As it occurs in any reliability study, statistically non-significant events report add a significant uncertainty level in the failure rates and basic events probabilities used on the Fault Tree Analysis (FTA) and in the probabilities of the End State sequence in the Event Tree (ET) analysis. In order to model this uncertainty, a fuzzy approach was employed to reliability analysis of the GRR -1 Loss of Coolant Accident (LOCA) as the Initiator Event (IE). As a case example, a guillotine rupture of the largest (10'') pipe connected to the bottom of the reactor during full power operation is assumed as the initiator event. The final results have revealed that the proposed approach may be successfully applied to modeling of uncertainties in safety studies. In the Figure 1 is showed the lower bound and upper bound ranking to fuzzy top event considering the Fault Tree full and with Minimal Cut Set (MCS). MCS results are presented for only one of front line system introduced at Event tree, Reactor Protection System (RPS).

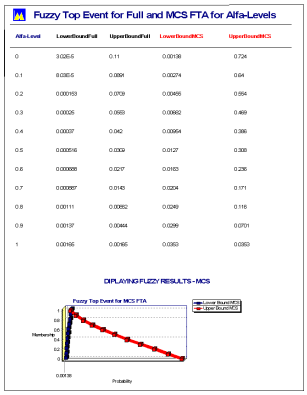

Figure 1. Ranking to fuzzy top event

In the Figure 2 is showed the RPS fuzzy results (importance and uncertainty for each basic event to general system) and the graphic representation of these results, using FT with Minimal cut set.

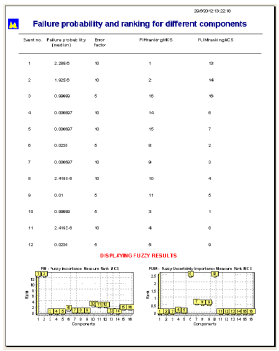

Figure 2. Ranking of components

Substituting the values of probability and performing fuzzy operations of subtraction, and multiplication, it could be found final values shown in the Table 1 for fuzzy probabilities.

Table 1 - Frequency of Release - EndState of the Event Tree

No.	End State Fuzzy Frequency
1	(1 1 1)
2	(2.38E-08 1.14E-06 1.52E-05)
3	(3.22E-11 4.92E-09 2.40E-07)
4	(2.41E-11 1.20E-10 6.00E-08)
5	(2.43E-08 1.28E-06 8.05E-05)
6	(4.89E-04 1.29E-06 4.11E-6)
7	(6.61E-14 5.57E-11 6.37E-08)
8	(4.96E-16 4.94E-15 4.15E-09)
9	(1.65E-08 4.23E-06 8.68E-04)
10	(2.23E-11 1.82E-08 1.34E-05)
11	(1.39E-13 4.87E-10 8.77E-07)
12	(3.31E-11 4.23E-08 3.62E-05)
13	(4.47E-14 1.82E-10 7.75E-07)
14	(3.31E-16 4.87E-12 4.34E-08)
15	(4.96E-02 4.53E-08 6.99E-05)
16	(4.53E-14 1.94E-10 9.03 E-07)
17	(2.80E-16 4.05E-10 6.71E-08)

Improvements could be developed in new projects of research reactors for the radioisotopes production, using this concept to increase the reliability of the project.

References

[1] Aneziris, O.N., Housiadas, C., Stakakis, M., Papazoglou, I.A. Probabilistic safety analysis of a Greek Research Reactor, Annals of Nuclear Energy 31 (2004) 481–516.

[2] Guimaraes, A.C, Moreira, M.L., PS Assessment Applied to Research Reactors. In: Amir Zacarias Mesquita. (Org.). Current Research In Nuclear Reactor Technology in Brazil and Worldwide. 1ed.Rijeka: InTech, 2013, v. 1, p. 125-149.