Fuzzy uncertainty modeling applied to AP1000 NPP LOCA

A. C .F. Guimarães[1], C. M. F. Lapa[1,2], F. F. L. A. Simões[1], D. C. Cabral[1].
e-mail: tony@ien.gov.br

[1] *Division of Nuclear Engineering - IEN*
[2] *PPGIEN – IEN*

Keywords: fuzzy, NPP, PSA, uncertainty

This report presents an uncertainty modeling study using a fuzzy approach applied to the Westinghouse advanced nuclear reactor. The AP1000 Westinghouse Nuclear Power Plant (NPP) is provided of passive safety systems based on thermo physics phenomenon that requires no operator actions soon after an incident has been detected. The use of advanced passive safety systems in NPP has a limited operational experience. As it occurs in any reliability study, a statistically non-significant events report introduces a significant uncertainty level about the failure rates and basic events probabilities used on the fault tree analysis (FTA). In order to modeling this uncertainty, a fuzzy approach was applied in a reliability analysis of the AP1000 large break Loss of Coolant Accident (LOCA). Based on Silva (2005) [1] and Schultz (2006) [2], we performed an AP1000 LOCA reliability study.
In the Figure 1, it is showed the general view of the operation site of AP1000 plant. In Figure 2, it is showed the Safety Injection Passive System and Reactor Cooling System.

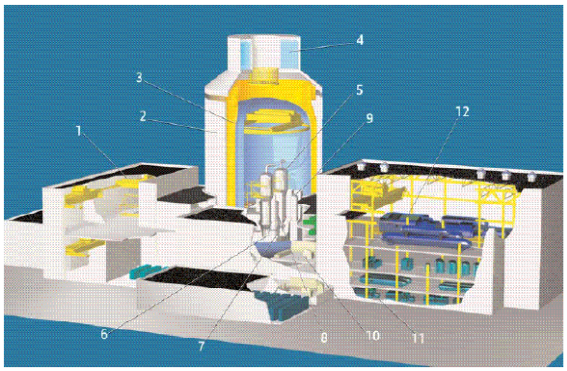

Figure 1. General view of nuclear site area of AP1000 reactor.

In each system also allows us to evaluate the upper and lower bound of the fuzzy sets corresponding to AI top event, LPI top event,

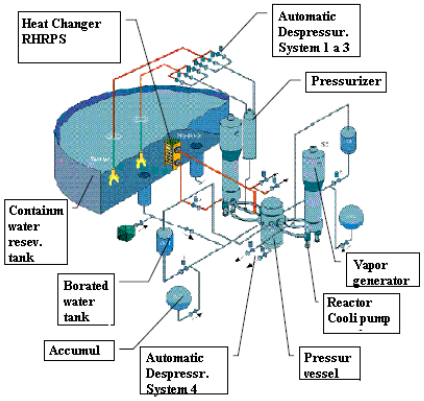

Figure 2. Safety Injection Passive System and Reactor Cooling System

Table 1. The Systems Fuzzy Sets plus Fuzzy LTC top event and the AP100 reactor LOCA fuzzy core melt frequency.

System / probability	Lower bound	Upper bound
AI top event probability	7.59 E-7	7.59 E-5
LPI top event probability	9.69 E-13	9.71 E-7
LTC top event probability	2.21 E-14	5.81 E-9
Fuzzy core melt frequency (CMF) by year	***4.69 E-13***	***9.71 E-7***

The uncertainty evaluation presented here allows us to propose the use of this methodology as an alternative approach to be applied in probabilistic safety assessments, particularly in cases where relevant operational data records are not available. [3]

References

[1] Silva, G. F., 2005. Estudo de Confiabilidade do Reator AP1000 para o Cenário de um Grande LOCA no Contexto de uma APS nível 1, UFRJ – COPPE, Master Thesis published in Portuguese.
[2] Schultz, T.L. Westinghouse AP1000 Advanced Passive Plant. Nuclear Engineering and Design, v. 236, pp. 1547-1557, 2006.
[3] GUIMARAES, A. C. F. ; LAPA, C. M. F. ; CABRAL, D. C. ; SIMOES FILHO, F. F. L. . Fuzzy Uncertainty Modeling Applied to AP1000 Nuclear Power Plant LOCA. Annals of Nuclear Energy, v. 38, p. 1775-1786, 2011.