NUCLEAR EUROPE WORLDSCAN

PSA results & trends for Spain's NPPs

*by J.A. Carretero**

In 1983, the Consejo de Seguridad Nuclear (CSN) – the Spanish nuclear safety regulatory body – requested the utility owner of Santa Maria de Garoña NPP to do a Probabilistic Safety Analysis (PSA) on his plant. This was to analyze its overall safety and facilitate decisions regarding design modifications to be implemented as part of the safety reassessment being performed after three years of operation. This PSA was required to be Level 1 and did not take into account external initiating events.

The CSN subsequently prepared an "Integrated Program for Performance and Use of PSA in Spain" so that all the Spanish NPPs could benefit. This programm was sent for comments to all interested Spanish organizations, and was approved by the CSN in June 1986 after incorporation of the accepted comments.

PSA program development

Since then, the CSN has demanded the performance of PSAs for all of the country's operating NPPs, with progressively larger scope.

In parallel with the PSA, the CSN urged the development of a data bank to store the experience gained on operating incidents and component and system failures at Spanish NPPs.

The Table gives the main characteristics of PSAs completed to date or in the process of development.

It can be seen that, at Trillo NPP (the latest required to undergo a PSA), the scope of study demanded is the widest foreseen within the CSN program. In future, therefore, the other NPPs would need to complete the scope of their PSA to reach the level set for Trillo.

Once the Trillo PSA is completed, every Spanish nuclear station will have a quantitative model of facility safety.

The general features of the PSA organizational structure are:

- direct management of the project by the utility owner;
- sufficient technical participation by the utility owner to provide him with thorough knowledge of the models developed and techniques applied;
- an interactive review by the CSN of PSA tasks carried out, as the project advances, to guarantee that the PSA has been done in keeping with the requirements established for it;
- a task force with technical experience in both PSAs and the project in general;
- an internal review of the project to guarantee its technical quality.

The Table shows that leading Spanish architect-engineers involved in the plant design have pooled their experience in these task forces.

For performance of the first PSAs, expert advice was sought from consultants for probabilistic techniques. Practical experience subsequently acquired in doing the PSAs, together with interactive review by the CSN, led to development of a specific PSA methodology and highly detailed models which incorporate the methodological advances made in the various disciplines of a PSA during similar programs or studies carried out in other countries.

A large volume of human resources has been assigned to develop the program, because of the level of detail of the models and the scope of the studies.

For example, in all the PSAs a specific plant data analysis has been performed to obtain the frequencies of initiating events and also unavailabilities due to maintenance or testing, or failure probabilities/rates of numerous types of components. This is because the launching and development of a national data base was out of step with performance of the first PSAs, and it was therefore necessary to carry out data analysis at the same time.

PSA development results

The first conclusions obtained from the PSAs carried out refer to evaluation of the importance of certain aspects prior to commencing a PSA:

- clear definition of the objectives to be met with the PSA models;
- definition of the scope and level of detail required to fulfil the objectives;
- realistic planning of the project in accordance with the scope, level of detail and available human resources;
- organization of the project team, assigning the appropriate human resources according to plant characteristics.

Successful fulfilment of the expectations held at the time it is launched depends on whether the PSA is capable of effectively dealing with these aspects.

The somewhat theoretical nature of the first probabilistic studies is not advantageous when developing the PSAs with the aim of allowing the maximum possible applications in keeping with the state of the art and providing feedback to the project, procedures and operation practices with the conclusions obtained.

In this context, the PSA results should be suitably interpreted taking into account the various uncertainties of modeling. This calls for appropriate integration of the factors involved in safety of the facility; design and operation. Consequently, the participation of personnel familiar with actual operation of the plants analyzed is of prime importance, as this would contribute to reducing the uncertainties of modeling presented in other PSAs as a result of a weak relation between the Task Force and Plant Operation.

PSA task development: conclusions

The specific data analysis carried out as part of the PSA has contributed to providing a realistic view of the results which could be achieved from a PSA. Without this knowledge, the theoretical development of failure tree models and the theoretical analysis of their results could lead to an unrealistic evaluation of its results. Extensive use of the national data base in the future will permit the use of the maximum number of

* José A. Carretero, manager of studies & reliability section, Empresarios Agrupados, C. Magallanes 3, E-28015 Madrid.

possibilities of the models developed to date.

At modeling level, the importance of having sufficient detail should be pointed out. This will assist in evaluating, from the probabilistic perspective, the suitability or inadequacy of the test or periodic inspection procedures and of the maintenance needs that could have a significant influence on plant risks which could only be evaluated through a PSA with a sufficient level of detail.

In modeling, emphasis is also placed on detailed representation of all the functional dependencies presented by the systems (actuation logics, room and equipment cooling, etc.). When evaluating the complete range of possible initiating events to be considered in the PSA, particularly common-cause initiating events, certain design limitations with obscure functional dependencies usually exist and only come to light through a quantitative analysis such as the PSA. Very often, the discrepancies observed in the results of different PSAs on the same plant are due to not considering such functional dependencies in the same degree of detail, and therefore their importance should be emphasized when the PSA is required to be a product which may serve to take decisions on design.

The identification of initiating events and success criteria ("plant familiarization") is usually a critical task in a PSA, as it conditions the scope of subsequent tasks. Inadequate identification of initiating events, especially those which present a functional impact on the mitigation systems, can lead to optimistic conclusions on the plant's safety.

As regards external events (fires, floods, earthquakes, etc.), the fact that in Spain the PSAs have been developed for plants of different generations, has revealed the importance of changes in standards for subjects such as fires.

While state-of-the-art techniques present certain limitations, it must be mentioned that the external event analysis in a PSA is capable of providing an integral evaluation of the various aspects of hazards affecting safety – an essential evaluation for facilities developed with outdated standards and subjected to a process of reevaluation or backfitting, where fires are dominant in overall plant risk.

Main characteristics of Spanish PSAs

NPP	Started	Status	Scope	Project team structure
Santa María de Garoña	1984	Finalized	Level 1	Nuclenor, INITEC, ETS Ingenieros Caminos Santander
Almaraz	1987	Approved	Level 1, fires, plant specific data	A.M. Almaraz, Empresarios Agrupados, UITESA
Ascó	1988	Finalized	Level 1, fires, internal floods, plant specific data	A.N. Ascó, INYPSA, INITEC, Empresarios Agrupados
Cofrentes	1989	Finalized	Level 1, fires, internal and external floods, plant specific data	Iberdrola, Empresarios Agrupados, UITESA
José Cabrera	1990	Development	Level 2, fires, internal and external floods, plant specific data	Unión Fenosa, UFISA, Empresarios Agrupados
Vandellós-2	1991	Development	Level 2, fires, internal and external floods, earthquakes, plant specific data, other modes of operation	A.N. Vandellós 2, Iberdrola Empresarios Agrupados, UITESA, UNITEC
Trillo	—	To be started	Level 2, fires, internal and external floods, earthquakes, other external hazards, plant specific data, other modes of operation	—

Spanish PSA trends

Expected trends in development of the PSA program are its conclusion in the maximum scope currently envisaged and the extension of the scope of the PSAs already carried out to the maximum indicated. Development of a PSA program such as the one described called for specific training of a large number of technical personnel to perform and license the PSAs.

On finalizing each project, a small but permanent technical group remained, with sufficient know-how of the entire project to enable it to form its own PSA applications, which came to be known as living PSAs and which complement the conclusions obtained in the initial study as they constitute yet another tool for safety analysis, fully integrated with other design activities.

In this respect, the quantitative models will provide a unique perspective of quantitative evaluation of operational experiences, complex functional dependencies, severe accidents and accident management, aging processes, common-cause failures, plant procedure modifications, technical specification requirements and several other subjects in which the PSAs have been recognized as a sound complementary tool for deterministic safety analyses. ■

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