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**FRENCH 900 MWe PWR PSA PRELIMINARY RESULTS**

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FRENCH 900 MWe PWR PSA  
PRELIMINARY RESULTS

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Abstract

A PSA is performed by the Safety Assessment Department of CEA for a 900 MWe standardized plant.

The paper presents the objectives, the scope of the study and the relative preliminary results. Some general insights are drawn, especially the benefit related to the implementation of emergency procedures.

1. Objectives

The general objective of the PSA performed by the CEA/IPSN is to provide the Safety authorities with an aid for making decision in case of problems which can be stated in term of relative or differential risk assessments.

For example :

- technical specifications,
- priorities for plant modifications,

- improvement of emergency procedures,
- severity of incidents.

Moreover the PSA will be an aid for the periodic reassessment of 900 MWe plants safety.

## 2. Organization

A preliminary phase of the study was performed by the Safety Department of CEA with the participation of FRAMATOME, for some specific issues.

An external review is conducted by EDF. Moreover the PSA performed by EDF for a 1300 MWe PWR is reviewed by CEA/IPSN.

The provisory phase will take into account the insights drawn from this crossed review and the improvements which appeared as necessary during the preliminary phase.

The final phase of the study, mainly devoted to the presentation of the results, is planned for 1989.

## 3. Main options

- Reference plant : the reference plant is a standardized 900 MWe PWR of the CP1-CP2 series. 34 similar plants are presently in operation in France. A standardized series is of a great interest for a PSA study, because on one hand it allows to collect specific data from an important and homogeneous operating experience, and on the other hand an unique PSA will be representative of 34 plants.
- Risk criterion : the study is a level 1 PSA (core melt frequency assessment),
- Scope of the study : the PSA takes into account all the internal events (including loss of off-site power, but not internal flooding nor internal fires) and all the plant states (especially cold shut down and long term post accidental situations),

- Methods : the PSA used the classical event trees and fault trees methods, although some developments were necessary due to specific investigations,
- Living PSA : the model must be easily updated according to the operating experience, the plant modifications, the knowledge evolution, and allow sensitivity and uncertainties assessments. For that purpose a computerized system will be implemented.

#### 4. Specific aspects

- Data : specific data issued for french data banks (reliability-incidents) are used as far as possible. Data problems are treated jointly with EDF, for example common mode failures and human reliability,
- Operating procedures and human factor : the french safety approach for preventing severe accidents is the implementation of a set of special emergency procedures which identify optimal actions even for out of design situations. So by accounting for these procedures (correctly or incorrectly applied) an important set of operator actions can be included in the PSA. Quantification of the corresponding probabilities leads to several problems including physics of the sequence (physical efficiency of the procedure) systems availability (including instrumentation) and human behaviour in diagnosis and decision making process. Moreover the human redundancy due to the presence of the ISR (Safety and Radioprotection Engineer) is taken into account,
- Long term post accidental situations. The accident sequences are treated until risk becomes really negligible.

This has required :

- . Definition of the most realistic equipment utilization strategies based on existing emergency procedures for 900 MWe french plants,

- . Evaluation of the potential to repair failed equipment, given accessibility, repair time, and specific radiation conditions for the given sequence,
  - . Definition of the event bringing the long-term sequence to an end,
  - . Establishment of an appropriate quantification method, capable of taking into account the evolution of assumptions concerning equipment utilization strategies or repair conditions over time,
- Accidents during cold shutdown : we have taken into account the specific problems of this state which are the absence of various automatisms and the systems unavailabilities for maintenance. In these situations the human interventions have a great importance,

## 5. Preliminary results

The relative contributions of the different initiating events to core-melt frequency are given by the figures 1 and 2.

### 5.1. General remarks

Before giving some comments about these results, it is necessary to precise that an important number of sequences will be reassessed during the provisory phase. This reassessment, which will probably induce some changes in the above results, is mainly due to :

- Modifications of the plant systems or procedures implemented during the course of the preliminary study,
- An up-dating of the reliability data base, according to the operating experience of the 900 MWe series,
- Particular studies or investigations, especially thermohydraulics calculations and special inquiries concerning the behaviour of equipments beyond their design conditions (e.g. primary pump seals),

Fig. 1 - With long term post-LOCA situations

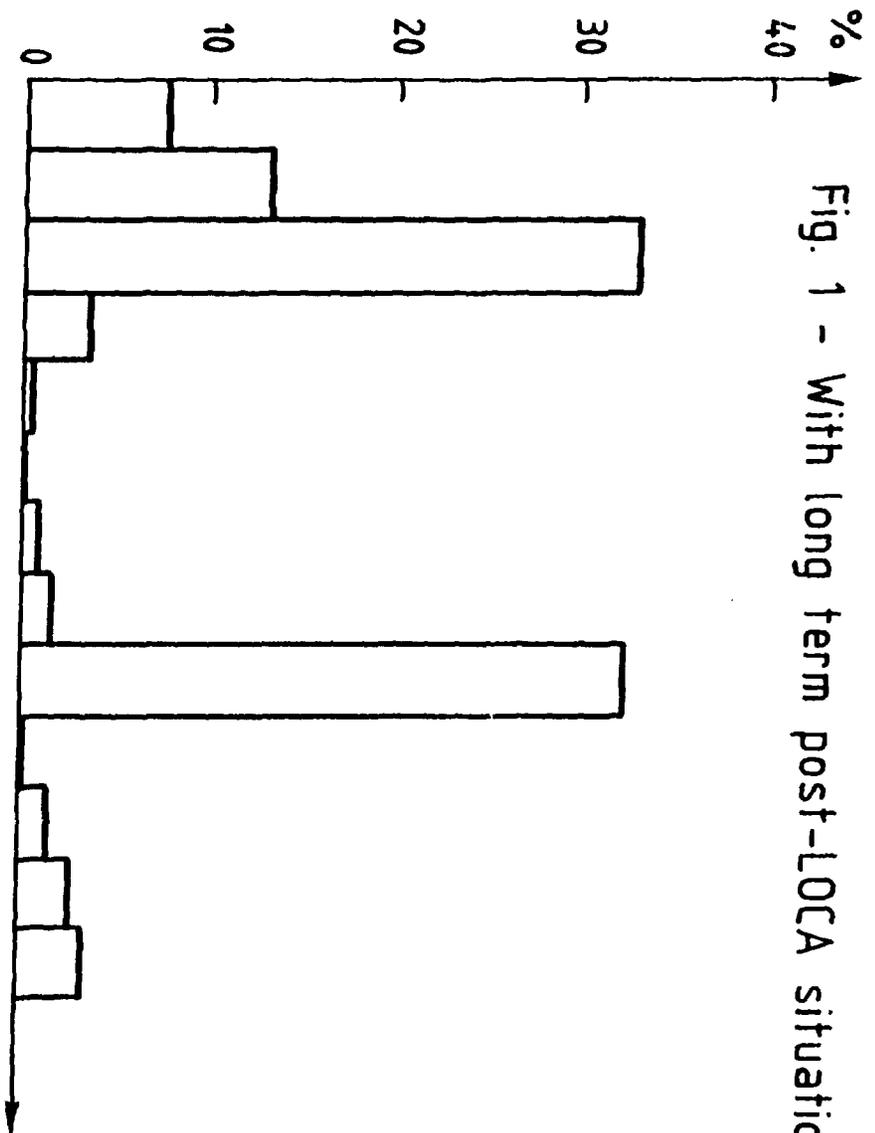
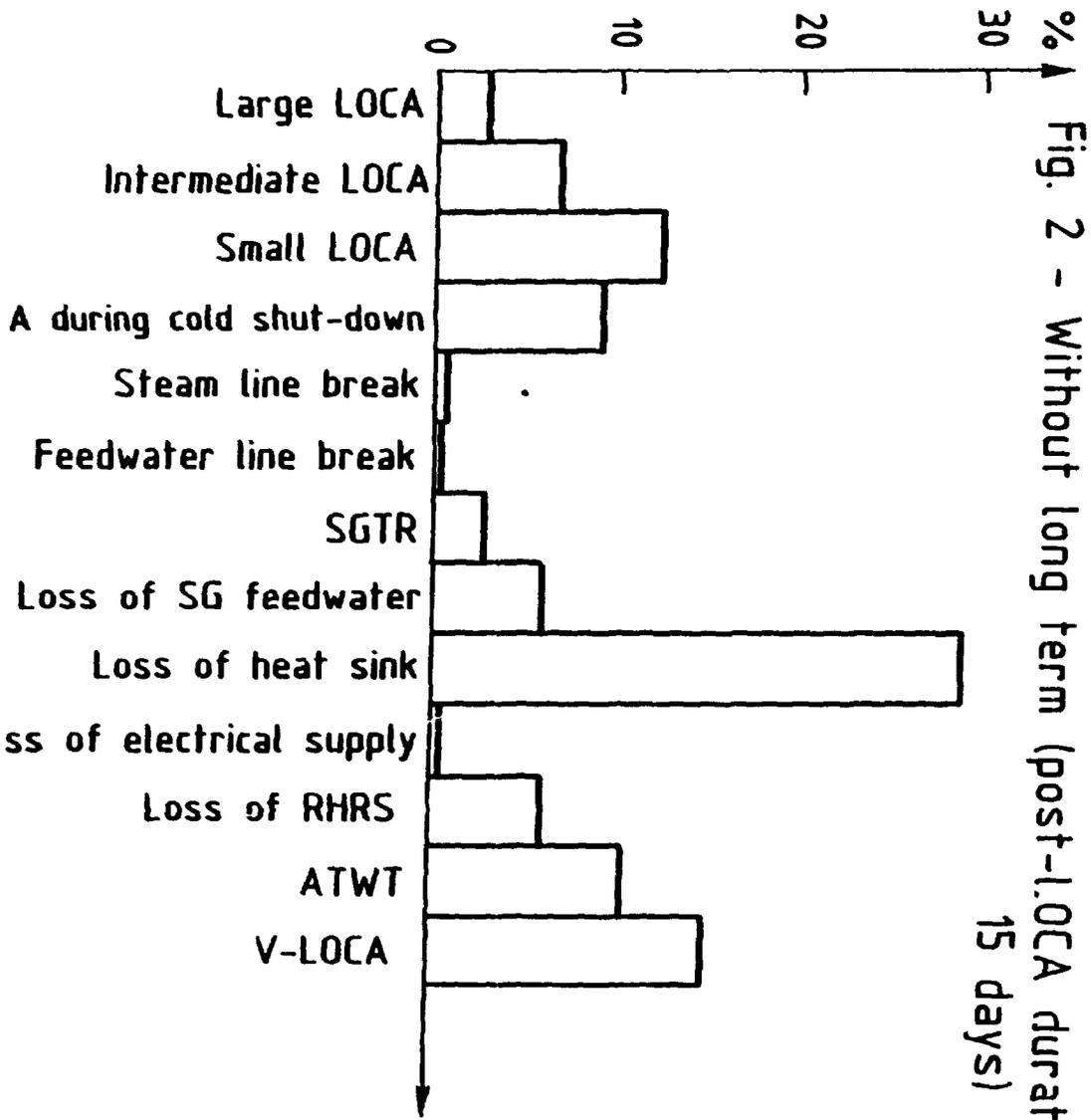


Fig. 2 - Without long term (post-LOCA duration : 15 days)



- The remarks made by EDF during the external review.

However some interesting insights can be already drawn from the preliminary results.

## 5.2 Comments on the risk contributions

- Long term post-LOCA situations : the preliminary study does not take into account any special measure related to these situations, and the results indicate that the corresponding risk is dominant (fig. 1). However a specific procedure related to post-LOCA situations is presently implemented on the 1300 MWe series, and partly on the 900 MWe. This important modification will be taken into account in the provisory study,
- Cold shutdown situations : the risk related to this state is not negligible, especially due to the unavailability of various automatisms, and to system unavailabilities for maintenance. In order to limit the risk in these situations, a project of technical specifications during cold shutdown was proposed by EDF, and the efficiency of this project was judged by using the PSA results.

The analysis included a basic calculation, without any scheduled unavailability, and sensitivity assessments taking into account the systems required by the technical specifications (fig. 1 and 2 present the results of the basic calculation).

- Loss of heat sink : the high contribution of this initiating event relies mainly on conservative assumptions related to the behaviour of primary pumps seals. Expert judgement will be used to define a more realistic model for the provisory study. In these accident sequences the role of human intervention is dominant.

- Loss of steam generators feedwater and loss of electrical supply : the risk related to the initiating events is relatively low. This result is due to the existence of specific emergency procedures (H2 and H3 procedures). The PSA provides an assessment of the benefit related to the procedures : in both cases the risk is divided by a factor of about 100. The study justifies the additional measures implemented by EDF in these specific emergency procedures.
  
- V-LOCA's : there is a large uncertainty related to the initiating event frequency. The preliminary study was done with conservative assumptions, especially for common mode failures. Further investigations are needed.
  
- Secondary breaks : the results indicate clearly that these sequences are not significant.

## 6. Conclusion

Although these results may be partly changed during the provisory and final phases, the preliminary phase of the 900 MWe PSA provides interesting results, both on the main contributions to core-melt frequency and on the necessary improvements of the study.

The preliminary results point out the importance of long term post-LOCA situations and of cold shut-down states. the interest of adequate accidental procedures, and in a general way the importance of human factor.

The further phase will take into account some plant modifications, an updated data bank, the results of additional studies or investigations, and a computerized system which will allow the necessary assessment of uncertainties.

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