PSA EXPLANATORY NOTE
(Issued: March 2007)

Objective of the Note
The RHWG has agreed upon a "PSA- Explanatory Note" explaining the group´s understanding behind the current reference levels for PSA and the related benchmarking.

Roles of deterministic and probabilistic approaches in the safety analysis
We consider that the safety of nuclear power plants shall rely essentially on a deterministic design based on the concept of defence in depth. The design provisions adopted by the licensee are justified based on, among other elements, the study of a limited number of representative event sequences (bounding cases) resulting from the full range of postulated initiating events, and the application of deterministic rules and criteria which include margins and conservative assumptions The results of such studies must satisfy criteria intended to limit the consequences of the specified events. More severe consequences can be accepted for less frequent events or conditions.

In this respect, a probabilistic safety analysis (PSA) shall be used to complement the conventional deterministic analyses. Indeed, PSA is based on proven methods such that risk can be assessed realistically with the help of logical models representing the plant responses to a broad range of initiators and failures under different operating modes. The probabilistic evaluation of these models offers insights in the relative safety importance of initiators, response of SSC's and of operating procedures. PSAs provide an overall view of safety characteristics, including both equipment and operator's behaviour. PSA helps to assess whether the design objectives regarding reliability, protection against vulnerabilities and effectiveness of different lines of defence have been achieved satisfactorily. It can be used to prioritise the safety issues related to the design or operation of reactors, and it is also a tool to support the dialogue between the licensee and the regulatory body. For operating reactors, PSA contributes to assessment of their overall safety performance and highlights points for which design or operating changes can be examined or even judged necessary. For future reactors, PSA is developed while the design is being defined, so as to highlight situations involving multiple failures for which arrangements must be made to reduce their frequency or limit their consequences.

Scope and content of PSA
For each plant, a specific PSA shall be developed for level 1[1] and level 2[2] including all modes of operation, all relevant initiating events, including internal fire and internal flooding. The licensee has to develop a PSA which represents the plant specificities. When the licensee owns a standardized fleet, this can be obtained by developing a "basic PSA" which represents the reactor

[1] *Level 1 PSA identifies the sequence of events that can lead to core damage, estimates the core damage frequency and provides insights into the strengths and weaknesses of the safety systems and procedures provided to prevent core damage.*

[2] *Level 2 PSA identifies ways in which radioactive releases from the plant can occur and estimates their magnitude and frequency. This analysis provides additional insights into the relative importance of accident prevention and mitigation measures.*

type, and that is adapted to each plant of the same type, taking into account its specificities.

Additionally, external hazards such as severe weather conditions and seismic events shall be addressed[3]. in the PSA so that the overall risk of a plant is assessed realistically.

Quality of PSA

The licensee shall document all the technical content of the study to ensure its traceability and facilitate applications. In particular, the results of the basic PSA, the uncertainty assessments and the sensitivity studies shall be presented in a clear and legible manner to enable detailed external review of the PSA.

It is important to note that PSA shall be performed according to up-to-date proven methodology, and taking into account international experience currently available.

Moreover the licensee shall regularly update the PSA to correspond to the operating experience and to reflect changes in the design of the plant, new technical information, and more sophisticated methods and tools that become available. The status of the PSA should be reviewed regularly to ensure that it is maintained as a representative model of the plant.

The quality requirements to be applied shall be commensurate with the role of the PSA in the licensee's decision making process. The more important the role, the better the quality requirements for:

- the scope of PSA application,
- the level of detail,
- up to date methodologies and modelling.

N.B: When we refer to international experience currently available, it is in terms of methodology and quality used to develop a PSA and not in terms of scope of the PSA. Therefore it is not contradictory that some countries do not meet RL 1.1 on the scope of PSA but meet RL 2.2 on the quality of PSA. It may simply mean that they have developed only a level 1 PSA with a sufficient level of quality (in compliance with up-to-date proven methodology, and taking into account international experience currently available).

Use of PSA

The uses of PSAs are very broad and can be encompassed by the term "PSA application". This term qualifies any approach to reactor safety management that makes use of probabilistic methods to support decision-making, particularly in terms of changes in design, operation and preparation for accident management.

As nuclear safety regulators, we decided to orient the reference levels on PSAs towards practical applications that clearly enhance the effectiveness of safety management. Other applications of PSAs are possible but it is up to the licensee to develop and apply them if he wishes so, provided that they do not degrade the safety level.

[3] *This means that these two hazards shall be included in the PSA, except if a justification is provided for not including them, based on site-specific arguments on these hazards or on sufficient conservative coverage through deterministic analyses in the design, so that their omission from the PSA does not weaken the overall risk assessment of the plant.*

The methods and data used for PSAs and its characteristics—including their scope— depend on the application. The relevance of the PSA results must be assessed against the findings of other safety analyses on a case by case basis, according to the application considered. For certain applications, probabilistic objectives (absolute or relative values, total or partial) can be set, taking into account the uncertainties. Nevertheless, this is not required by our reference levels because the added value of a PSA for safety in general does not require quantitative objectives; some countries practice that such objectives must be considered as guideline values and not as strict limits.

Uncertainties and limitations of PSAs

There are basically two types of uncertainties: uncertainties related to quantitative input data and uncertainties related to modelling and simplifications. Concerning the uncertainties related to the most important quantitative input data, Monte Carlo simulation can be used to obtain the uncertainty of the overall result.

The uncertainties related to modelling and simplifications and to the assumptions made for quantification include the initiating event grouping choices, the choices of scenarios and models for the supporting thermohydraulic and neutronics calculations, the uncertainties related to knowledge of the phenomena, the uncertainties related to the modelling of human actions, to the simplified modelling and the estimation of software reliability, to the estimation of the reliability of equipment operating beyond its qualification conditions, and to the choice of probabilistic methods. The variation of the results according to the principal simplifications and assumptions can be assessed by means of sensitivity studies.

The limitations of PSAs concern their completeness. The level of completeness is assessed according to the relevance of the models, the difficulties associated with quantification and with regards to the use of the results. Incompleteness concerns, for example:

- the scope (lack of processing of internal fire or flooding events or external events),
- the choice of human interventions processed in the PSAs,
- the definition of the component families affected by the common cause failures (common cause failures affecting components belonging to different systems not being processed in all cases),
- unidentified scenarios.

The impact of incompleteness cannot usually be assessed quantitatively. Nevertheless, its assessment contributes to defining the limits of the scope of PSAs

The uncertainties and the limits associated with PSAs imply that the interpretation of their results and their use in the decision-making process should be done in a cautious way. On the other hand the PSA makes visible the uncertainties and limitations that otherwise would be hidden behind deterministic assumptions. Therefore it is essential that all possible contributions from different kinds of safety analysis can be integrated into a consistent overall picture.

PSA and risk informed approach

Reference levels on PSAs do not explicitly refer to risk-informed approach as this term has different meanings according to countries.

A risk-informed approach is justified where the two complementary processes of deterministic and probabilistic assessment lead to a more complete basis for decision-making in order to maintain or improve safety. Therefore a risk-informed approach based on deterministic design assumptions complemented by a probabilistic assessment can be useful in order to address design and operational issues in an efficient and effective manner.

However, a risk-based approach solely based on numerical results might be detrimental to safety.