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REGULATORY APPROACH TO RISK INFORMED DECISION MAKING IN INDIA

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Abstract

Atomic Energy Regulatory Board (AERB), the authority for licensing and monitoring safety in Indian Nuclear Power Plants (NPPs), makes use of insights gained from PSA together with the results of the other deterministic analyses in taking decisions regarding the acceptability of the safety of the NPPs. PSA provides an estimation of risks; it also gives information on a balanced design by revealing interaction between engineered features and weak areas in a design. For regulatory use, PSA needs to be carried out using standardized methodology and state of the art technology. PSA helps regulators in taking faster and consistent decisions. Keeping in mind the limitations associated with PSA study, AERB has decided to adopt risk-informed decision making in regulatory licensing process.

This paper describes the AERB policy regarding PSA and gives overview of the experience in this area.

1. INTRODUCTION

1.1. Licensing process

The licensing process of Indian Nuclear Power Plants is based on deterministic regulatory requirements where the intent is to ensure safety with multiple layers of defense in-depth. Design basis accidents are defined and engineered safety features are incorporated into the design to respond to these accidents. The safety analysis must then prove the adequacy of safety systems to meet their objective and ensure safety of plant, personnel and environment.

1.2. Deterministic analysis

The classical and deterministic safety analysis submitted by the utilities to support license applications cover various areas like reactor physics, fuel design and thermal hydraulics to assess the adequacy of engineered safety systems including reactor shutdown system, containment systems, etc. and safety support systems.

As per AERB Safety Guide D5 [1], all accidents can be broadly classified into two categories:

(a) Design basis accidents, which are deterministically analysed to define limiting conditions for operations, limiting safety system settings and safety limits.

(b) Beyond design basis accidents, which are analysed using best estimate methods and taking credit for realistic response of systems and operators.

The regulatory review of license application ensures that design basis accidents are analysed conservatively and engineered features are able to cope with them. Some identified beyond design basis accidents are also analysed to show that they do not result in unacceptable risks to the public.

1.3. Probabilistic safety analysis (PSA)

The PSA study includes analysis of all potential accidents and confirms the effectiveness of the engineered safety provisions. With the help of state of the art technology, reactor safety studies are being done in an integrated way. PSA systematically integrates information on plant design, phenomenology of accidents, operating practices and history, hardware and human reliability, and health and environmental effects in case of radioactive release. It generates a variety of quantitative information on the events and failures associated with various consequences such as core melt and release of radioactivity.

Although the use of best estimate method is always claimed in PSA study, limitations still exist in a number of areas such as, failure database, knowledge of different modes of core damage phenomenon, failure dependencies, human performances, external events and equipment behaviour under accidents. Therefore, a decision-maker has to understand all significant strengths and limitations to make more effective use of all available analyses, including the information obtained from deterministic and probabilistic evaluation.

2. THE PRESENT REGULATORY POLICY REGARDING PSA

The present policy of AERB is to integrate the PSA based study results into regulatory decision-making in an evolutionary and progressive manner. AERB encourages utilities to supplement all license applications with PSA studies as a desirable practice. The results of PSA studies in their present form are used only as complementary tool for risk informed regulatory decision-making.

While making the regulatory policy on PSA, AERB has taken cognizance of the present developmental work of PSA in India, present state of the art of the technology and availability of plant specific failure data. The inherent limitations of database and modelling accuracy particularly in respect of human reliability, common cause failure & uncertainty analysis are considered while binding PSA results into risk informed decision-making process.

AERB's current view on PSA is as follows: -

(a) PSA results should be increasingly used in regulatory matters.
(b) PSA results supported by the present state of the art and plant specific failure data together with generic database can only be used as complementary tool to current regulatory practice.
(c) PSA and associated sensitivity studies and importance measures should be used extensively during designing of new NPPs to get a balanced design.
(d) PSA based studies with appropriate consideration of uncertainties should be used during regulatory decision in the context of plant modification, back-fitting of new requirements and resolution of safety significant issues.

Benefit of PSA study comes from getting an understanding of safety status in terms of relative importance of contributors to core damage frequency and in making comparative assessment, rather than in deriving bottom-line absolute numbers for risk/core damage frequency, to be checked against formal numerical goals. AERB only desires that plant should meet some targets as a good practice and not as mandatory requirements.

AERB has decided to enforce in a phased manner, submittal of PSA report and reliability study results (Level-1) along with all new license applications. The requirement also calls for utilities to develop plant specific failure database for components, common cause failures and human reliability within a fixed time frame.

Submissions of PSA level-1 study with only internal events have been considered by AERB during licensing of Kaiga Generating Station. For other new projects such as Tarapur 3&4 and Prototype Fast Breeder Reactor, PSA studies have been insisted and are in progress. PSA level-1 studies with external events like fire & flood will be considered for regulatory purpose in near future. On trial basis Level-1

study with external events is under progress for Madras Atomic Power Station and is likely to be completed by year-end.

It is also proposed to use PSA in the areas like configuration management, technical specification optimization with regard to Allowed Outage Times (AOT) and Surveillance Test Intervals (STI) of components, risk based inspections and maintenance. Ageing management of components, accident management plan and improving operator's training with risk inputs from PSA based studies are also being encouraged.
A comprehensive review of India's most vintage BWR plant Tarapur 1&2 has been taken up by AERB as a part of its programme for improving safety status of older plants. Level-1 PSA for this plant is in the last phase of completion. Findings of this study will be used extensively for this review and subsequent design up-gradation.

In risk informed decision-making process, the regulatory decisions are taken mainly based on deterministic regulatory requirements and other regulatory inputs (e.g. Experience feed back, Inspection results, Performance review, etc.), supported with the findings from PSA study results. In Indian scenario this risk informed decision-making process is being adopted initially to build confidence and increase experience on regulatory decisions using PSA results.

Presently only a few PSA studies are carried out and availability of plant specific failure data is also limited. Consequently, adequate confidence to base decisions on these studies is yet to develop. With directions from regulatory body, the utility has agreed to carry out comprehensive PSA studies for all plants with plant specific failure data in a phased manner. This will help in comparative decision-making. With time, the experience of PSA analysts will increase which will improve the quality of PSA. The expertise and knowledge base of regulators will also increase in this process.

In risk informed decision-making, interpretation of findings of deterministic analysis and judgment of regulators and experts govern the decisions. With the availability of quality PSA report and experience in risk informed decision-making, the regulatory decision-making could be transformed to Risk-based one.

3. LEGAL BASIS FOR RISK BASED DECISION MAKING

At present there are no regulatory stipulations regarding PSA. However, it is considered to be a tool to evolve a balanced design to ensure that no single accident sequence is likely to dominate the total risk. Within the present framework, regulatory guidance is given in AERB Safety Guide D10 [2] regarding plant failures and reliability analysis of engineered safety features. Guidance on Containment failure analysis is provided through AERB Safety Guide D21 and D22 [3,4]. Safety Guide G-1 [5] prescribes the methodology for the regulatory body to assess the PSA reports submitted by utilities.

Full scale PSA based on standardized PSA methodology is necessary for use in regulatory decision-making process. AERB has proposed a format for submission of any PSA report for regulatory review.

AERB is also in the process of setting up probability safety goals in almost all applications areas of PSA. Before using PSA study results for risk informed regulatory decision-making, they will undergo detailed regulatory review in accordance with checklist prescribed by AERB.

4. PRESENT STATUS AND EXPERIENCE

The importance of PSA in design and operation is already recognized and PSA level-1 study has been carried out in three of the Indian PHWRs. In Kakrapar Atomic Power Station (KAPS), level-1 studies are in advance stages of completion. Some of the PSA reports have been submitted to AERB for assessment. Regulatory evaluations of these PSA results are already in progress. Highlights of such PSA studies are given below.

4.1. Narora Atomic Power Project (NAPP)

A PSA study of NAPP was carried out during 1989 to perform design evaluation to improve safety and reliability. The failure rate data from the established sources was used. Bayesian techniques have been used to obtain better estimation in view of the availability of limited information based on experience from Rajasthan Atomic Power Station.

Some design modifications carried out as a result of the analysis are: -

(a) Reliability improvement in the design of interlocks and D_2O condensate lines in Reactor Building (RB) isolation system to effectively isolate RB in an accident condition.
(b) Comparative evaluation of alternate designs for secondary shutdown system to obtain optimum configuration.
(c) Provision of isolating valves in the interface of moderator circulation system with liquid poison addition systems to reduce the probability of loss of moderator.
(d) Addition of a third Diesel Generator in each unit to reduce the unavailability of emergency power supply by a factor of three. This was done since Station Black Out (SBO) related events are major contributors to Core Damage Frequency (CDF).

4.2. Kaiga Generating Station (KGS)

During 1996, the PSA Level-1 study of KGS was carried out as a part of design assessment. Even for this study, failure data based upon the operational experience was found inadequate and hence, component failure data from the established sources was used.

It was observed that accident sequences initiated by failures of Class-IV power supply are highly significant due to high frequency of this initiating event (2/yr). The Fire Fighting System (FFS) was found capable of handling the situations following a station black out. However, there is a need for operator action in FFS. Since human error in FFS was found to be a significant contributor to CDF, well-written operating procedures and improved training were suggested.

4.3. Madras Atomic Power Station (MAPS)

PSA Level 1 study of an operating plant was first taken up in 1998. The main feature of this PSA study of MAPS Unit-1 is the use of plant specific data. Human cognitive reliability co-relation method (IAEA TECDOC 591) has been used to determine the human error probability. Common cause failure based on plant specific data has been taken into account. Pipe line failures and cable failures have also been considered based on plant specific data.

The accident sequence, involving medium LOCA followed by failure of ECCS has the highest contribution to the CDF. The importance of ECCS is evident from this analysis with respect to availability. The PSA study suggests the following changes in ECCS, which can reduce the CDF significantly:

(a) Introduction of high-pressure ECCS to cater to medium LOCA.
(b) Provision for redundancy in the design of ECCS, since single component failures directly lead to the total unavailability in some cases.

4.4. Shutdown risk assessment in MAPS

Both the operational feed back from NPPs and the PSA studies indicate that the risk associated with shutdown and low power operations can be significant. Keeping this in mind, an overall risk assessment under Shutdown State is done for MAPS. Based on the presently available data, the overall CDF is estimated to be of the order of 10^{-5}/yr during shutdown state, assuming that the reactor will be in that state for 30% of the time.

5. CONCLUSION

In AERB's current policy, the insights gained from PSA are considered together with those from other analyses in decision-making regarding the acceptability of the safety of the NPPs. PSA provides an

estimation of risks; it also gives information on a balanced design by revealing interaction between engineered features and weak areas in a design. If PSA is carried out using standardized methodology and the state of the art technology, it can help regulators in taking faster and consistent decisions. Keeping in mind the limitations associated with PSA study AERB has adopted risk-informed decision making in regulatory licensing process. This can be improved to risk based decision-making in a phased manner.

References:

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