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QUALITY ASSURANCE AND ISSUES OF PSA STUDIES PERFORMED IN ATOMENERGOPROEKT, MOSCOW

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1. INTRODUCTION

Since 1988 Atomenergoproekt has performed a number of probabilistic risk studies for different types of VVER reactors from advanced VVER-1000 in design to the first VVER-440 operated at Unit 3 of Novovoronezh NPP. These studies were carried out in cooperation with Russian and Western institutions working in the field of PSA as well as NPPs. They were done within both national and international programs. The scope of probabilistic risk studies varies from reliability analyses to PSAs including both internal and external initiating events as well as PSA level 2.

PSAs performed by Atomenergoproekt for VVER-1000 plants in design:

- Novovoronezh NPP Unit 6 (advanced VVER)- PSA Level 1 and 2 including fire and seismic analyses
- Bushehr NPP in Iran - PSA Level 1 and 2 including fire and seismic analyses
- Kudamkulan NPP in India (advanced VVER) - PSA Level 1 including fire analysis
- Tianwan NPP in China (partly) - PSA Level 1

PSAs performed by Atomenergoproekt for operating plants:

VVER-1000 units

- Balakovo Unit 4 - PSA Level 1 and 2 including seismic analysis within TACIS Programme in cooperation with European companies
- Balakovo Units 1,2,3 - PSA Level 1 (request of REA)
- Balakovo Unit 4 - fire PSA to support safe shutdown analysis (request of REA)
- Rostov Unit 1 - PSA Level 1 (request of REA) - partly

VVER-440/230 units

- Novovoronezh Unit 3 - PSA Level 1, including screening external hazards study, within NOVISA project funded by US DOE and supported by US companies

RBMK-1000 units

- Smolensk Unit 3 – fire PSA to support safe shutdown analysis funded by US DOE and supported by US companies

PSA related software experience includes RiskSpectrum and Saphire codes for PSA models, Compas code for data treatment, Abaqus for structure reliability analysis support,

Raduga for thermohydraulic analyses support, FirePro for fire analysis, and some others. Supporting teams (in AEP and other companies) are using codes for thermohydraulic analyses, severe accidents, fire growth and propagation, and fracture mechanics.

PSA results are used for NPP's safety level evaluation as well as for the identification of design/procedure improvements needed. The results of PSAs have been used for the following purposes:

- development of design basis for the new generation VVER-1000 reactor
- justification that advanced NPP with VVER-1000 meets probabilistic safety criteria established in national safety rules
- identification of weaknesses in design and procedures of operational VVERs where improvement needs
- support of modifications implemented in operating plants with VVER-440 and VVER-1000 reactors by evaluating of risk reduction
- validation of allowable outage times and surveillance test intervals as well as testing strategy for safety systems of operating NPPs with VVER type reactors
- development of the list of beyond design basis accidents to support accident management for VVER-1000 according to requirements of national rules
- support of safe shutdown analysis for fires at Balakovo and Smolensk NPPs

Some lessons learnt from the PSA studies performed are presented below with respect to issues related to PSA quality and consistency.

2. PSA QUALITY HIERARCHY

Working process in Atomenergoproekt is monitored by a quality management system consistent with DIN EN ISO 9001-2000 certified by the TÜV management Service Gmbh (Germany). Hence PSA development is also controlled by the quality management system over all steps up to the issue of final documentation, its translation, and shipment to a customer. A Quality Assurance (QA) program is established for any project. QA in PSA development is based on regulatory documents issued by the Regulatory Body of the Russian Federation - Gosatomnadzor (GAN) and set of internal guidelines and procedures issued as company standards and aimed at improving PSA quality and consistency.

3. GAINED EXPERIENCE IN MULTI-FACETED PSA PROJECTS

Most projects Atomenergoproekt has been involved in are multi-faceted ones. Different projects were directed by a company from Western country such as Spain, the UK, France, Germany or the USA. Therefore, our PSA team has a valuable experience from working in different QA environment. Managing such projects was found to be a complex process requiring numerous management tools, constant monitoring, and effective communication skills. Employing management tools to resolve unanticipated problems one of the keys to project success and avoid inconsistency and degraded quality of the final product.

As an example, the Novovoronezh In-depth Safety Analysis (NOVISA) Project carried out as part of the International Nuclear Safety Program funded by the US DOE is considered /1,2/. It was a multi-faceted project with participants from sixteen different international organizations from five different countries scattered across eleven time zones. The purpose of

the project was to provide a thorough probabilistic and deterministic safety analysis for Units 3 and 4 of the Novovoronezh NPP. The NOVISA PSA study was started in October, 1998. All tasks within the PSA activity have already been completed.

The NOVISA project was managed and performed by the Russian project team consisting of Novovoronezh NPP, Atomenergoproekt Moscow, OKB Gidropress, Kurchatov Institute, and Gosatomnadzor Science and Engineering Center. So technical work was carried out by several Russian subcontractors. Technical assistance and internal review were provided by US supporting institutions. In addition, all technical deliverables were reviewed by an independent Russian Peer Review organization - IBRAE responsible for external review of the overall PSA. Now an extra external review is carried out by the Russian Regulatory Body.

All tasks were performed according to project guidelines that carefully delineated every step of the study. A QA program was implemented according to the QA project guideline.

Specific examples of problems that have been faced on the NOVISA project are described below.

- NOVISA was performed by staff located in Novovoronezh, Podolsk and Moscow in Russia, the Czech Republic, Slovakia, and various locations in both East and West coasts of the USA. In order to maintain constant interaction, organizing regular meetings, including logistical details, preparing agendas, follow-up and addressing unanticipated situations, had a major impact on the progress on the project.
- Availability of effective means of communication and document transfer in electronic form (i.e. paperless form) through e-mail between NOVISA team members was also the key to project performance.
- Majority of the documents required to perform the NOVISA project were generated in both English and Russian, followed by technical and peer reviews. That required changes to be incorporated in both versions in adequate way. This process is extremely time-consuming and difficult to implement.
- In many occasions, incompatibility of some of the software applications used by various team members, difficulties in providing computer hardware, software, and services, and bilingual nature of the project could become a serious threat to meet deadlines.
- Russia and the US have different norms and standards for work performance and failure to address this in the project management approach could lead to disastrous results.

4. SOME QA AND CONSISTENCY ISSUES OBSERVED OR EXPECTED IN FUTURE

- Paperless documents are going to be the norm but QA control of computer files is difficult in practice. Even the same file sometimes looks different at different computers. PSA producers and users from various teams involved in the project should have the similar computer environment and software (graphic, word processing, spreadsheet, templates, analysis support tools, etc.) to look at what have been done adequately. Even subtle differences in software may create discrepancies. It seems useful to test software consistency using the same sophisticated file from the very beginning of the project. Electronic signatures under reports in future may need signature verification procedures to ensure their authenticity.
- Issues with data consistency at the interface between PSA team and support teams. Support information sometimes seems adequate but careful attention should be paid to sources and methods it was obtained and compiled. (See an example on Fig.1).

- Multi-language issues appear when there are difference in languages between PSA producers and PSA users. It results in minimum two versions of the documents (i.e. Russian and English). From the very beginning, a common glossary of terms is very important as the different translators tend to translate the same terms differently. Typical situation when a number of translators work on a number of PSA work packages resulting in inconsistency in terms and phrases. Tracking changes in both languages become an additional problem. As a rule, a limited number of the experts involved in a project are fluent in both languages. Depending on knowledge of the languages, meetings and correspondence can be carried out in different languages. Adequate changes should be incorporated in the documents, files, and models written in opposite language.
- A key issue related to the use of PSAs in decision making is uncertainty treatment because the extent to which PSAs can be used strongly depends on their quality and completeness. Unfortunately, PSA is accompanied by uncertainties at all levels of analysis which should be taken into account in the decision making process. In general, uncertainties are usually classified into three types: parameter, model, and completeness uncertainties. Regarding the first type, uncertainty associated with common cause data was found to be very significant. The last two types of uncertainty are difficult to quantify. Therefore, modeling issues and limited scope of PSAs may significantly restrict PSA applications. The issue of completeness is of considerable concern, because many PSAs do not address all the modes of operation and potentially important contributors, e.g. fires, floods, and seismic. This is a potentially significant drawback to risk-informed decision making.
- High reliability of passive safety systems makes it possible to enhance significantly safety of advanced VVERs because the safety of future passive reactors is determined by high reliability of passive features. However, the risk profile of advanced reactors with passive features is being changed. Failure mechanisms not being addressed carefully due to their insignificance in the PSAs for operating NPPs can become dominant. External events, system interactions, subtle dependencies, etc. tend to increase their weight while effect of internal events is being reduced.
- Reliability analyses of digital I&C systems are of special interest. Digital systems widely incorporated in advanced VVERs seem to be not addressed only in terms of hardware or software. Hardware and software are supposed to be treated together as a system, in particular for the treatment of common cause software errors.

5. REFERENCES

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