
Assessment Review Expertise of the Balakovo Probabilistic Fire Study and Elaboration of A Guide for Reviewing Fire PSA

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Abstract: The importance of an effective review approach to obtain realistic and applicable fire risk assessment/evaluation results is well known. The needs for independent reviews with the intent of identifying errors and weaknesses of a Probabilistic Safety Analysis (PSA) has been demonstrated several many times. Many Many studies by different/several international organisations have been published. A review process covers the major aspects of fire PSA as well as of and deterministic fire hazard analysis (FHA).

In this field, the report on the assessment of the fire influence and its consequences on fulfilling the of nuclear power plant (NPP) safety functions performed by the Russian industry in the frame of a PSA study for the NPP Balakovo, Unit 4 has been reviewed by the Scientific Centre of Nuclear Radiation and Safety (SEC—NRS) of Gosatomnadzor of Russian Federation (GAN RF) under Western Expert's leadership.

In this presentation given here, the objectives of this co-operation, the organisation of the respective TACIS project, the main results, and the insights gained from the project are will be shown.

1. INTRODUCTION

At the beginning of 1998, the European Community (EC) represented by the European Commission and a consortium lead by RISKAUDIT IPSN/GRS International (GEIE), named the contractor, decided to conclude a contract related to the support to Gosatomnadzor of Russian Federation (GAN RF) in the review of the nuclear power plant (NPP) Fire Risk Assessment. This work has been performed within the context of the European Communities' TACIS Programme (TACIS RF/TS/15).

This expert consortium was formed by experts from of RISKAUDIT IPSN/GRS, IPSN (French Institute for Nuclear Safety and Protection), CIEMAT (Spanish Research Centre for Energy, Environment and Technology) and VTT (Technical Research Centre of Finland). All four/three companies are members of the European Technical Safety Organisations Group (TSOG).

2. GOALS OF THE CONTRACT

The importance of an effective review approach to obtain realistic and applicable fire risk assessment/evaluation results is well known. The needs for independent reviews with the intent of identifying errors and weaknesses of a Probabilistic Safety Analysis (PSA) has been demonstrated several many times. Many studies by different/several international organisations have been published. A review process covers the major aspects of the fire PSA as well as of the and deterministic fire hazard analysis.

Paying specific attention to the aspect of reviewing a fire PSA would permit to better appreciate the safety ~~relevance~~ importance of ongoing modifications, the identification of ~~potential eventual~~ weak points as well as ~~the~~ corresponding requirements for further improvements.

~~Thus, So,~~ the report on ~~the~~ assessment of ~~the~~ fire influence and its consequences on fulfilling the nuclear power plant (NPP) safety functions performed by the Russian industry in the frame of a PSA study for the NPP Balakovo, Unit 4 has been reviewed by the Scientific Centre of Nuclear Radiation and Safety (SEC-NRS) of Gosatomnadzor of Russian Federation (GAN RF) under Western Experts leadership.

3. OBJECTIVES OF THE PROJECT

The main objectives of the TACIS RF/TS/15 project were:

- to provide GAN RF with a technical ~~assessment/evaluation~~ of a fire risk ~~analysis/evaluation performed for a developed~~ selected ~~on one~~ VVER 1000-320 ~~reactor type~~ unit by the Russian industry,
- to take benefit from the lessons learnt from this ~~assessment/evaluation~~ in order to develop guidance documents for ~~the fire PSA review of fire risk evaluation~~, taking into ~~consideration/account the~~ Western practice.

4. PROJECT DESCRIPTION

The main tasks of the project were the following:

- Review of ~~the~~ report on ~~assessing the ment of~~ fire influence and its consequences on fulfilling of NPP safety functions ~~performed by the industry company "Rosenergoatom/Rosenergoatom"~~ for ~~the NPP Balakovo, NPP U~~ unit 4. This review has been performed on:
 - Review of collected data [1],
 - Analysis of initiating events,
 - Analysis of selection of critical zones (deterministic ~~as well as and including~~ probabilistic approach)[2],
 - Review of fire event trees and deterministic analysis [3],
 - Analysis of event tree quantification [4],
 - Analysis of core ~~melt~~ damage frequencies (CDF) [4],
 - Analysis of uncertainties [5].
- This work ~~additionally covered/included the~~ development of ~~a Guide/Guides~~ for Gosatomnadzor of Russian Federation ~~procedure~~ for reviewing ~~of fire PSA/risk evaluation~~: "Guide for review of material on assessment of fire influence and its consequences on fulfilling of NPP safety functions" [6]. The review ~~approach for the above mentioned fire PSA/process of mentioned fire risk evaluation as well as Western experience feedback~~ have been ~~is~~ used as ~~the~~ basis for this ~~Guide/Guide, as well as Western experience feedback~~.
- ~~A~~ Quality Manual [7] for ~~the~~ review process has been developed and included in the Guide.

5. PROJECT ORGANISATION

One important ~~aspect/aim~~ of this project was to perform a ~~know-how~~ transfer ~~of know-how~~ from the ~~Western~~ contractor to the organisations concerned in the ~~b~~ beneficiary ~~s~~ State (Gosatomnadzor (GAN))

and SEC-NRS) in order to allow them to perform similar work on their own in the future, integrating the feedback of Western experience. ~~For this~~ ~~Se, to achieve this transfer of~~ know-how ~~transfer~~, the ~~projectwork~~ has been performed in close relation ~~of the Western experts~~ to the ~~specialists of the~~ Beneficiary ~~state and the Western Experts~~. ~~For the exchange of information and expertise on the technical subject, time periods of one week~~ ~~A week~~ per two months ~~were~~ necessary ~~to exchange on technical subject~~. ~~In addition, The contract foresaw to perform a specific training of Russian experts on fire simulation codes in Western TSO countries on simulation fire codes~~ ~~was foreseen within the contract, if necessary, in order to verify assumptions for the fire modelling and to get~~ ~~have~~ a better understanding of the performance of this ~~type~~ ~~kind~~ of ~~simulation tools~~ ~~codes~~. The contract ~~was limited from~~ ~~began in~~ July, 1998 to ~~finish in~~ ~~February~~ ~~March~~, 2000.

For the consistency ~~ent~~ of this type of project, the ~~European~~ Commission required that the project had to follow a technical reporting program specifying the work undertaken and the results achieved ~~during~~ each review period. An inception report had to be submitted at the beginning of the project containing a final schedule of work required ~~for~~ ~~in~~ all parts of the project. A few progress reports (quarterly reports) have been submitted, ~~presenting the progress~~ ~~describing progress with regard to~~ ~~in~~ all aspects of ~~the~~ work and ~~to~~ specify work schedules for the next period. All ~~the~~ ~~is~~ project was directed towards the beneficiary organisations, and the technical reporting schedule was structured in a manner ~~providing~~ ~~which give~~ the Beneficiary ~~with a the~~ maximum ~~of~~ information and benefit. A few technical reports have been ~~have been~~ performed at the end of each ~~of the~~ major tasks. ~~At the end of the project, and~~ a final report has been performed, summarising the ~~main results of the projectwork and the main results~~.

6. MAIN RESULTS OF THE ~~PROJECTWORK~~

6.1 Review of ~~C~~ollected ~~D~~ata and ~~I~~nformation

For this task, ~~at~~ ~~the~~ review has been performed on the selection of initiating events caused by fire, compartments, systems and equipment ~~including and~~ electrical cables ~~inside a fire compartment, the~~ fire load from ~~permanently available~~ equipment, ~~and~~ cables ~~as well as from~~ ~~and~~ transient ~~combustible~~ ~~sources~~, fire ~~occurrence~~ frequencies, fire barriers, openings between compartments, ~~etc.~~ ~~---~~

~~All the above mentioned items~~ ~~he objectives~~ have been ~~analysed under the following aspects~~:

- ~~to find out whether~~ ~~to evaluate if~~ the data were exhaustive and sufficient to perform ~~the~~ review,
- to estimate the level of confidence of the data presented (estimation by studies, information from factories and/or manufacturers, use of foreign/internationally available data),
- ~~to verify~~ ~~the verification of~~ the data by a sample verification and/or ~~NPP unit~~ walk-downs.

6.2 Review of ~~the Selection of C~~ritical ~~Z~~ones ~~-selection~~

The approach used for the ~~selection of~~ critical zones ~~-selection~~ has been analysed. But the data and the assumptions ~~applied~~ ~~used~~ on fire propagation, justification of ~~fire barrier rating~~, estimation of ~~the~~ fire duration in the compartment, ~~etc.~~ ~~---~~ were not sufficiently detailed ~~for~~ ~~to have~~ a high level of confidence on the results presented.

6.3 Review of ~~F~~ire ~~E~~vent ~~T~~rees and ~~D~~eterministic ~~A~~nalysis

~~The damage of all equipment inside a fire compartment in case of fire~~ ~~it h~~ has been conservatively assumed ~~that all the equipment has been damaged by fire~~. ~~Furthermore~~ ~~Moreover~~, for the most significant fire zones, ~~a fire simulation has been performed in the probabilistic study~~ to confirm that a fire propagation is not to be assumed. ~~Therefore~~ ~~So~~, ~~numerical calculations for modelling the fire effects~~ ~~to verify numerical fire-related deterministic results obtained~~, ~~fire modelling calculations~~ have been

performed with the FLAMME-S fire simulation code from IPSN during the mission of Russian experts from SEC-NRS (Moscow) to Cadarache, France where the code is developed, to verify fire related deterministic results obtained.

A general result/conclusion is that all in whole fire deterministic the deterministic analysis results obtained in the Balakovo fire PSA study have been confirmed by FLAMME-S simulations. Nevertheless, but to obtain more specific and detailed the results and conclusions more specific, more detailed information on the data used within the Balakovo study and more analyses are required. A plant walk-down of the NPP Balakovo, Unit 4 has been performed on Balakovo unit 4 by GAN RF in July of 1999. This walk-down was particularly performed/carried out for two compartments considered as the most critical compartments within the study. This first walk-down performed by GAN RF was very useful to increase the level of confidence of the information included in the Balakovo report. The approach way to perform a plant walk-down and the manner way to take into account the results from such a walk-down in the fire PSA has been included in the review on fire event trees.

6.4 Review of Event Tree Quantification and Assessment of Core damage Frequency

The supporting documentation of the study is incomplete. Not all of the results obtained were available for the review. Therefore, for a considerable number of cases, the reviewer's were not able to come up with a certain judgement on the adequacy of the quantification approaches and results.

There is a concern on the about adequacy of approaches and assumptions implemented in the study under review for the event (ETs) modelling and quantification, which could lead to introduce a not a-justified optimism in the quantitative estimations.

The event trees ETs from the Level 1 Internal Events PSA were modified to take into account the fire-induced equipment failures. However, there are no comprehensive information / listings on about equipment including components the respective and electrical cables located in the affected fire zones. This was also a source of the reviewer's' concern.

In principle general, the fire PSA study under review demonstrated a comprehensive work on the of identification of plant vulnerabilities towards internal fires and identification of most hazardous fire scenarios. However, to make the results more consistent, additional more justifications is are required for the confirmation of the optimistic assumptions and approaches implemented in the study (or the elimination of unconfirmed optimistic assumptions not confirmed). In addition, and the documentation on the analysis work performed should be essentially improved.

6.5 Review of Uncertainty Analyses

An The uncertainty analysis has not been performed in the Balakovo fire PSA study. Due to this fact, the review of BR the Balakovo report only included the consisted in the list of the main sources of uncertainties with indications on their potential effects on the results. Based on the review performed, the general conclusion can be given made that the uncertainties related to the Balakovo study are considerable. In order to make the fire risk results more consistent with the state of the art, additional analyses would be helpful.

6.6 Guide for Reviewing A Fire Risk Analyses assessment

The recommendations in the Guide [6] are designed for the use by experts engaged for performing a review of a fire PSA FRA.

This Guide has been developed in accordance with the Russian «Statement on the organisation and performance of review of nuclear plant safety, radiation sources and storage places (RD-03-13-97)» [8].

The recommendations of this Guide should be taken into consideration account by central machinery administrations, SEC-NRS and district administrations of GAN RF in case of contracts with foreign strange expert organisations companies recruited to perform carrying out such a the review.

This [Guide document](#) consists of two parts:

- Part 1: Recommendations for ~~the~~ performing [a review](#) ~~performance~~ of [the](#) fire influence analysis and [the](#) fire consequences on the safe [NPP shutdown](#) ~~of reactor~~.
- Part 2: Guide on the quality of performing [analysis](#) review of [the](#) fire influence [analysis](#) and [the](#) fire consequences on the safe [NPP shutdown](#) ~~of the reactor of a NPP unit~~.

6.7 Quality Manual

The present Quality Manual [7] for reviewing [of](#) the documents on fire PSA (~~further – Quality Manual~~) regulates principles, administrative provisions and procedures of quality assurance ([QA](#)) in [the](#) review of the documents on fire PSA ~~based on the basis of~~ fundamental principles of quality assurance, specified in international standards, ~~such as~~ IAEA Safety Guides of [the IAEA Safety Series](#) series 50-C/SG-Q, ~~and~~ taking into account provisions of [ISO](#) standards ~~ISO~~ series 9000.

The ~~Quality~~ Quality Manual takes into account [international](#) recommendations of [the](#) IAEA, requirements of the [Russian national](#) guidance document RD-03-13-98 [8], ~~(standard norms~~ and regulations of Gosatomnadzor of Russia) PNAE G-1-028-91 [9], PNAE G-01-036-95 [10] and requirements of regulatory documents of Gosatomnadzor of Russia, and provisions of [the ISO](#) standards ~~ISO~~ series 9000.

The Quality Manual is the basic document regulating principles, [organisation](#) organization, planning, performance and control of works, carried out by SEC-~~NRS~~ to provide [the](#) required quality of review.

7. INSIGHTS FROM THIS PROJECT

During ~~these~~ [project](#) meetings, there were ~~several many~~ [discussions](#) debates between Russian ~~people~~ and Western ~~e~~Experts on [the](#) information exchanged. ~~In the following, only~~ So, in this chapter, we only ~~summarise~~ the major [in](#) [aspects](#) points of the technical discussions ~~are summarised~~.

- To improve the exchange of information between all the participants of ~~the~~ [this](#) project, it ~~was~~ has been necessary to ~~develop~~ elaborate a glossary defining the technical terms, added to the Guide for review.
- To ~~assist help~~ SEC-~~NRS~~ into performing [ing](#) the review of the ~~the study of~~ Balakovo fire PSA study, the Western ~~e~~Experts have provided information to perform the review of all the tasks foreseen in the contract.
- ~~For further know-how transfer, a~~ few copies of [internationally available documents](#) reports on fire hazard analysis and fire ~~PSA~~ risk analysis have been provided to SEC-~~NRS~~, ~~such as~~ documents from [the](#) IAEA ~~S~~safety ~~R~~report ~~S~~series ~~as well as the OECD/NEA and CSNI r~~Report "Fire Risk Analysis, Fire Simulation, Fire Spreading and Impact of Smoke and Heat on Instrumentation Electronics" [11].
- The Western ~~e~~Experts pointed out that plant walk-downs ~~are necessary to be carried out~~ by the analysts ~~are necessary~~ to verify and to complete the actual state of the plant for the analysis. A plant walk-down by the reviewers is recommended for a meaningful assessment of the analysis, in particular for cross-checks of the analysis assumptions and, especially, if the results of the data obtained from plant walk-downs have ~~been~~ found to be sensitive for the analysis.
- ~~In case of a lack of data from Russian NPP. The Western Expert advised, in case of lack of data from Russian NPP, to apply equivalent data from foreign NPP exercise carefully~~ carefulness and ~~with~~ proper consideration ~~in the use of, similar data evaluated from foreign NPP,~~ notably for the determination of the [fire occurrence](#) frequencies, ~~and the~~ fire load ~~by~~ of permanent equipment and cables as well as ~~by~~ transient combustibles, ~~fire load of equipment, the~~ behaviour of ~~the~~ electrical [equipment](#) and cabinets in case of fire, ~~and~~ functional consequences of the loss of electrical cabinets. ~~All these~~ Indeed, ~~these~~ data are strongly dependent of the management policy of the NPP and of the design of the equipment.

- Western ~~e~~Experts have established a list of ~~those items within a critical zone being what is~~ important to ~~be~~ controlled/examined, during ~~an~~ inspections, ~~about a critical zone~~

8. CONCLUSIONS

In the opinion of all ~~participants in this TACIS project, Western experts as well as the specialists from the~~ beneficiary organisations, ~~the~~ projectwork has ~~principally~~ been very fruitful and ~~very~~ mutually profitable, ~~here and there~~.

~~Information exchanges~~Exchanges between the Western TSOs and the beneficiary organisations are in progress to define ~~further~~ opportunities for mutual activities, notably on the possibility to extend ~~the~~ co-operation in the field of fire analysis (~~state-of-the-art~~modern knowledge, skills in fire ~~safety~~ analysis including ~~calculational~~calculation methods and the ~~using~~ of simplified as well as ~~highly sophisticated~~ modern fire simulation codes, ~~such in fire simulation~~ as ~~FLAMME-Flamme_S~~ by IPSN, ~~COCOSYS~~ by GRS, etc.

9. REFERENCES

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- [3] RISKAUDIT: Tasks 3-4 : Review of fire event trees and deterministic analysis, Final report, RISKAUDIT Report, February 2000
- [4] RISKAUDIT: Task 5 : Review of event tree quantification and core damage assessment, Final report, RISKAUDIT Report, February 2000
- [5] RISKAUDIT: Task 6 : Review of uncertainty analysis, Final report, RISKAUDIT Report, February 2000
- [6] RISKAUDIT: Task 7 : Guide for reviewing Fire Risk Analysis, Final report, RISKAUDIT Report, February 2000
- [7] RISKAUDIT: Task 8 : Quality Assurance Manual, Final report, RISKAUDIT Report, February 2000
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