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NPP Krško Living PSA Concept

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Abstract

NPP Krško developed PSA model of internal and external initiators within the frame of the Individual Plant Examination (IPE) project. Within this project PSA model was used to examine the existing plant design features. In order to continue with use of this PSA model upon the completion of IPE in various risk-informed applications in support of plant operation and evaluations of design changes, an appropriate living PSA concept needed to be defined. The Living PSA concept is in NPP Krško considered as being a set of activities pursued in order to update existing PSA model in a manner that it appropriately represents the plant design, operation practice and history. Only a PSA model which is being updated in this manner can serve as a platform for plant-specific risk informed applications. The NPP Krško living PSA concept is based on the following major points. First, the baseline PSA model is defined, which is to be maintained and updated and which is to be reference point for any risk-informed application. Second, issues having a potential for impact on baseline PSA model are identified and procedure and responsibilities for their permanent monitoring and evaluation are established. Third, manner is defined in which consequential changes to baseline PSA model are implemented and controlled, together with associated responsibilities. Finally, the process is defined by which the existing version of baseline PSA model is superseded by a new one. Each time a new version of baseline PSA model is released, it would be re-quantified and the results evaluated and interpreted. By documenting these re-quantifications and evaluations of results in a sequence, the track is being kept of changes in long-term averaged risk perspective, represented by long-term averaged frequencies of core damage and pre-defined release categories. These major topics of NPP Krško living PSA concept are presented and discussed in the paper.

1. Introduction

The purpose of NPP Krško (NEK) Living PSA Concept is to define the process by which NEK Baseline PSA Model is updated in a manner that it appropriately represents NEK plant and reflects the general current state of PSA methodology.

Hence, the concept generally covers the topics:

- Monitoring of the issues that may have potential for impact on NEK Baseline PSA Model,
- Evaluating of particular issue with respect to its impact on NEK Baseline PSA Model,
- Management of changes to NEK Baseline PSA Model and its supporting documentation, and
- Archiving of superseded NEK Baseline PSA Models and their results.

The process of periodical re-quantification of Baseline PSA Model and evaluation of results is also established within the frame of Living PSA concept. By documenting and evaluating the re-quantifications in sequence, the track of changes in long-term average risk (represented by core damage frequency and release categories frequencies) could then be kept.

The platform for the concept is provided by NEK engineering services procedure [1].

2. NEK Baseline PSA Model

The NEK Baseline PSA Model, which is a central point of Living PSA Concept, is a model that was developed within the frame of NEK IPE/IPEE projects. It consists, [2], of:

- Internal Initiating Events (IEE) PSA Model
- External Initiating Events PSA Model
    - Seismic PSA Model
    - Internal Fire PSA Model
    - Internal Flood PSA Model
    - Other External Initiators PSA Model

The model consists of event tree / fault tree structure integrated on Risk Spectrum code platform. It includes Level 1 and Level 2 models.

NEK Baseline PSA Model represents average plant systems configurations, status of equipment, operation practices and, in general, average relevant conditions to which plant is exposed. Hence, it per definition calculates long term average core damage frequency (Level 1) and long term average release frequencies (Level 2).

Additionally, shutdown modes PSA model, which is "ORAM-type", [4], is part of NEK Baseline PSA Model. It contains representations of various shutdown plant configurations and states and calculates frequencies of their specific risk indicators (core damage, Reactor Coolant System boiling or Spent Fuel Pit boiling). As a result it provides a time-dependent risk profile of specified plant outage.

The key point of NEK Living PSA Concept is that the NEK Baseline PSA Model per definition is a reference point and basis for any PSA application within NEK, such as evaluation of proposed plant design change. It is also a starting point for development of any application-specific NEK PSA model, such as, for example, PSA model to be used for risk monitoring. Any application-specific PSA model used within NEK must reflect the NEK Baseline PSA Model. This specifically means that if the latter has been modified, the former must be modified accordingly.

3. Need for Change of NEK Baseline PSA Model

The crucial part of NEK Living PSA Concept is identification of sources of a need for change of NEK Baseline PSA Model. In order to enable their systematical monitoring, they were grouped into the following three general categories, [1]:

1) Matters related to changes of plant design (i.e. plant modifications) and/or relevant procedures;
2) Matters related to plant operational experience, i.e. those arising from the monitoring of equipment performance and on-site events;
3) All other matters, the major representatives of this category being methodological improvements, corrections of errors observed in the model, industry experience, regulatory requirements, etc.

Matters of all three categories need to be monitored for their potential impact on NEK Baseline PSA Model in order to meet the objective of Living PSA program, i.e. to ensure that it appropriately represents NEK plant and PSA methodology. Thus, the monitoring that would cover the matters of all three categories had to be formalized as a part of NEK procedure, which defines Living PSA Concept. This was done in a following manner, [1].

In NEK the category 1) matters are normally subjected to the process defined by the procedure for authorization of changes, tests and experiments, [3]. This procedure requires that safety screening and, if required, safety evaluation is performed for each proposed change on the plant in order to determine if it involves an unreviewed safety question (as defined by 10 CFR 50.59, [3]). Per the procedure, all the safety screenings and safety evaluations are archived permanently and the electronic data base is kept in order to enable easy access to the data base. Thus, monitoring of the matters of category 1) for the purposes of Living PSA program is ensured by permanent monitoring of safety screening items archive.

Category 2) matters are monitored by another NEK engineering service procedure, "PSA Data Collection and Analysis Guideline", [5]. This procedure defines the process for collection and processing of data relevant for the quantification of Baseline PSA Model. The process results in calculation of relevant parameters, such as failure probabilities, failure rates, equipment unavailability, etc. The parameter values need to be re-calculated periodically in order to reflect actual plant experience. Thus, implementation of matters of category 2) is ensured by periodical updates of Baseline PSA Model data base with re-calculated values of parameters.

Category 3) matters would generally be observed and implemented by NEK PSA engineers.

The matters from three categories are formally defined as “issues” in the NEK Living PSA procedure, [1]. According to the definition in the procedure of concern, [1], an "issue" is a matter that has a potential for impact on NEK Baseline PSA Model. The definition further postulates that an "issue" is either 1) a safety screening data base item, 2) a master data base update or 3) "other issue" (specifically meaning, an "issue" that is not either 1) or 2)).

4. Process of Updating of NEK Baseline PSA Model

In NEK the Living PSA concept is considered as being a set of activities pursued in order to update currently existing Baseline PSA Model in a manner that it appropriately represents the plant design, operation practice and history. The process of updating of

Baseline PSA Model, as it is defined by NEK Living PSA procedure [1] is illustrated by Figure 1.

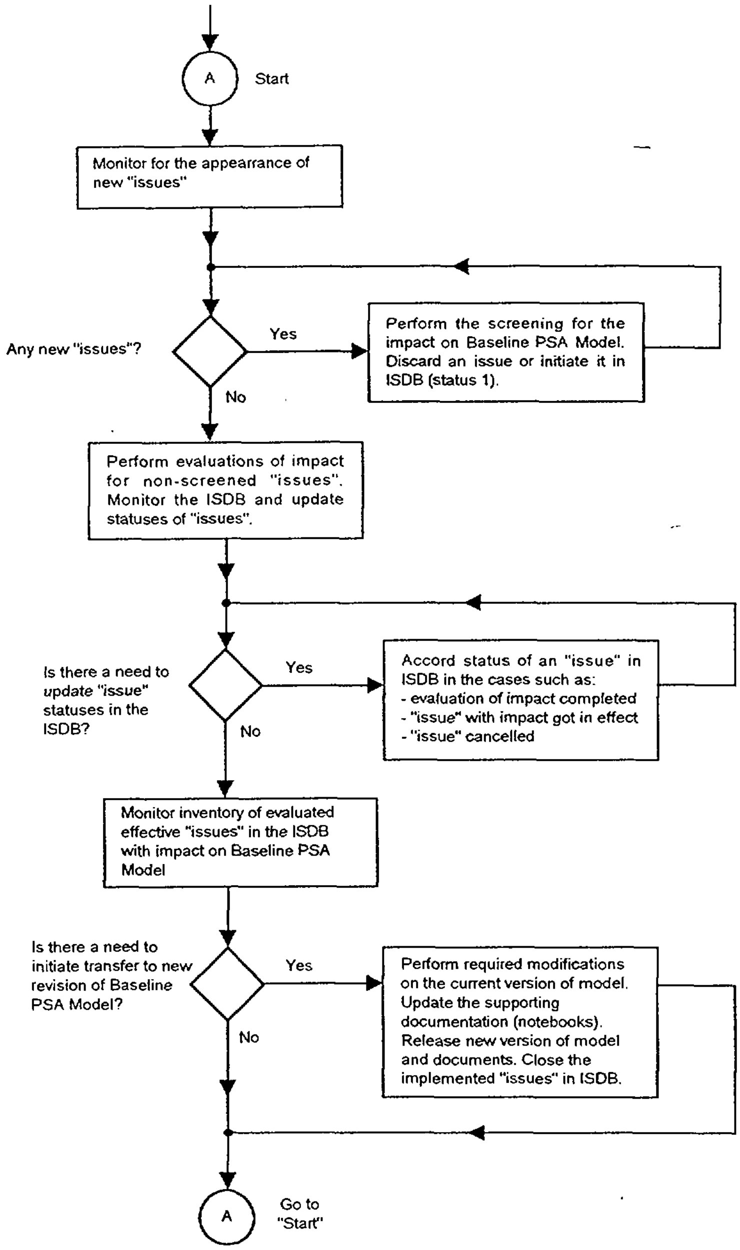


Figure 1

The process goes on continuously and permanently and results in periodical updates of NEK Baseline PSA Model and consequential releases of its new revisions. It relies on the processing of "issues", defined and formalized by procedure [1] as described in Section 3 above. According to the procedure, electronic data base is kept with all "issues" that were identified along the implementation of Living PSA program. It is referred to as "Issue Status Data Base" (ISDB). Each "issue" in ISDB is assigned an appropriate status. Statuses are defined, such as:

- "issue" initiated (status 1);
- potential for impact - evaluation opened (status 2);

- evaluation completed proving the impact - "issue" pending for implementation (status 3).

The ultimate status is - "issue" closed (status 4). The overall process, as could be seen on illustration in Figure 1, can be broken down into the following permanent tasks:

- observing as new "issues" arise and initiating them in the ISDB;
- evaluating the initiated "issues" for the impact on NEK Baseline PSA and keeping the ISDB up-to-date with statuses of "issues";
- monitoring the requests for change of Baseline PSA Model by means of the ISDB and initiating periodical model revisions.

In order to facilitate the process of evaluating an impact that particular "issue" may have on Baseline PSA Model, relevant aspects of Baseline PSA Model were defined in Living PSA procedure [1]. The relevant aspects of Internal Initiating Events PSA model are divided into groups:

- Initiating events,
- Event tree structure,
- Bridge tree structure,
- Success criteria,
- Fault tree structure,
- Quantification of basic events,
- Level 2
- Others.

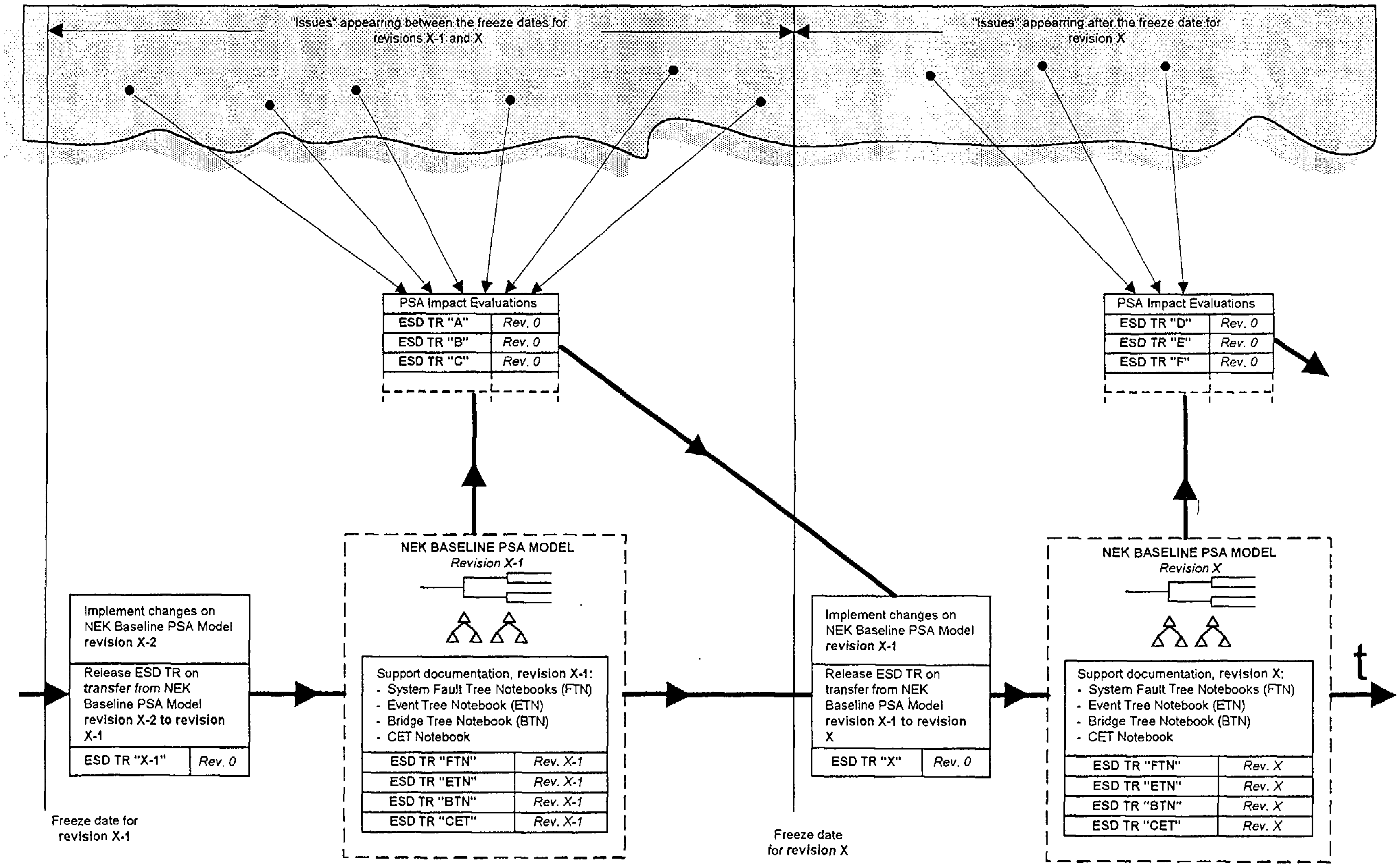
Relevant aspects for other models (i.e. seismic, internal fire, internal flood, other external events and shutdown modes events) are defined analogously, as applicable.

In the overall NEK Baseline PSA Model inherent dependencies exist that may cause a propagation of potential "issue" impact. As an example, one may consider the seismic event trees, which were derived from the event trees for internal initiators by imposing the seismically-induced boundary conditions upon them. This generally means that a potential impact on the PSA model for internal events, such as change in event tree brought by certain "issue", may imply a potential impact on model of seismic events also.

Thus, to determine the scope of impact of particular "issue" on Baseline PSA Model, one should first identify those relevant aspects on which an "issue" of concern may have direct impact, and then propagate the direct impact on other relevant aspects by considering inherent dependencies.

The NEK Living PSA Concept, as postulated by the procedure [1] is illustrated in Figure 2. Generally, the revision "x-1" of NEK Baseline PSA Model was obtained by implementation of requests for changes of preceding revision (i.e. "x-2"), that existed in ISDB at the specified "freeze date". The transfer from revision "x-2" to revision "x-1" was documented in NEK Engineering Service Division Technical Report (ESD TR), which is designated as ESD TR "X-1" in Figure 2.

Figure 2


"Issues" appearring between the freeze dates for revisions X-1 and X
"Issues" appearring after the freeze date for revision X
PSA Impact Evaluations
ESD TR "A" Rev. 0
ESD TR "B" Rev. 0
ESD TR "C" Rev. 0
PSA Impact Evaluations
ESD TR "D" Rev. 0
ESD TR "E" Rev. 0
ESD TR "F" Rev. 0
Implement changes on NEK Baseline PSA Model revision X-2
Release ESD TR on transfer from NEK Baseline PSA Model revision X-2 to revision X-1
ESD TR "X-1" Rev. 0
NEK BASELINE PSA MODEL Revision X-1
Support documentation, revision X-1:
- System Fault Tree Notebooks (FTN)
- Event Tree Notebook (ETN)
- Bridge Tree Notebook (BTN)
- CET Notebook
ESD TR "FTN" Rev. X-1
ESD TR "ETN" Rev. X-1
ESD TR "BTN" Rev. X-1
ESD TR "CET" Rev. X-1
Implement changes on NEK Baseline PSA Model revision X-1
Release ESD TR on transfer from NEK Baseline PSA Model revision X-1 to revision X
ESD TR "X" Rev. 0
NEK BASELINE PSA MODEL Revision X
Support documentation, revision X:
- System Fault Tree Notebooks (FTN)
- Event Tree Notebook (ETN)
- Bridge Tree Notebook (BTN)
- CET Notebook
ESD TR "FTN" Rev. X
ESD TR "ETN" Rev. X
ESD TR "BTN" Rev. X
ESD TR "CET" Rev. X
t
Freeze date for revision X-1
Freeze date for revision X

The "issues" that keep arising after the "freeze date" for revision "x-1" are evaluated for their impact on Baseline PSA Model, as they appear. The evaluations are based on the currently effective model version (i.e. "x-1"). Each of them results in a detailed description of changes to be done to the model. The evaluations are documented in the ESD TRs (designated as "A", "B", "C"; ... on Figure 2), which are archived in accordance to the respective NEK procedures. When the new "freeze date" is specified, the version "x-1" of Baseline PSA Model would be subjected to implementation of changes defined in these ESD TRs. The implementation itself would be documented in the separate technical report, designated as ESD TR "X" in Figure 2.

Thus, each release of a new revision of Baseline PSA Model is accompanied by release of ESD TR, which documents the transition from superseded to new revision. Included in this report should also be a presentation of results obtained by the quantification of updated model, their interpretation and evaluation of new risk profile. In this manner, series of reports that document the transitions to new revisions of Baseline PSA Model would provide means for tracking the changes in long-term risk due to plant changes. This would make the Baseline PSA Model suitable tool for risk-informed decisions in accordance to the widely accepted guides, such as US NRC Regulatory Guide 1.174 [6]. Tracking changes in risk that are due to plant changes would provide a mechanism to account for the cumulative and synergistic effects of the plant changes and would demonstrate the risk management philosophy at NEK.

5. Conclusions

The living PSA concept at NPP Krško defines the process by which baseline PSA model is maintained to be up-to-date with plant design and operational practice and to reflect the current state of PSA methodology. It makes the PSA model a suitable basis for variety of risk-informed applications according to widely accepted practices and provides means for tracking the changes in long-term risk profile.

6. References

[1] "NEK Baseline PSA Model Update", NEK ESP-2.401, draft

[2] "NE Krško PSA Project Summary Report", NEK ESD TR-14/97, Revision 0

[3] "Authorization of Changes, Tests and Experiments (10 CFR 50.59)", NEK ESP-2.303, Revision 2

[4] "NEK PSSA Final Report", NEK ESD TR-10/98, Revision 0

[5] "PSA Data Collection and Analysis Guideline", NEK ESP-2.315, Revision 0

[6] "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis", US NRC Regulatory Guide 1.174, July 1998