Workshop

Basics of Safety Assessment of LWR Nuclear Power Plants

Time: 14-18 October 2024

Place: Dubrovnik, Croatia

Organizer and Scope

The workshop is organized by APOSS, Croatia (https://aposs.hr/). Its scope covers basic elements of design basis safety assessment and evaluation of changes to licensing bases, introduction to content of Safety Analysis Report, basic elements of probabilistic risk assessment for internal and external events and introduction to usual risk-informed applications.

Lecturers

The lecturers will be **dr. Ivica Bašić** (principles of design bases and safety margin assessment in plant design and operation) and **dr. Ivan Vrbanić** (risk assessment and risk-informing principles in plant design and operation) from APOSS. Both lecturers have long time international experience with safety assessment and safety review, as well as lecturing and training on these topics.

Venue

Center for Advanced Academic Studies (CAAS)

Don Frana Bulića 4

20000 Dubrovnik

Croatia

http://www.caas.unizg.hr

Time-table and description of lectures are provided below. Training material (PDF) will be given to each participant at the end of the workshop.

Registration fee: 1700 euros per participant

To register or to inquire about any additional details, send a mail to:

basic.ivica@kr.t-com.hr (dr. Ivica Basic)

ivan.vrbanic@zg.t-com.hr (dr. Ivan Vrbanic)

Number of seats is limited. Make sure to register in time.

Basics of Safety Assessment of LWR Nuclear Power Plants: Time-Table of Lectures					
Time / day	**Monday (14-October)**	**Tuesday (15-October)**	**Wednesday (16-October)**	**Thursday (17-October)**	**Friday (18-October)**
9:00 – 10:30	Opening, Introduction of lecturers and participants - **All** **L1.** NPP (LWR) Systems and Their Design Bases - **I. Basic**	**L6.** Postulated Initiating Events (PIE) for Design Bases **– I. Basic** **L7.** Deterministic Safety Analyses (DSA) for DBC and PRA Level 1 **– I. Basic**	**L11.** NPP Abnormal and Emergency Operating Procedures **– I. Basic** **L12.** Severe Accident Management Guidelines **– I. Basic**	**L18.** NPP Technical Specifications (Operational Limits and Conditions) **– I. Basic** **L19.** Environmental and Hazard Zones **– I. Basic**	**L25.** Design Principles with Regard to Seismic Hazard and Other External Hazards **– I. Basic** **L26.** Extensive Damage Management Guidelines (EDMG) **–I. Basic**
10:30 – 11:00	**Break**	**Break**	**Break**	**Break**	**Break**
11:00 – 12:30	**L2.** Risk vs. Safety – Integral View - **I. Vrbanic**	**L8.** Initiating Events Analysis and Accident Sequence Modeling in PRA **– I. Vrbanic**	**L13.** Human Reliability Analysis (HRA) **– I. Vrbanic** **L14.** Reliability Data Collection and Analysis **– I. Vrbanic**	**L20.** Risk-Informing of TS, ISI and Safety Classification **– I. Vrbanic** **L21.** Principles of Internal Hazards PRA **– I. Vrbanic**	**L27.** Seismic PRA and PRA for Other External Hazards **– I. Vrbanic** Course Closing and delivering of certificates - **All**
12:30 – 14:00	**Lunch**	**Lunch**	**Lunch**	**Lunch**	**Adjourn**
14:00 – 15:30	**L3.** Methodology Elements for DBC Safety Margin Assessment **– I. Basic** **L4.** Safety Analysis Report (SAR) **– I. Basic**	**L9.** System Analysis in PRA **– I. Vrbanic**	**L15.** Safety Screening and Safety Evaluation of Proposed Plant Design Modifications and Other Changes to Licensing Bases **– I. Basic**	**L22.** Level 2 PRA Modeling and Quantification **– I. Vrbanic**	
15:30 – 16:00	**Break**	**Break**	**Break**	**Break**	
16:00 – 17:00	**L5.** Methodological Prerequisites and Main Elements of Risk Assessment **– I. Vrbanic**	**L10.** Safety Review over NPP Operational Lifetime **– I. Basic**	**L16.** Risk Model Integration, Quantification and Direct Applications **– I. Vrbanic** **L17.** Risk Significance of Operational Events and Issues **– I. Vrbanic**	**L23.** DSAs and Evaluations for Containment DBCs, Level 2 PRA and SAMGs **– I. Basic** **L24.** Aging Management and Life Extension Programs **– I. Basic**	

Basics of Safety Assessment of LWR Nuclear Power Plants

Description of Lectures

Principles of Design Bases and Safety Margin Assessment in Plant Design and Operation

Dr. Ivica Basic

L1. NPP (LWR) Systems and Their Design Bases (DB) (Focus on PWR)

Design basis concept; Plant states; System classification; Basic SSCs design (Core, RCS), Power conversion systems (FW, Condensate, TG…), Frontline safety systems (ECCS, EFW…), Support systems (ESW / CCW; AC/DC/EDG…) and containment systems.

L3. Methodology Elements for DBC Safety Margin Assessment

Defense-in-depth (DiD) concept, concept of safety margin; TH analyses methodology outline (computer codes, engineering handbook…); boundary and initial conditions; conservative vs best estimate; SFC; structural analyses, practical elimination concept.

L4. Safety Analysis Report (SAR)

Structure and content of SAR; cross-references; review of SAR; other Licensing Basis (LB) documents.

L6. Postulated Initiating Events (PIE) for DBC, DEC and SA

Postulation of IEs for DB analyses and verification of safety margins; categories / types of PIEs; ANS classes; selection of initiators and scenarios for Design Extension Conditions (DEC) and Severe Accident (SA) analyses.

L7. Deterministic Safety Analyses (DSA) for DBC and PRA Level 1

DBC DSAs for PIEs – demonstration of safety margin, examples; DSAs supporting Level 1 PSA: determining LOCA categories; system / sequence-level success criteria; time windows for operator actions (e.g., Feed and Bleed) and support system recovery (e.g. SBO)… Other DSAs…

Risk Assessment and Risk-Informing Principles in Plant Design and Operation

Dr. Ivan Vrbanic

L2. Risk vs. Safety – Integral View

Integrated view on risk; risk curve – exceedance frequency; Design Basis Condition (DBC) analysis vs. risk analysis; risk management concepts; deterministic criteria vs. prob. targets; elements of risk model; risk assessment methods; NPP risk metrics

L5. Methodological Prerequisites and Main Elements of Risk Assessment

Prerequisites: logic and probability elements; reliability modeling: non-repairable / repairable; reliability / availability; failure / repair intensities and rates. Overview of PRA elements. Level 1, Level 2 and Level 3 PRA; PRA standards and guides.

L8. Initiating Events (IE) Analysis and Accident Sequence Modeling in PRA

DBC vs beyond-DBC (DEC/SA) IEs in PRA; grouping and identification - methods; LOCAs and transients; LOCA classification for PRA; event trees (ET): LOCAs; transients, loss of offsite power (LOOP) / Station blackout (SBO); event sequence diagrams; DB vs Beyond-DB sequences; success criteria; (system-level and sequence-level); treatment of support system (small / large ETs).

Principles of Design Bases and Safety Margin Assessment in Plant Design and Operation

L10. Safety Review over NPP Operational Lifetime

Review of SAR changes; regulatory conformance programs; Periodic Safety Review (PSR); safety factors; findings, ranking of safety issues and corrective measures; safety upgrades and action plans.

L11. NPP Abnormal and Emergency Operating Procedures

Alarm Response Procedures (ARPs), Abnormal Operating Procedures (AOPs), Emergency Operating Procedures (EOPs): structure and technical bases; supporting deterministic analyses; verification and validation.

L12. Severe Accident Management Guidelines

SAMG structure and technical bases; supporting analyses; verification and validation

L15. Safety Screening and Safety Evaluation of Proposed Plant Design Modifications and Other Changes to Licensing Bases

Effects of proposed plant modification and related activities on the safety analyses contained in the SAR; process of screening / evaluation for proposed plant modifications / changes (various international practices: IAEA SSG-71, NEI 96-07, etc.); assessment of cumulative effects of modifications on the plant safety.

L18. NPP Technical Specifications (Operational Limits and Conditions)

Format, requirements and bases; concept of operational limits and conditions; safety limits; limiting settings for safety systems; surveillance and testing requirements; development of operating / inspection / testing procedures.

L19. Environmental and Hazard Zones

Principles for definition of EQ and hazard zones; supporting DSA analyses; principles for fire / explosion and flooding zones; qualification and survival ability assessment; walkdowns.

Risk Assessment and Risk-Informing Principles in Plant Design and Operation

L9. System Analysis in PRA

Fault Tree (FT) elements; top event and ET success criteria; basic events; FMEA: identification of component failure modes and support system requirements; human interface; main reliability models for basic events; common cause failure (CCF) importance and modeling; minimal cutsets (MCSs); examples.

L13. Human Reliability Analysis (HRA)

Types of human errors. Human failure event (HFE). Human error probability (HEP). Framework for modeling. General model. Quantification techniques.

L14. Reliability Data Collection and Analysis

Types of reliability parameters and data needed; estimators; plant specific vs generic data; grouping for data collection; parameter uncertainty; Bayesian analysis.

L16. Risk Model Integration, Quantification and Direct Applications

Model integration; master FT; top-level MCSs generation; preliminary quantification and refinements; risk profiling and identification of contributors; risk importance measures and criteria; risk-informed improvements; risk configuration monitoring.

L17. Risk Significance of Operational Events and Issues

Principles of probabilistic accident precursor assessment; initiator precursors; condition events; principles of risk significance determination of safety issues and findings.

L20. Risk-Informing of TS, ISI and Safety Classification

Risk-informing allowable outage times (AOT) and surveillance test intervals (STI); RI-ISI: likelihood vs consequence of pipe segment failure; risk-informing inspection requirements; RI classification: risk-importance categories.

L21. Principles of Internal Hazards PRA

Elements of internal fire PRA and internal flood PRA; plant partitioning; screening of areas; mapping of scenarios to PRA model; risk quantification.

Principles of Design Bases and Safety Margin Assessment in Plant Design and Operation

L23. DSAs and Evaluations for Containment DBCs, Level 2 PRA and SAMGs

DBC DSAs for containment structures and systems; supporting evaluations for Level 2 PRA: in-vessel and ex-vessel phenomenology; supporting DSAs for plant damage states and APET, including source term analyses; application to SAMGs.

L24. Aging Management and Life Extension Programs

Features of an ageing management program; aging considerations during design development; degradation mechanisms; integrity assessment of SSCs; regulatory frameworks on ageing management.

L25. Design Principles with Regard to Seismic Hazard and Other External Hazards

Site evaluation; engineering design rules, design provisions against external events; seismic design and qualification; design extension conditions for external hazards.

L26. Extensive Damage Management Guidelines (EDMG)

EDMG structure and bases; mobile equipment and connections; verification and validation; accessibility to plant areas.

Risk Assessment and Risk-Informing Principles in Plant Design and Operation

L22. Level 2 PRA Modeling and Quantification

Plant damage states (PDS) analysis; accident progression event tree (APET); probabilities of phenomena; concept of convolution of load and capacity; probability of hydrogen combustion; containment pressure fragility; radioactivity release risk model integration and quantification; risk metrics; uncertainty; results evaluation.

L27. Seismic PRA and PRA for Other External Events (OEE)

Seismic hazards curve; seismic fragility curves; induced initiating events; seismic initiating event tree; seismic risk model integration and quantification: convolution of hazard and fragility; OEE screening; OEE hazard and vulnerability assessment; bounding or detailed risk quantification;