Multinational Design Evaluation Programme

EPR Working Group

Closure Report

Related to Design-Specific Working Group Activities

MDEP EPR Working Group (EPRWG)
Closure Report
Activities and outcomes 2008-2021

Activities and outcomes of the Multinational Design Evaluation Programme
EPR Working Group
2008-2021

1) Purpose

This report is a record of the activities of the MDEP EPR Working Group (EPRWG), its products and other related information. This closure report sets down a framework enabling a future working group on EPR to be re-established with significant grounding that will accelerate its future work programme. This report summarises the successes as well as the challenges and lessons learnt of the design-specific working group (DSWG) and provides recommendations for further work that lay outside the terms of reference of MDEP.

2) History of the DSWG

The interest in co-operating through an MDEP working group on the EPR reactor design safety issues was initially raised in January 2008 by the nuclear safety authorities of Finland (STUK), France (ASN), and the US (NRC). The nuclear safety authorities of the UK (ONR), China (NNSA) and Canada (CNSC) joined soon after during 2008 and 2009. Sweden (SSM) joined the EPRWG in 2013 and India (AERB) in 2012.

In 2012, CNSC completed its EPR review and then left the EPRWG. In 2016, US NRC announced they will no longer participate to the DSWG activities due to the suspension of the design review.

In 2019, with the withdrawal of the EPR project in Sweden, SSM left the DSWG.

The first meeting took place in January 2008.

In order to look at certain aspects of the design in more detail, the group set up a number of technical expert subgroups (TESGs) to support and discuss on a detailed technical level.

The following technical expert subgroups were agreed at the first meeting:

- Digital I&C
- Emergency core cooling system (ECCS) performance
- Large break loss of coolant accident (LBLOCA) methodology
- Severe accidents
- Criticality safety during fuel load
- Probabilistic safety analysis

However, a number of these (ECCS performance, LBLOCA methodology and criticality safety during fuel load) were soon combined into the accident and transient TESG. A further TESG was agreed in 2016 on commissioning activities. This led to the following five TESGs that operated until late in the EPRWG programme:

- Accident and Transients (A&T TESG)
- Commissioning Activities (CA TESG)
- Digital Instrumentation and Control (DI&C TESG)
- Probabilistic Safety Analysis (PSA TESG)
- Severe Accidents (SA TESG)

The long-term objectives of the EPRWG were:

- Leverage national regulatory resources by sharing information and experience on the regulatory safety design reviews and commissioning of the EPR with the purposes of enhancing the safety of the design and enabling regulators to make timely licensing decisions to ensure safe designs through:

- exchanging experience on licensing processes and design reviews, lessons learnt, and design-related construction, commissioning, and operating experience;
- working to understand the differences in regulatory safety review approaches in each country to support potential use of other regulators' safety design evaluations, where appropriate; and
- looking for opportunities to provide input to issue-specific working groups on potential topics of significant interest.

- Promote safety and standardisation of designs through MDEP co-operation (consideration should be given to promoting harmonisation of regulatory practices where there may be a safety benefit) through:
  - identifying and understanding key design differences including those originating from regulatory requirements and then documenting the reasons for differences;
  - documenting common MDEP positions on aspects of the review to enhance safety and standardisation of designs;
  - communicating and coordinate communications on MDEP views and common positions to vendor and operators regarding the basis of safety evaluations and standardisation; and
  - using experience gained in learning about similarities and differences between the designs as a result of different licensing frameworks to identify impediments to further standardisation of the EPR design.

Between 2008 and 2021, a substantial number of interactions between the EPRWG members and the vendors/licensees (EPR Operators and Owners Group (OOG)) took place, followed by detailed collaborative analyses of the responses by the EPRWG members. This work resulted in a series of detailed technical reports (TR) and Common Positions (CP) of the EPRWG designs, which are summarised below.

In 2020, the group reviewed the need for further work of its members and concluded their Programme Plan had been accomplished and that there were no tasks to take forward within the MDEP framework. The group identified a significant number of issues of interest to EPRWG and operating PWRs that were outside design assessment, particularly related to sharing operational experience from commissioning and early operation of the EPRs, thus outside the MDEP scope of work. These are presented in Section 8 of this report. The group considered that these could be of interest to a broader membership and it encouraged the Steering Technical Committee (STC) and policy Group (PG) to consult the NEA Secretariat on the possibility of transferring these issues to be addressed in a regulators forum, or equivalent, within NEA.

Although the long-term goals remained unchanged, the following factors needed to be considered regarding future activities:

- The MDEP STC and PG required the DSWG and its TESG to close if:
  - There were no activities of interest, that (a) were within the purview of MDEP or (b) could be resourced, that would deliver a product for the group within a two-year timescale;

- There were no activities in the plans of the individual regulators within the group that would lead to collaborative work within a two-year timescale;
- There were no anticipated activities of interest, that (a) were within the purview of MDEP and/or (b) could be resourced, that would deliver a product for the group that would commence within a timescale of two years.

EPRWG members decided that the group and its supporting TESGs had no continuing work programme or the possibility, within the following two years, of initiating a potential new work programme within the terms of reference of MDEP and thus there was no justification to the DSWG.

The members also determined that the evidence supported decisions to:

- Close all TESGs with the exception of the CA TEWG, although this was merged with the EPRWG in late 2021;
- Request the STC to endorse the conclusion that the EPRWG should hold no further meetings under MDEP framework;
- Advice the STC to recommend to the PG that the EPRWG be closed, having completed its tasks within the framework of MDEP.

Both the MDEP STC and PG accepted the recommendation and the EPRWG was closed on 31 December 2021 with a direction that the group produce a closure report highlighting its successes and recommendations for any future work that lay outside the terms of reference of MDEP.

3) Successes of the DSWG

From 2008 to 2021, the EPRWG and its TESGs issued the following outcomes.

Common Positions

The purpose of common position papers is to identify common positions among the regulators reviewing the EPR accidents and transients in order to:

- Promote understanding of each country's regulatory decisions and basis for the decisions;
- Enhance communication among the members and with external stakeholders;
- Identify areas where harmonisation and convergence of regulations, standards, and guidance can be achieved or improved; and
- Supports standardisation of new reactor designs.

Common position 01 (CP-EPWWG-01): EPR instrumentation and controls design
(www.oecd-nea.org/mdep/documents/CPEPRWG01_I&C_2020.pdf)

This common position identifies the areas of common agreement between regulatory bodies regarding the EPR I&C design, that were identified during DI&C TESG interactions.

Common position 02 (CP-EPWWG-02): Addressing Fukushima Daiichi-related issued
(www.oecd-nea.org/mdep/documents/CP-EPRWG-02-addressing-fukushima-related-issues-v6-September2015.pdf)

This common position identifies common preliminary approaches to address potential safety improvements for EPR plants, as well as common general expectations for new nuclear power plants, as related to lessons learnt from the Fukushima Daiichi accident or Fukushima Daiichi-related issues.

The following areas are also explored in the paper:

- arrangements for long-term loss of electrical power (supplies and distribution systems) to ensure long-term decay heat removal;
- reliability and qualification of severe accident management instrumentation;
- management of pressure in-containment during severe accidents;
- long-term cooling of spent fuel pool, reliability of cooling and make-up water systems, instrumentation and hydrogen management; and
- management of primary circuit residual heat removal and sub-criticality.

Common position 03 (CP-EPRWG-03): EPR containment mixing
(www.oecd-nea.org/mdep/documents/2015-03-16_CP-EPRWG-03-common-position-containment-mixing-March2015.pdf)

This common position examined the two-room concept in the containment of the EPR, which differs from many typical pressurised water reactor containments, and in particular the use of the CONVECT system in the EPR to promote heat transfer and mixing in accident conditions. The EPR two-room concept allows personal access to the outer room whilst the reactor is at power.

Common position 04 (CP-EPRWG-04): EPR containment heat removal system in accident conditions
(www.oecd-nea.org/mdep/documents/2015-03-16_CP-EPRWG-04-common-position-CHRS-SAHRS_March2015.pdf)

This common position compares and discusses the containment heat removal system across the different EPR reactors, including the regulatory requirements, EPR design and compliance with the regulatory requirements and the safety authorities' positions. It outlines the general expectations regarding containment integrity, and summarises the main EPR design characteristics regarding containment integrity to prevent and mitigate the consequences of severe accidents.

Common position 05 (CP-EPRWG-05): IRWST pH control in accident conditions
(www.oecd-nea.org/mdep/documents/2015-03-16_CP-EPRWG-05-common-position-IRWST-ph-Control-March2015.pdf).

This common position compares and discusses the different approaches to control IRWST pH in the EPR plants, and notes the importance of pH control.

Common position 06 (CP-EPRWG-06): EPR boron dilution during a small break loss of coolant accident (SB-LOCA)
(www.oecd-nea.org/mdep/documents/CP-EPRWG-06_Boron_dilution.pdf)

The potential for rapid reactivity insertion due to inherent boron dilution resulting from a Small Break Loss of Coolant Accident (SB-LOCA) is of significant safety importance. The aim of this paper is to represent the common position developed by the participating regulators to ensure consistency in the assessment of this aspect of the design.

Common position 07 (CP-EPRWG-07): addressing the Vienna Declaration on nuclear safety
(www.oecd-nea.org/mdep/documents/CP-EPRWG-07%20Vienna%20Declaration%20on%20Nuclear%20Safety.pdf)

This common position summarises the regulators' views on how the EPR design complies with the Vienna Declaration.

MDEP generic common position 01 (CP-STC-01): First-Plant-Only-Tests (FPOT)
https://www.oecd-nea.org/mdep/documents/CP-STC-01-FPOT-rev1_April_2018.pdf

This common position provides high-level guidance to applicants and licensees that wish to take credit for a FPOT performed during the commissioning of the first unit of a similar type.

Technical Reports

Technical Report 01 (TR-EPRWG-01): Regulatory approaches and criteria used in the analysis of accidents and transients in MDEP EPRWG member countries
(www.oecd-nea.org/mdep/documents/EPR-Survey-Regulatory-Approaches.pdf)

This report summarises key aspects of practices used by the regulatory agencies in evaluation of safety analyses in support of licensing (or certification) of the EPR.

Technical Report 02 (TR-EPRWG-02: Insights from PSA Comparison in Evaluation of EPR Designs, paper presented by the Chairman of the EPR technical experts' subgroup on probabilistic safety assessment at the PSAM 12 meeting in June 2014 (Update of 20 November 2014) (www.oecd-nea.org/mdep/documents/PSAM-12-PSA.pdf)

Technical Report 03 (TR-EPRWG-03): the definition of primary coolant source terms used in the different EPR designs for shielding, radiation zoning, DBA consequences
(www.oecd-nea.org/mdep/documents/TR-EPRWG-03-Source-term-survey_May2015.pdf)

This report considers the way EPR primary coolant source term was elaborated and used in the different countries at the design stage. It identifies main discrepancies and their origin. Discrepancies are not really linked to the EPR design but on historical practices, feedback available and different used methods.

Technical Report 04 (TR-EPRWG-04): Limited Comparison of EPR™ Probabilistic Safety Assessment
(www.oecd-nea.org/mdep/documents/2017-11-30%20TR-EPRWG-04%20Limited%20Comparison%20of%20EPR%20PSA.PDF)

This report describes the outcome of a limited PSA comparison on the following EPR designs: Olkiluoto 3 Nuclear Power Plant (NPP) in Finland, Flamanville 3 NPP in France, UK EPR design, and U.S. EPR design. Originally, Taishan NPP Unit 1 (TSN, China) was not part of the comparison but it was later added for the comparison of I&C, HVAC and fuel pool cooling systems. The objective of this comparison was to identify differences in the modelling aspects and results of EPR PSAs, as well as to assess the rationale for these differences. The comparison covered various types of initiators challenging a broad scope of safety functions. Insights from the EPR PSA comparison and rationale for the differences originated from modelling assumptions, applied reliability data, designs, and operational aspects. The EPR designs chosen for comparison represents various design and licensing stages, as well as level of detail, which gives the main rationale for the identified differences. The main comparison work was performed a few years ago and therefore the most recent developments in the EPR design and PSA models are not reflected or discussed in this report.

Technical Report 05 (TR-EPRWG-05): FPOT considered for EPR
(www.oecd-nea.org/mdep/documents/EPRWG-EPR05-EPR-for-FPOT.pdf)

This report provides background to FPOTs and the development of the generic FPOT CP, and the planned EPR FPOTs. It then describes the CA TESG observation of the Taishan unit 1 special vibration measurements on the reactor pressure vessel internals (RPVI) FPOTs and the lessons learnt associated with the practical arrangements that should be considered when preparing to observe any future FPOTs.

Technical Report 06 (TR-EPRWG-06): hydrogen management for EPR
(www.oecd-nea.org/mdep/documents/EPRWG06_TechnicalReport_Hydrogen_Management.pdf)

This report identifies what is common and what is different between the EPR designs related to hydrogen management, focusing mainly on hydrogen Passive Autocatalytic Recombiners (PARs). During the course of a severe accident large amounts of hydrogen could be generated and released into the containment during reactor core degradation.

Technical Report 07 (TR-EPRWG-07): EPR assessment of 2A large break loss of coolant accident analysis
(www.oecd-nea.org/mdep/documents/EPRWG07_TechnicalReport_2A%20LOCA_public.pdf)

This report presents the work carried out by regulators to demonstrate a common understanding of the response of a generic EPR plant following a double-ended Large Break Loss of Coolant Accident (LOCA) referred to as "2A-LOCA" and how this has been addressed within the safety submissions supporting the EPR reactor design.

- Major technical issues discussed during EPRWG including TESG meetings

In addition to the development of common positions and technical reports a large number of other technical topics and issues have been discussed, which are captured in the summary meeting records and meeting papers.

The TESG meetings have also discussed many technical topics, with the key ones being summarised in Appendices A to E.

- The group encouraged the appropriate inclusion through discussion and advice of the following within its activities where appropriate:
  - CNRA (WGRNR, WGCS, WGDIC);
  - Vendors, utilities and licensees and other applicants/licensees/operators, as applicable.
- Identified a number of recommendations and inputs to other issue and design-specific MDEP working groups regarding potential generic issues and harmonisation opportunities – from 2008 to 2021.

In addition to the successes outlined above, many successes were achieved within the TESGs, in particular relating to having a common understanding on technical aspects of the EPR design and regulatory positions on these; these are summarised in Appendices A to E. TESGs have supported and aided regulatory harmonisation in a broad range of topics and have produced a significant number of outputs developed by sharing regulatory knowledge and experience. The discussions have been supplemented by the sharing of independent confirmatory analysis commissioned to support regulatory assessments.

Other key successes facilitated by the EPRWG included:

- Having a structured information sharing platform. The regulators benefitted greatly when they were able to compare on the one hand different requirements in different countries, and on the other hand similar and different technical solutions created by plant supplier.
- Technical exchanges with the licensees and vendors in different countries. This included engaging with the EPR Owners and Operators Group (OOG) and visits to the EPR construction sites including direct engagement with the relevant licensee; this is discussed in more detail in Section 6. The construction site visits allowed direct and

open engagement with the local licensees, sharing of relevant operational experience and also observation of the EPR projects at the different stages of their construction, and gathering the relevant learning. The meetings with industry (OOG) allowed the EPRWG to explore the justification and rational for a number of differences between the EPR designs.

- Co-operation between regulators to provide a means for the regulators to leverage resources and to focus design reviews on safety issues in areas that are critical to making licensing decisions in member countries.

4) Challenges or limitations

The key challenges and limitations were:

- The EPR projects were at different stages and therefore the regulators were at different stages of assessment. This inhibited the level of engagement and the information that could be shared. Subjects were not always topical for all members. A proportionate approach had to be taken regarding the level of detail that could be presented in reports and caveats added where assessments were less advanced in some regulatory bodies.
- Resource availability of country members to progress MDEP products in a timely manner was always a challenge due to the significant demands on members' time within their regulatory bodies. A realistic programme of work had to be developed that prioritised areas of interest.
- Different regulatory frameworks limited what could be achieved in terms of harmonisation. Within EU members this was slightly easier thanks to WENRA and ENREG. This meant working towards consensus where possible and a focus on high-level outcomes. In some cases, CPs could not be produced, or were at high-level, and instead technical reports were produced that could explore the basis of differences. The members had to be realistic about what could be achieved.
- Licensees cannot share information about other EPR projects to their national regulator. However, this challenge has been overcome through the MDEP framework by allowing regulators to openly discuss and share information freely. It has given us a good understanding of progress, challenges and issues across all EPR projects. This sharing challenge is also a success of the EPRWG. This has further been a success by arranging meetings near to the different EPR projects, allowing open engagement with foreign licensees that would otherwise have been very difficult outside the MDEP framework.
- Sharing detailed design-specific information between regulators remained a challenge. Although one of the main objectives of MDEP co-operation was to enhance the sharing of information, this goal was reached only partially, since in all member countries some information is categorised as proprietary and/or confidential. Distribution of this kind of sensitive information proved too difficult even within the MDEP framework and thus limited the scope and details of some activities and slowed down the work process. Thus, for example, the PSA TESG was able to partially use the MDEP Library for storing and sharing documents. To overcome the apparent obstacles in sharing of proprietary and/or confidential information, we engaged directly with the EPR vendors and licence applicants and invited them to discuss and provide additional details on selected topics. With their approval some of the detailed PSA information could be utilised by the TESG

members. Furthermore, another factor enabling better sharing of information and insights was the co-operation with other EPRWG and joint meetings. The overall conclusion was very positive, and all participants felt that these joint meetings provided useful insights for the EPR safety reviews.

5) Lessons learnt

The nature of the interactions within the EPRWG, including the TESGs, has allowed significant technical issues and concerns to be shared and discussed, increasing the efficiency and effectiveness of design assessment work by individual regulators as they could learn from and take some credit for the progress already made and conclusions reached without repeating all the work, notwithstanding the different regulatory regimes.

Appendices A to E provide a detailed summary of the regulatory and technical issues that were discussed and the outcomes achieved that will allow future members from spending significant resources on the same or similar issues.

Ensuring the right people were available to engage on technical topics was critical, which included arranging EPRWG and TESG meetings in different locations, close to regulator offices or site, in countries where the topic of interest was more pertinent. This enabled members to be supported by relevant specialists and more detailed and productive engagements to take place.

Similarly, arranging site visits and workshops with the EPR OOG allowed regulators to engage with licensees their country and more open access to information.

TESGs were also found to be critical to the success of the EPRWG as it allowed the specialists from within regulators to explore topics in much more detail than could be by EPRWG members alone. This allowed more fruitful discussions.

6) Interactions with stakeholders

In addition to engagement between regulators, the EPRWG regularly met the EPR Operating Owners Group (OOG) in order to discuss with vendors and utilities. Moreover, the EPR OOG also provided feedback on products (CPs and TRs) issued by the EPRWG.

A number of in-depth workshops were held with the EPR OOG:

May 2019 workshop; focused on:

- General commissioning and early commercial operations
- Reactor physics data

Nov 2016 meeting, focused on:

- First-plant-only-tests

In addition, TESG met EPR OOG representatives at several occasions in order to address a specific topic or to discuss an outcome. The list of meetings is provided in TESG closure reports.

EPRWG also met external stakeholders on a regular basis.

7) Location of MDEP DSWG information and reports

The information regarding all MDEP EPRWG activities is held within the dedicated portion of the MDEP Library. The MDEP Library is managed by the secretariat, the OECD Nuclear Energy Agency (NEA). According to the MDEP terms of reference, permission to access the information should be sought through the NEA which has an agreed protocol for seeking permission to allow access from the relevant member countries via the MDEP STC and PG.

The MDEP Library contains the meeting records for each EPRWG and TESG meeting, which provides a summary of the main areas of engagement, which includes supporting information such as presentation slides and papers considered during the meetings. Other key information is contained in the products (CRs and TRs) summarised in Section 3.

8) Recommendations generated by the DSWG for further work

The following topics are recommendations for further work from the EPWG that fall within design but are considered outside the terms of reference of MDEP.

They have been set down according to the lifecycle of a nuclear power reactor:

Design

The design was one of the main scope of discussion with the EPRWG. However, members would be interested to continue discussing design evolution after commissioning.

Commissioning experience

Commissioning experience was one of the key topic of discussion within the EPRWG but also within the CA TESG. This topic will continue to be addressed as long as country members are interested in sharing on this topic.

Operational experience

Operational experience was out of the scope of MDEP activities. However, operation of TSN unit 1 and 2 generated a lot of discussion and very valuable lessons learns have been shared. Members expect to learn from Finish, French and British reactors' operation as well. That is one of the main reason that justified the request from the EPRWG to continue its activities under CNRA.

9) Conclusion

The nuclear safety authorities of China (NNSA), Finland (STUK), France (ASN) and UK (ONR) published their EPR safety evaluation reports and granted construction and operating licences.

The EPRWG successfully:

- Achieved its main goal of developing co-operation between member regulators on topics of interest and value within the scope of the MDEP;
- Generated a number of reports on those topics as well as contributing to the MDEP task of determining common positions related to the Fukushima Daiichi Nuclear Power Plant accident and the Vienna Declaration;
- Identified a number of MDEP DSWG tasks that might be followed when member country build programmes are at the right point;
- Identified a number of tasks that could be progressed in a forum with wider membership;
- Shared these proposals with a wider forum in the CNRA;

This closure report provides a framework to enable MDEP members to re-establish a DSWG for this design with significant grounding to facilitate its future programme of work at the corresponding time.