

Multinational Design Evaluation Programme APR1400 Working Group Closure Report

Related to Design-specific Working Group Activities

APR1400WG Closure Report Activities and outcomes 2012-2021

**Activities and outcomes of the
Multinational Design Evaluation Programme
APR1400 Working Group
2012-2021**

1) Purpose

This closure report sets down a framework enabling a future WG on APR1400 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 APR1400WG 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 APR1400 Reactor design safety issues was initially raised in May, 2012 by the nuclear safety authorities of Republic of Korea (KINS and NSSC), United Arab Emirates (FANR), Finland (STUK), and the USA (NRC).

The first meeting took place in Daejeon, Korea in December 2012. At this meeting, the group accepted the generic terms of reference for MDEP design-specific working groups and agreed on its objectives to exchange information on the status of their projects and to provide general feedback from the design, construction, and manufacturing reviews.

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

- Accidents and Transients (A&T TESG)
- Severe Accidents (SA TESG)

In August 2015, with the withdrawal of the application for a construction licence for Olkiluoto Unit 4 project in Finland, STUK left the APR1400WG.

Between 2012 and 2021, a substantial number of interactions between the APR1400WG members and the vendors/licensees took place, followed by detailed collaborative analyses of the responses by the APR1400WG members. This work resulted in a series of detailed technical reports (TR) and Common Positions (CP) of the APR1400 designs. Appendix A includes a list of all TRs and CPs developed by the APR1400WG.

During this period, the regulatory agencies in three countries actively reviewed the licensing applications for the APR1400 reactors.

The UAE started construction of four APR1400 reactors at the Barakah nuclear power plant site in February 2010. Barakah Unit 1 was issued the operating licence in February 2020 and was connected to the power grid in August 2020. Barakah Unit 2 granted the operating license in March 2021.

Korea started construction of a total of 6 APR1400 reactors, such as Shin-Kori Unit 3&4, Shin-Hanul Unit 1&2, and Shin-Kori Unit 5&6, sequentially from 2010. The operating licences were issued for Shin-Kori Unit 3 and 4 in October 2015 and February 2019, respectively. In July 2021, the operating licence was issued for Shin-Hanul Unit 1. Three reactors, Shin-Hanul Unit 2 and Shin-Kori Unit 5&6, are under construction.

The USNRC received a design certification application for the APR1400 reactor in December 2014. In April 2019, Final Design Approval was issued, and Design Certification for APR1400 was finally published in August 2019

In 2019, given the complete of USNRC's APR1400WG Design Certificate Review and Rulemaking Process and USNRC's decision to reduce its participation in the activities of the APR1400WG, the WG had submitted a new configuration of the WG with two active participating countries (Korea and UAE) and one passive participating country (US). The MDEP Policy Group (PG) approved this new configuration at the 13th meeting in September 2019.

In 2020, the APR1400WG officially decided to close by 2021. This decision was consistent with the MDEP Steering Technical Committee (STC) and PG requirements. Therefore, APR1400WG 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 the corresponding TESGs;
- Request the STC to endorse the conclusion that the APR1400WG should hold no further meetings;
- Advise the STC to recommend to the PG that the APR1400WG be closed, having completed its tasks within the framework of MDEP.

Both the MDEP STC and PG accepted the recommendation and the APR1400WG 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 2012 to 2021, the APR1400WG and its TESGs issued the following outcomes:

- CP-APR1400WG-01, "Common Position Addressing Fukushima-Related Issues" was developed to identify the characteristics of post-Fukushima enhancements putting in place by each countries and set common position to achieve balanced and harmonised APR-1400 design. The common preliminary approaches are organised into five sections, namely, external hazards, reliability of safety functions, accidents with core melt, spent fuel pools, and emergency preparedness in design, supplemented by appendices. For each section, APR1400 specific design features was discussed with areas for further studies in appendices.
- CP-APR1400WG-02, "Common Position on the APR1400 Post Loss of Coolant Accident (LOCA) Strainer Performance and Debris In-vessel Downstream Effects" was developed in order to promote and understand each country's regulatory decision and basis and to aid in the assessment of ECCS performance considering debris effect and sump strainer, Also, the Common Position discussed the common regulatory position on the Sump Strainer Debris Bypass Testing, Fuel Assembly Head Loss Testing, Reactor Core Long Term Cooling Thermal-Hydraulic Analysis, and Risk Informed Approach and Margin Assessment Approach.
- CP-APR1400WG-03, "Common Position on the Fuel Thermal Conductivity Degradation (TCD)" was developed in order to promote and understand each country's regulatory decision and basis and to aid regulatory review of the issue. The issue was that irradiation damage and the progressive build-up of fission products in fuel pellets by

reactor operation result in reduced thermal conductivity of the pellets, which was not included in some existing fuel thermal performance analysis codes. The Common Position has a general position such that the degradation of the thermal conductivity with fuel burnup should be taken into account in an appropriate manner and the compliance with the acceptance criteria based on the evaluation should be confirmed. And a specific position such as a replacement of old fuel performance code with new codes having a capability to account the burnup effect was provided. As an interim approach, penalty to Peak Cladding Temperature (PCT) and Peak Local Oxidation (PLO) due to absence of the consideration of TCD in the old fuel analysis codes was also discussed.

- CP-APR1400WG-04, “Common Position on Irradiation Effect on the APR1400 Fuel Bundle Spacer Grid Strength” was developed in order to promote and understand each country’s regulatory decision and basis and to aid regulatory review of the issue. The issue was that the crush strength of fuel assembly spacer grids may decrease during the life of a fuel assembly, whereas, the review guidance currently used is based on an assumption regarding the combined effects of operating conditions on grid strength. It was also shown that the irradiation hardening also relaxes the coupling between the spacer grid and fuel rods. The combined effects of hardening and relaxation could lead to the reduction of the crush strength of fuel bundle spacer grids throughout the life cycle of the fuel. Therefore, it was specified as a general common position, that an evaluation of the spacer grid strength shall appropriately address the potential degradation of the spacer grid crush strength due to irradiation throughout the lifetime of a fuel bundle. In the common position, the methodology of demonstration approved by Korea, USA and UAE regulators was described including a series of tests on spacer grid and fuel assembly together with a re-analysis of the seismic/ LOCA response of the PLUS7 fuel in APR1400 design.
- TR-APR1400WG-01, “Design Description and Comparison of Design Differences between APR1400 Plants” This technical report documented differences in the design of APR1400s submitted for licensing applications. With APR1400s in different licensing stages among member countries, APR1400WG members identified design differences in order to better understand the associated rationale, such as design improvements or regulatory requirements which are different for each member countries.
- TR-APR-1400WG-02, “Technical Report on Background Information relevant to addressing Severe Accidents in the APR1400 design” This technical report was developed in recognition of differences in the governing legislative requirements of the country in which the APR1400 is to be constructed and operated, that largely influence the design and implementation of measures provided to prevent and/or mitigate the effects of Severe Accidents in Nuclear Power Plants. The report complied regulatory requirements applicable to Severe Accidents in APR1400WG member countries, Severe Accident prevention and mitigation features of the APR1400 designs, and the summary of codes, methodologies and counter-measures for severe accident analysis adopted for each APR1400WG member country.
- TR-APR1400WG-03, “Report on the findings of the review of the Moten Core Concrete Interaction (MCCI) phenomena for the APR1400” This technical report documented the technical assessments performed by KINS, FANR, and USNRC on the MCCI phenomena in their respective APR1400 designs. The report also summarised applicable regulatory requirements in each member country relevant to MCCI. FANR, KINS, and USNRC have concluded that the evidence provided by their respective

applicants is adequate to demonstrate that the applicable regulatory requirements are met and that the MCCI phenomena does not present an unacceptable threat to containment integrity.

- TR-APR1400WG-04, “Report on the Hydrogen Recombiner Survey Results for APR1400 design in place, or proposed, for the MDEP Member Countries” This technical report presented a common understanding of the regulatory requirements pertaining to the hydrogen control for the APR1400 designs of MDEP member countries (i.e., Korea, UAE, and USA). The contents and scope of the technical report was based on a survey on hydrogen control system conducted amongst the APR1400WG members which attempts to address specific regulatory requirements applicable in each country on hydrogen control, hydrogen control system design and implementation as well as its maintenance and availability.
- TR-APR1400WG-05, “Report on the Comparison of the Regulatory Requirements for Probabilistic Risk Assessment (PRA) of the APR1400 nuclear power plants, for the MDEP member countries” This technical report is prepared by KINS and FANR to compare regulatory requirements that are applicable to the PRA and to better understand the extent to which the PRA is used in each member country. The report documented each participating member countries assessment in a form of survey that compares the contents of the applicable regulations and regulatory guides, probabilistic safety goals, scope of PRA, quality control, technical adequacy, peer review, PRA maintenance and updates as well as the use of PRA for changes in licensing basis between KINS and FANR.

4) Challenges or limitations

The APR1400WG experienced a number of challenges over the course of the membership. They are briefly summarised below.

- In regard to the APR1400WG membership, there were changes in the composition of member countries over the years. Finland withdrew from the group due to the cancellation of their respective project related to APR1400, and the United States became an inactive member following the completion of their licensing work on APR1400 in the country. Such changes in the membership presented challenges in finalising reports at times. In particular, when contribution had already been made by an inactive member before the change in their membership status, the group needed to allow additional time for the inactive member to respond during the comment resolution period which affected effectiveness of the group in terms of scheduling of issuance of reports.
- Given the competing priorities and allocation of resources in each member country, there were inevitable changes to individuals representing the member countries, including the NEA secretariat assigned to the group. This presented additional learning curve for the new member to be kept up to date on group’s activities.
- On some topics that required sharing of detailed technical information, the group needed to consider sensitivity of information (e.g., export controlled information and commercial/ proprietary information) for the respective member country as it affected the scope of the work and contents of reports being prepared by the group.
- From early on through discussions, the group recognised differences in regulatory requirements and practices in each member country. Even with the same reactor type, the design can be partially changed in accordance with regulatory requirements in the

country. In addition, each country was at different stages of APR1400 licensing review through most of the period. Such differences affected the priorities and review areas for each member country and required the group to align the activities that benefited all members.

5) Lessons learnt

- The group found that understanding differences in regulatory requirements and practices in each member country early at the beginning was very helpful in planning the WG activities in such a way that allowed the group to focus more effectively on technical issues that are relevant to all members.
- It is very fruitful for countries with different regulatory experiences and regulatory systems to develop common position reports and technical reports through technical discussions on a common topic. The APR1400WG allowed the group to address safety significant issues common to all members, and in some instances, resolution of such issues had been reflected in the regulatory review of a member country. Regulatory co-operation and information exchange among countries need to be continuously expanded after the MDEP.
- Formation of technical expert subgroups (TESGs) within the WG allowed members to stay focused on specific areas of interest and facilitated many useful discussions that benefited all member countries. Sharing technical discussions on current issues and operational experiences were especially helpful for member countries who were at different stages of licensing reviews.

6) Interactions with stakeholders

The co-operation of the stakeholders (i.e., KEPCO, KNF, and KHNP) has been essential in the success and accomplishment of the APR1400WG. However, it is worthwhile noting that there has been an unwillingness from stakeholders to include proprietary information in some common position papers, e.g., Common Position on Irradiation Effect on the APR1400 Fuel Bundle Spacer Grid Strength. Through discussion with stakeholders, APR1400WG decided to include only information necessary to understand the common position, such as the testing processes and response analysis. In addition, APR1400WG allowed in principle the deletion of proprietary information in common position papers and technical reports to protect the stakeholders.

7) Location of MDEP DSWG information and reports

The information regarding all MDEP APR1400WG 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 records for each APR1400WG and TESG meeting, which includes a summary of the main area of engagement and supporting information such as presentations and documents considered during the meeting. Other key products (Common Positions and Technical Reports) are also contained.

8) Recommendations generated by the DSWG for further work

The following topics are recommendations for further work from the DSWG 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

- New types of fuel designs (i.e., Accident Tolerant Fuels with new cladding and fuel pallet designs)

Construction experience

- Sharing of issues occurred during construction
- Impact of deficiencies in construction on the safe long term operation (e.g., voiding in containment building concrete ...)

Commissioning experience

- Sharing of specific APR1400 commissioning challenges and lessons learnt

Operational experience

- Changes to technical specifications

Decommissioning

- Developing design for decommissioning

The following APR1400WG TESSG topics are recommendations for further work that fall within design but are considered outside the terms of reference of MDEP.

Accidents management program

- Regulatory Review and Practices for Accident Management
- Regulatory Review and Applications of PRA
- Operating Limits and Conditions for Severe Accidents

9) Conclusion

The nuclear safety authorities of Rep. of Korea (KINS), United Arab Emirates (FANR), and USA (NRC) published their APR1400 safety evaluation reports and granted construction and operating licences on Shin-Kori Units 3 and 4, and Shin-Hanul Unit 1 in Korea; Barakah Units 1 and 2 in UAE; and Design Certification Rule for the APR1400 Design (10CFR52 Appendix F) in USA.

The APR1400WG 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;
- 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.

Appendix A

Report #	Title
CP-APR1400WG-01	Common Position Addressing Fukushima-Related Issues www.oecd-nea.org/mdep/common-positions/cp-apr1400wg-01-common_position_fukushima.pdf
CP-APR1400WG 02	Common Position on the AP1400 Post Loss Of Coolant Accident (LOCA) Strainer Performance and Debris In-vessel Downstream Effects www.oecd-nea.org/mdep/common-positions/cp-apr1400wg-02-debris-common-position.pdf
CP-APR1400WG-03	Common Position on the Fuel TCD www.oecd-nea.org/mdep/documents/DCP-APR1400-Fuel_Thermal_Conductivity_Degradation.pdf
CP-APR1400WG-04	Common Position on Irradiation Effect on the APR1400 Fuel Bundle Spacer Grid Strength www.oecd-nea.org/mdep/common-positions/cp_apr1400wg_01_fuel%20seismic.pdf
TR-APR1400WG-01	Design Description and Comparison of Design Differences between APR1400 Plants www.oecd-nea.org/mdep/documents/TR-APR1400-01%20Design%20Description%20and%20Comparison%20of%20Design%20Differences.pdf
TR-APR-1400WG-02	Technical Report on Background Information relevant to addressing Severe Accidents in the APR1400 design www.oecd-nea.org/mdep/documents/2017-11-30%20TR-APR1400-02%20on%20the%20comparison%20of%20the%20prevention%20and%20mitigation%20measures%20against%20severe%20accident.pdf
TR-APR1400WG-03	Report on the findings of the review of the MCCI phenomena for the APR1400 www.oecd-nea.org/mdep/documents/TR-APR1400-03%20on%20the%20findings%20of%20the%20review%20of%20the%20MCCI%20phenomena.pdf
TR-APR1400WG-04	Report on the Hydrogen Recombiner Survey Results for APR1400 design in place, or proposed, for the MDEP Member Countries www.oecd-nea.org/mdep/documents/TR-APR1400WG-04_hydrogenrecombiner_surveyreport_FINAL.pdf
TR-APR1400WG-05	Report on the Comparison of the Regulatory Requirements for PRA of the APR1400 nuclear power plants, for the MDEP member countries www.oecd-nea.org/mdep/documents/TR-APR1400WG-05_ComparisonRegulatoryRequirements_PRA_NPP_Final.pdf