Multinational Design Evaluation Programme

HPR1000 Working Group

HPR1000WG Closure Report: Activities and Outcomes 2017– 2026

Countries involved in the MDEP working group discussions:	ARN (Argentina), NNSA (People's Republic of China), NNR (South Africa)

Contents

List of abbreviations and acronyms

ARN	*Autoridad Regulatoria Nuclear* (Nuclear Regulatory Authority, Argentina)
CGN	China General Nuclear Power Corporation
CNNC	China National Nuclear Corporation
CP	Common Position
DAC	Design Acceptance Confirmation
DSWG	Design Specific Working Group
EA	Environment Agency
FSAR	Final Safety Analysis Report
GDA	General Design Assessment
HPR1000WG	Working Group on HPR1000 Reactor
Hz TESG	Internal and External Hazards Technical Expert Subgroup
IAEA	International Atomic Energy Agency
IRWST	In-Containment Refuelling Water Storage Tank
IVR	In-Vessel Retention
LOCA	Loss of Coolant Accident
MB	Management Board
MDEP	Multinational Design Evaluation Programme

NNR	National Nuclear Regulator (South Africa)
NNSA	National Nuclear Safety Authority, (China)
NEA	OECD Nuclear Energy Agency
ONR	Office for Nuclear Regulation, (United Kingdom)
PARs	Passive Autocatalytic Recombiner
SAMGs	Severe Accident Management Guidelines
SA TESG	Severe Accidents Technical Expert Subgroup
SoDA	Statement of Design Acceptability
TESG	Technical Expert Subgroup
TR	Technical Report
WG	Working Group

1. Purpose

This closure report sets down a framework enabling a future Working Group on Hualong One 1000 Mwe (HPR1000WG) 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 HPR1000WG and provides recommendations for further work that lay outside the terms of reference of Multinational Design Evaluation Programme (MDEP).

2. History of the Design Specific Working Group (DSWG)

The interest in co-operating through an MDEP working group on the HPR1000 reactor (hereafter HPR1000WG) design safety issues was initially raised in September 2017 by the nuclear safety authorities of Argentina (*Autoridad Regulatoria Nuclear*, ARN), China (National Nuclear Safety Authority, NNSA), South Africa (National Nuclear Regulator, NNR) and the United Kingdom (UK) (Office for Nuclear Regulation, ONR).

Picture 1. First HPR1000WG Meeting, Beijing, China

The first meeting took place in Beijing, China, in March 2018. 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 consider 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:

- Internal and External Hazards (Hz TESG)
- Severe Accidents (SA TESG)

In 2022, with the completion of the General Design Assessment (GDA) for the HPR1000 in the UK and the termination of the HPR1000 nuclear power project in that country, the ONR left the HPR1000WG.

Between 2017 and 2026, a substantial number of interactions between the HPR1000WG members and the vendors/licensees took place, followed by detailed collaborative analyses of the responses by the HPR1000WG members. This work resulted in a series of detailed technical reports (TR) and Common Positions (CP) of the HPR1000 designs. Appendix A includes a list of all TRs and CPs developed by the HPR1000WG.

During this period, the regulatory agencies in two countries actively reviewed the licensing applications for the HPR1000 reactors.

In the UK, the GDA review for the HPR1000 officially commenced on January 19, 2017. On January 19, 2022, the ONR and the Environment Agency (EA) respectively issued the Design Acceptance Confirmation (DAC) and the Statement of Design Acceptability (SoDA).

China has completed a total of 8 HPR1000 reactors operation license safety reviews, such as Fuqing unit 5&6, Fangchenggang unit 3&4, Zhangzhou unit 1&2, Taipingling unit 1, and Sanao unit 1. The operating licenses were issued for Fuqing unit 5 and 6 in September 2020 and November 2021, respectively. The operating licenses were issued for Fangchenggang unit 3 and 4 in November 2022 and February 2024, respectively. The operating licenses were issued for Zhangzhou unit 1 and 2 in October 2024 and October 2025, respectively. The operating licenses were issued for Taipingling unit 1 and Sanao unit 1 both in December 2025. Now, all these 8 reactors have been put into operation.

In 2022, the HPR1000WG discussed its status and future work direction. Given that the UK

has completed the GDA for the HPR1000, the UK HPR1000 project has been terminated, and the ONR has decided to withdraw from the HPR1000WG. The Hz TESG and the SA TESG considered that all established tasks have been completed with no pending work remaining and thus decided to close these TESGs. The closure was officially approved by the HPR1000WG in November 2022.

By the end of 2024, considering that 7 HPR1000 units have entered the operation phase globally, and that the technical documents planned by the HPR1000WG have been basically completed, with the established tasks fulfilled, the conditions for closing the working group were met and the HPR1000WG submitted a request for closure to the Management Board (MB). The 8th MB meeting, held in December 2024, required the HPR1000WG to hold a meeting to assess whether the working group's objectives have been achieved and whether to close the working group.

On December 16, 2025, the HPR1000WG held the 12th meeting and officially decided to close the working group in 2026 and reported the decision to the MB on December 17, 2025. Members of the HPR1000WG believe that currently, in the light of 10 HPR1000 units having entered the operation phase, the technical documents planned by the working group having been concluded, and the established tasks of the working group having been completed, the conditions for termination of the working group have been met.

The members also determined that the evidence supported the decisions to:

- Close the corresponding TESGs;
- Request the MB to acknowledge that the HPR1000WG has completed its tasks within the MDEP framework and no longer needs to convene, and to agree to its closure.

3. Successes of the DSWG

From 2017 to 2026, the HPR1000WG and its TESGs issued the following outcomes:

(a) CP-HPR1000WG-01, "Common Position Addressing Fukushima Daiichi NPP Accident-Related Issues" was developed based on lessons learned from the Fukushima Daiichi accident to establish common preliminary approaches and regulatory expectations for HPR1000 safety improvements. CP-HPR1000WG-01is structured into six sections: evolutionary improvements in safety, hazards, reliability

of safety functions, accidents with core melt, spent fuel pools, and emergency preparedness in design, and covers both HPR1000 design Option 1 and Option 2[1]. It emphasizes defence-in-depth principle, passive safety features, and robustness against external hazards, aiming to harmonize regulatory practices among member countries.

(b) CP-HPR1000WG-02, "Common Position of the IRWST Strainer Performance and Downstream Effects of HPR1000 after LOCA" focuses on addressing excessive blockage of the In-Containment Refuelling Water Storage Tank (IRWST) strainer and associated downstream risks after Loss of Coolant Accident (LOCA). It defines common positions on in-containment material selection (e.g., Reflective Metal Insulation materials), strainer performance testing (head loss, chemical effects), and downstream effects analysis (in-vessel and ex-vessel), aiming to ensure long-term core cooling and reduce risks to safety systems.

(c) CP-HPR1000WG-03, "Common Position addressing In-Vessel Retention strategy for HPR1000" is dedicated to the In-Vessel Retention (IVR) strategy, a key severe accident management measure for HPR1000. It outlines IVR design features (e.g., active plus passive injection, optimized flow channels), thermal and mechanical assessment methods (e.g., Critical Heat Flux testing, Finite Element Analysis), and sets common expectations for scenario identification, corium configuration modelling, and system design. The goal is to ensure RPV integrity and prevent molten core concrete interaction during severe accidents.

(d) "Common Position Addressing the Vienna Declaration on Nuclear Safety for HPR1000" (To be officially released). This CP focuses on the fact that the design should practically eliminate the early radioactive release or large radioactive release, which is consistent with IAEA SSR2/1. All HPR1000WG members agree that the demonstration of practical elimination by "extremely unlikely with a high degree of confidence" should be based on both deterministic and probabilistic considerations. Although probabilistic targets can be set, demonstration of the "practical elimination" of conditions that could lead to an early radioactive release, or a large radioactive release should not be based solely on low probability values. The

[1] Refer to CP-HPR1000WG-01, "Common Position Addressing Fukushima Daiichi NPP Accident-Related-Issues".

HPR1000WG members recognize the efforts performed by the HPR1000 designers to reach the realization of practical elimination of early or large radioactive releases. ONR and NNSA have completed the corresponding safety review of HPR1000 design and confirm that design of HPR1000 can achieve the safety objective of practical elimination of early or large radioactive releases.

(e) TR-HPR1000WG-01, "Hydrogen Control During Severe Accidents" is a technical report analysing the HPR1000 Containment Combustible Gas Control System, focusing on Passive Autocatalytic Recombiners (PARs). It covers PARs' rationale, quantity, layout, regulatory requirements, and qualification testing across member countries and compares differences between HPR1000 Option 1 (29 PARs) and Option 2 (33 PARs) to accept the assurance that hydrogen concentrations are controlled to avoid containment failure from deflagration or detonation.

(f) TR-HPR1000WG-02, "Technical Report on Regulatory Requirements and Practices for Severe Accidents" compiles regulatory requirements and practices for severe accidents from member countries (China, UK, Argentina, South Africa). It addresses severe accident definition, analysis methodologies, design requirements (e.g., equipment qualification, independence), and severe accident management guidelines (SAMGs), highlights the application of severe accident analysis (e.g., supporting Probabilistic Safety Assessment, emergency planning), and identifies consensus and differences to enhance regulatory coordination.

(g) TR-HPR1000WG-03, Technical Report "HPR1000 HAZARDS" examines regulatory approaches to hazards assessment for HPR1000, focusing on typical hazards such as high energy pipe failure, dropped loads, and combined hazards. It compares differences in exclusion criteria, screening methods, and analysis methodologies among member countries, aligns with IAEA safety standards, and identifies common practices to ensure the design’s robustness against internal and external hazards.

In addition, the HPR1000WG has carefully analysed the differences between the two options of HPR1000. While promoting further understanding among members of the HPR1000WG regarding the design differences between the two options, it has also effectively facilitated the continuous harmonization between the two options of HPR1000.

4. Challenges or limitations

The HPR1000WG encountered several challenges or limitations during its operation, which ultimately affected its effective operation and led to the decision to close.

There are inherent differences among HPR1000WG members in terms of regulatory frameworks, safety requirements, and project stages, which affect the consistency of work priorities. China is advancing multiple construction and licensing projects for the HPR1000 reactor, while the UK withdrew from the working group shortly after completing the GDA for the HPR1000 and deciding to terminate its domestic HPR1000 projects. Other members are still in the early stages of planning or project suspension, making it difficult to carry out review activities that benefit 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 HPR1000WG 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 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

As a vendor of the HPR1000, the Hualong Nuclear Power Technology Co., Ltd., a joint venture between China National Nuclear Corporation (CNNC) and China General Nuclear Power Corporation (CGN), has actively participated in relevant work since the

establishment of the HPR1000WG. Hualong Nuclear Power Technology Co., Ltd., has conducted in-depth exchanges at multiple working group meetings and TESGs meetings, focusing on introducing the unique design features, specific measures for severe accident management, and overall considerations for protection against internal and external hazards of the HPR1000. This has been crucial for the HPR1000WG to advance technical work, produce CPs and TRs. The vendor has provided content such as an overview of the design concept, responses to technical questionnaires, and descriptions of general safety features, enabling the HPR1000WG to effectively complete its designated work within the MDEP framework.

To promote sharing while safeguarding the vendor's commercial interests, the HPR1000WG engaged in constructive consultations with the stakeholder. A consensus was reached to include only information essential for understanding the group's CPs and TRs—such as general testing methodologies, high-level performance analysis results, and non-proprietary design principles—rather than sensitive details that could impact the vendor's competitive advantage. Additionally, the group adopted a principle allowing the redaction or omission of proprietary information in final CPs and TRs, ensuring that the published documents balanced transparency for regulatory collaboration with the protection of the vendor's intellectual property.

Although not a member of the working group, including the supplier in part of the meetings was beneficial to all. It gave regulators the opportunity to gain knowledge from the vendor that they would not otherwise have access to on a day-to-day basis, as well as lessons learned more quickly.

7. Location of MDEP DSWG information and reports

The information regarding all MDEP HPR1000WG activities is held within the dedicated section 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 MB.

The MDEP Library contains the records for each HPR1000WG 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 (CPs and TRs) 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

- Major design changes identified later
- Changes needed to address new regulations
- New types of fuel designs (i.e., Accident Tolerant Fuels)

Construction experience

- Sharing of issues occurred during construction
- Impacts of construction errors on long term operation

Operational experience

- Issues identified because of operational events
- Issues encountered with Technical Specifications

Decommissioning

- Need to develop design for decommissioning

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

Severe accidents

- Regulatory review and practices for severe accident management
- Any issues in this area identified as the plants gain operating experience

9. Conclusion

Between 2017 and 2026, ONR and NNSA have completed their safety assessments for the HPR1000 design and drew the conclusion that the HPR1000 design was acceptable according to the regulations of the UK and China. These assessments were outside the terms of reference for MDEP, but the outcomes facilitated the member regulators understanding and provided significant grounding for HPR1000WG discussion and cooperation.

The status of the ONR and NNSA safety assessments for HPR1000 design are listed below:

- ONR has completed GDA and DAC) for the HPR1000 Reactor design. The detailed information is described in: https://www.onr.org.uk/generic-design-assessment/assessment-of-reactors/uk-hpr-1000.
- NNSA has completed the safety review of the Final Safety Analysis Report (FSAR) for the 8 HPR1000 reactors-Fuqing units 5&6, Fangchenggang unit 3&4, Zhangzhou unit 1&2, Taipingling unit 1, Sanao unit 1, and issued the operating licences for these units.

The DSWG 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 CPs related to the Fukushima Daiichi Nuclear Power Plant accident.

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 Number	Title
CP-HPR1000WG-01	Common Position Addressing Fukushima Daiichi NPP Accident-Related Issues https://www.oecd-nea.org/mdep/documents/CP-HPR1000WG-01_CP_AddressingFukushimaDaiichiNPPAccident-RelatedIssues.pdf
CP-HPR1000WG-02	Common Position of the IRWST Strainer Performance and Downstream Effects of HPR1000 after LOCA https://www.oecd-nea.org/mdep/documents/HPR1000_CP-2_IRWSTStrainerPerformance_DownstreamEffects_FINAL.pdf
CP-HPR1000WG-03	Common Position addressing In-Vessel Retention strategy for HPR1000 https://www.oecd-nea.org/mdep/documents/HPR1000_CP3_InVesselRetentionstrategy_FINAL.pdf
CP-HPR1000WG-04	Common Position Addressing the Vienna Declaration on Nuclear Safety for HPR1000 https://www.oecd-nea.org/mdep/documents/HPR1000_CP4_CommonPositionAddressingtheViennaDeclarationonNuclearSafetyforHPR1000.pdf
TR-HPR1000WG-01	Hydrogen Control During Severe Accidents https://www.oecd-nea.org/mdep/documents/TR-HPR1000WG-01%20Hydrogen%20Control%20During%20Severe%20Accidents_clean%20copy_FINAL.pdf
TR-HPR1000WG-02	Technical Report on Regulatory Requirements and Practices for Severe Accidents https://www.oecd-nea.org/mdep/documents/TR-HPR1000WG-02_TR_RegulatoryRequirements_Practices_Severe%20Accidents.pdf
TR-HPR1000WG-03	HPR1000 HAZARDS https://www.oecd-nea.org/mdep/documents/HPR1000_TR03_FINAL.pdf