SESSION 1

SMMR DESIGNS

Monday, 10 June 2024

KEY POINTS OF DISCUSSION

Several different SMMR designs, and the relevant safety regulation experiences have been introduced, including the RITM-200N NPP design and the RITM-200S floating power unit design from Russia, the K-SMR design from Korea, as well as the SMR design from Argentina.

- The SMMR had attracted a lot of interest from many countries due to its wide range of applications, the short construction time, lower initial investment and the small EPZ, which can facilitate its deployment around the world.
- The participants emphasized that the nuclear community should make joint efforts to demonstrate the high safety features of the SMMR in order to accelerate its design and construction.
- The participants expressed a high degree of consensus that the application of the IAEA safety principles/standards is crucial for the safe design and operation of SMMR.
- Some of the SMMR designs were based on the long-term safely operated reactors, which could enhance the confidence in the safe operation of SMMR in the world, and also provided an opportunity to share more practical knowledge and experience as well as the lessons learned for the design, construction, operation and regulation of SMMR.
- In this regard, the cooperation in the nuclear community, particularly the cooperation between the designer, the operator and the regulator for the deployment of SMMR is crucial.

CHALLENGES AND RECOMMENDATIONS

- In many countries, the regulation of SMMR mainly follows the same existing regulatory framework of the large reactors and applies the same regulatory requirements and the technical rules, and there is a lack of dedicated technical standards/rules for SMMR, which may practically limit the deployment of SMMR.

- It was recommended for MDEP to carry out further research to identify the main differences in design between SMMR and large NPPs, and to identify the main issues in applying the existing standards for large reactor to SMMR , and to identify which specific technical standards should be developed for SMMR to support the establishment/optimization of the regulatory framework for SMMR in the world.

- It was pointed out that cooperation with the industry (including technology providers, owners, and operators) should be established so that real-life difficulties encountered can be correctly identified and meaningful solutions can be provided. Such kind of cooperation at the early phases of the SMMR designs would also make important design changes to be identified earlier and implementing necessary solutions without big impacts.

- As a new type of reactor, it is important to give serious consideration to the “mitigation design features” ,not only the “prevention design features "for the SMMR at the very beginning of the design to ensure the high safety feature of the SMMR and to protect the public and the environment.

- There is a crucial need to carry out research on the acceptance criteria for application of PSA in the design of SMMR and to promote the international consensus to support the SMMR design in the world.

SESSION 2

LW-SMMR'S PRINCIPLE FOR THE PREVENTION AND MITIGATION OF ACCIDENTS (APPLICATION OF THE FIRST PRINCIPLE OF VIENNA DECLARATION)

Monday, 10 June 2024

KEY POINTS OF DISCUSSION

- The principles of Vienna Declaration on Nuclear Safety (VDNS) were presented and explained.
- The IAEA safety standards fully meet the principles of the VDNS to implement the objective of the Convention on Nuclear Safety to prevent accidents and mitigate radiological consequences. In complement to the safety requirements on the prevention and mitigation of accidents (e.g. SSR-2/1 (Rev. 1)), the IAEA published in 2024 a new Safety Guide SSG-88 on "Design Extension Conditions and the Concept of Practical Elimination in the Design of Nuclear Power Plants".
- There is no need to develop new IAEA upper-level documents (SF, GSR, SSR). The assessment of the IAEA Guides (SSGs) in terms of their applicability for the SNPP project has shown that the existing IAEA Guides (SSGs) should be updated or new ones to be developed.
- CAREM design was shown to be in compliance with the requirements of Vienna Declaration on Nuclear Safety.
- RITM-200N is being developed in compliance with the Russian Standards, international requirements and with the best practices of using similar marine-based RITM-200S.

CHALLENGES AND RECOMMENDATIONS

- The unique design and construction features of small, medium, and modular reactors (SMRs) make it challenging to apply the general principles and regulatory requirements typically used for traditional large-scale nuclear reactors.
- The developers should demonstrate that the new SMMR designs fulfill the principles of Vienna Declaration.
- It is recommended to consider the experience in design, manufacture and operation of the marine-based reactors RITM-200S, as similar to land-based RITM-200N.
- MDEP members may compare different aspects of their national safety concepts from the perspectives of prevention and mitigation.
- There was noted an interest in discussing the balance between the prevention and mitigation strategies.

SESSION 3

JUSTIFICATION OF THE MATERIAL SELECTION FOR LW-SMMR REACTOR AND PRIMARY AND SECONDARY CIRCUITS; VALIDATION OF STRENGTH AND LIFETIME OF THE MATERIALS USED

Monday, 10 June 2024

KEY POINTS OF DISCUSSION

- A range of factors to be taken into account for a selection of materials
- Materials can be divided into those already approved (included in special lists) and new ones that require a special certification procedure
- The principles and approaches in the Russian Federation to justify the use of materials for nuclear facilities are equal to the documents of regulatory authorities of countries with developed nuclear infrastructure
- Most materials for NPPs are suitable for SMMRs, but there may be exceptions based on the specific chemical processes
- The frequency of submitting new materials for certification is not standard and depends on the current needs of designers

CHALLENGES AND RECOMMENDATIONS

- Reasonability of applying a graded approach in certification tests
- Differences in international legislation for land-based and floating SMMRs should be taken into account
- A kind of approved materials data bank may be developed within MDEP members
- Documents (TRs of CPs) within MDEP may be developed on material selection
- Documents (TRs of CPs) within MDEP may be developed on commendable requirements for Reports on Certification Tests

SESSION 04

FUTURE PERSPECTIVE OF RECYCLING OF SMMRS

Monday, 10 June 2024

KEY POINTS OF DISCUSSION

- Progress in any industry, including nuclear, depends on effective recycling solutions.
- Increasing deployment of SMMRs requires understanding of the decommissioning process. That include regulatory frameworks, technical challenges, environmental impacts, and economic implications.
- Implementing a comprehensive recycling cycle will enhance the commercial value of the SMR sector. Also, public belief in the feasibility of a recycling cycle is crucial for advancing the nuclear renaissance.
- By agreeing that spent nuclear fuel is an asset, we can safely store and utilize it when necessary, rather than immediately.
- Long-term management includes addressing environmental, logistical, and economic challenges.

CHALLENGES AND RECOMMENDATIONS

- Defining a clear scope for international radiation protection regulations is a key challenge for regulating recycled goods from SMMRs.
- Recycling is a distinct process that follows decommissioning. SMR designers should incorporate the entire lifecycle, including recycling, during the licensing stage.
- Recycled materials can be repurposed for public use, not just returned to the nuclear industry.
- Technical Challenges: The compact and integrated design of SMMRs may necessitate specialized dismantling techniques and equipment. While the modular nature of SMMRs is advantageous during construction and operation, it can pose difficulties during disassembly.

SESSION 5

VERIFICATION AND VALIDATION COMPUTER BENCHMARKING FOR LW-SMMR

Tuesday, 11 June 2024

KEY POINTS OF DISCUSSION

During this session, the design features of ACP100, the use of codes, the challenges in using codes, and the code validation activities relevant to the design of ACP100 were introduced.

- Most of the computer codes for ACP100 can directly adopt the codes used in existing large power PWRs because it follows some mature technologies of large reactors.
- For the code adaptability problems caused by the unique design of ACP100, mainly the sub-channel thermohydraulic code, the system thermohydraulic code and the containment analysis code.
- For the code validation on ACP100, the main challenges are the challenge posed by design features such as the integrated layout and passive safety system, and the challenge posed by the relative lack of operating and test data.
- Sufficient tests have been conducted during the design process of ACP100, which effectively verified the applicability of these codes.
- In the future, more sufficient and comprehensive code validation will be carried out in combination with the actual reactor operation and commissioning data.

CHALLENGES AND RECOMMENDATIONS

- The challenge for verification and validation of the SMMR codes is mainly related to the unique design features of SMMR, such as the integrated layout and passive safety system.
- The experimental tests are crucial for the validation of SMMR codes, especially for the sub-channel thermohydraulic code, the system thermohydraulic code and the containment analysis code, which are related to the main new design features of SMMR.
- Regarding the verification and validation of SMMR codes, it was strongly suggested by the participants that MDEP organize code benchmarking activities and share experimental data and analysis results to improve the efficiency of the validation and the reliability of the codes.
- It was discussed the possibility of different codes application to the same data / design solutions, e.g. for independent verification
- It was discussed to create the common database of different codes, e.g. for commercial use and application

SESSION 6

IMPLEMENTATION OF PROBABILISTIC SAFETY ASSESSMENT (PSA) OF LW-SMMR

Tuesday, 11 June 2024

KEY POINTS OF DISCUSSION

- The proper use of term ”probability” is discussed as a fundamental item in the PSA.
- The base of the Argentine Criterion is that the individual risk associated with potential exposure should be not greater than the individual risk associated with normal exposure.
- The total risk must be lower than 10^{-6} per year and per nuclear facility for any person of the public living around the facility.
- The use of passive system is an important advantage because its failure probability is much lower, however the assessment of probabilities is a challenge: certain simplification hypothesis that may be valid in active systems, are not acceptable for passive.
- One of the key issues of the passive safety system is a good assessment of the deterministic behavior and the reliability.

CHALLENGES AND RECOMMENDATIONS

- The estimation of doses must take into account the purpose of estimating risk.
- One of the biggest challenges are: lack of data and as the result of this difficulties which occur during fault tree analysis.
- As the project progress, a new and more realistic version of the PSA with non-conservative approach should be developed.
- A well-documented uncertainty should be complemented with a sensitivity analysis to detect the weakness points.
- Creation a data-bank with the help of the states-vendors of LWR-SMMR to fulfill the lack of information and proving the comprehensive probabilistic safety assessment.
- With the help of MDEP to generate consensus among regulators on common approaches in this path.
- How to summate many risks criteria in a several challenges which have not been yet touched.
- Attention to multi-unit PSA should be paid for SMMR because of possible dependencies between units or modules.
- Some SMMR projects are not linked to concrete site (for example floating SMR). In light of this It should be noted the importance of external hazards for SMMR may be higher than for traditional PWR.

SESSION 7

RESEARCH NEEDS RELEVANT TO LW-SMMR

Tuesday, 11 June 2024

KEY POINTS OF DISCUSSION

During this session, the R&D needs for LW-SMR focusing on passive system and the test facilities used for SMR R&D in China were introduced.

- A clear map of the research needs is crucial both for the study and understanding of the safety related phenomena and issues of SMMR, and for the functions verification of the systems and components of SMMR.
- The research needs for the passive system of SMMR have been highlighted and discussed in detail.
- There are some well developed large-scale test facilities available in the world to carry out study and test activities relevant to SMMR R&D.
- Some important experiments and tests relevant to SMMR R&D have been conducted, such as passive core cooling system performance, long-term recirculation after water loss, full-field power failure accident, steady-state thermo-hydraulic performance test , dynamic thermal hydraulic characteristic test, control rod driving line thermal state test, and control rod drive line seismic test etc.

CHALLENGES AND RECOMMENDATIONS

- As the importance of a clear research roadmap for the deployment of SMMR was highlighted, it was strongly suggested by the participants that MDEP should conduct researches focusing on the research needs maps of SMMR, including fuels, computing codes, etc., to support the interested country to prepare their SMMR research roadmaps.
- It was also highlighted the importance of early involvement of the regulatory body in the preparation of R&D research plans to reduce the risk of violating the existing regulatory requirements for the design and deployment of new types of reactors.
- In order to reduce research cost, avoid duplications and increase the efficiency of SMMR related research, it was strongly suggested by the participants that MDEP should organize joint projects to bring together the interested countries, to use the well-developed experimental facilities and existing expertise to conduct experiments and tests and to share experimental data to support the deployment of SMMR in the interested countries.

SESSION 8

DEFENSE IN DEPTH (DID) PRINCIPLES APPLICABILITY TO LW-SMMR

Tuesday, 11 June 2024

KEY POINTS OF DISCUSSION

- For SMMRs all 5 DiD levels are applicable and there are measures and systems to achieve the goals of each of the levels.
- Physical Barriers for RITM-200N reactor are: Fuel matrix, Fuel element cladding, Reactor coolant circuit boundary, Containment of the reactor facility, Containment of the reactor unit.
- Compliance with the provisions of the INSAG-10, SSR-2/1 is important for national legislation.
- The IAEA carries out a significant amount of work on SMMRs (and DiD concept in particular) within safety standards development, SMR Forum, NHSI and other activities.
- Many SMR concepts implement inherent characteristics and safety features at DiD levels 1-3 that are claimed to limit the potential for escalation of serious accident sequences to level 4.

CHALLENGES AND RECOMMENDATIONS

- A need in modifications to traditional DiD principles depends on certain design. And also there may be exceptions regarding the independence of DiD levels.
- There are radiological and other targets for each DiD levels which can be same or differ for different designs.
- Some DiD levels can be challenging to implement in comparison with NPPs.
- It is necessary to be in touch with SMR Forum, NHSI to avoid significant duplication in MDEP activities.
- New and updated relevant IAEA documents (SSG-88, INSAG-28 etc.) could be subjects for discussion within MDEP, as well as benchmarking national regulations against them.
- Findings of the International Conference on small modular reactors and their application (21-25 October 2024) as well as of other events could be useful in MDEP work.

SESSION 8

DEFENSE IN DEPTH (DID) PRINCIPLES APPLICABILITY TO LW-SMMR

Tuesday, 11 June 2024

KEY POINTS OF DISCUSSION

- For SMMRs all 5 DiD levels are applicable and there are measures and systems to achieve the goals of each of the levels.
- Physical Barriers for RITM-200N reactor are: Fuel matrix, Fuel element cladding, Reactor coolant circuit boundary, Containment of the reactor facility, Containment of the reactor unit.
- Compliance with the provisions of the INSAG-10, SSR-2/1 is important for national legislation.
- The IAEA carries out a significant amount of work on SMMRs (and DiD concept in particular) within safety standards development, SMR Forum, NHSI and other activities.
- Many SMR concepts implement inherent characteristics and safety features at DiD levels 1-3 that are claimed to limit the potential for escalation of serious accident sequences to level 4.
- During the discussion it is clearly recognized by the participants that the DiD principles has to be implemented in the design of SMMR. But the ways for realizing it could vary depending on the unique design features of different SMMR designs.

CHALLENGES AND RECOMMENDATIONS

- A need in modifications to traditional DiD principles depends on certain design. And also there may be exceptions regarding the independence of DiD levels.
- There are radiological and other targets for each DiD levels which can be same or differ for different designs.
- It is necessary to be in touch with SMR Forum, NHSI to avoid significant duplication in MDEP activities.
- New and updated relevant IAEA documents (SSG-88, INSAG-28 etc.) could be a subjects to discussion within MDEP.
- Findings of the International Conference on small modular reactors and their application (21-25 October 2024) as well as of other events could be useful in MDEP work.
- It was strongly suggested that the DiD principles should be implemented thoroughly and carefully, especially for the first of kind SMMR to make sure the SMMR has enough safety margin for prevention and mitigation.