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EPR Accident and Transient (A & T) Technical Expert Subgroup

TECHNICAL REPORT ON EPR ASSESSMENT OF 2A LARGE BREAK LOSS OF COOLANT ACCIDENT (2A-LOCA) ANALYSIS

Regulators/TSOs involved in the MDEP working group discussions:	ASN (France), STUK (Finland), ONR (UK), NNSA (China), SSM (Sweden)
Regulators which support the present technical report:	IRSN (France), STUK (Finland), ONR (UK), NNSA (China) , SSM (Sweden)
Regulators with no objection:	AERB (India)
Regulators which disagree:	none

Multinational Design Evaluation Program

EPR Working Group

EPR Accident and Transient (A & T) Technical Expert Subgroup

TECHNICAL PAPER ON EPR ASSESSMENT OF

2A LARGE BREAK LOSS OF

COOLANT ACCIDENT (2A-LOCA) ANALYSIS

1. AIMS OF THE PROGRAMME

1. To identify common positions among the regulators reviewing EPR accidents and transients in order to:

    1.1. Promote understanding of each country's regulatory decisions and the basis for these decisions;

    1.2. Enhance communication among members and with external stakeholders; and

    1.3. Identify areas where harmonization and convergence of regulations, standards, and guidance can be achieved or improved.

2. PURPOSE OF THE TECHNICAL PAPER

2. The purpose of this paper is to present the work carried out by participating 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.

3. TECHNICAL POSITION

3. The participating regulators consider that the potential for a 2A-LOCA is of significant safety importance. The analysis of relevant phenomena is intended to demonstrate the resilience of the plant in such a rapidly developing scenario. This includes consideration of the impact of the safety injection system on the core cooling, fuel behaviour, containment response and the effect on the pressure vessel internals.

4. It is acknowledged that this initiating event has been the subject of different approaches and methodologies in different countries, depending upon whether this event is treated as a design basis scenario or a specific study in support of the safety submissions.

5. The aim of the design is to assure that the plant can withstand such initiating event and that the proposed protection or safety systems can perform the necessary safety functions, such as core cooling, to limit damage to the fuel assemblies.

6. The regulators note that the reactor designer and the licensees have developed their approach to this potential initiating event using established codes and methods to demonstrate the plant behaviour and substantiate the arguments presented in the supporting safety submissions.

7. The regulators have performed independent assessment of the safety submissions and have carried out, if appropriate, confirmatory analysis to develop a view on the adequacy of the safety justification supporting the EPR design for the relevant phenomena post LOCA.

8. The regulators consider that the safety submissions supporting the EPR design include an adequate substantiation of conformance with safety criteria.

9. In summary, the participating regulators consider that the work carried out by the reactor designer or the licensees demonstrates conformance with safety criteria following a double-ended Large Break LOCA, and that this initiating event has been addressed within the safety submissions supporting the EPR reactor design.

4. INTRODUCTION

10. The EPR reactor coolant system features four primary coolant loops that connect the Reactor Pressure Vessel (RPV) to the Steam Generators (SG). Each loop contains sections referred to as hot leg, cold leg and cross-over leg. The hot leg lies between the RPV upper plenum and SG and transfers the water heated within the reactor core to the SGs. The cross-over leg connects the cold side of the SG to the Reactor Coolant Pump (RCP) inlet and the cold leg connects the RCP outlet to the RPV inlet nozzle.

11. A non-isolable double-ended guillotine break normally referred to as the 2A Loss of Coolant Accident (2A-LOCA) is a breach of one of the reactor coolant loops. This leads to a discharge of primary coolant into the containment environment, and is typically simulated at one of the following locations in the primary circuit:

- cold leg between the reactor coolant pump and the reactor pressure vessel, or
- hot leg between the reactor pressure vessel and the steam generator.

12. The 2A-LOCA results in a rapid loss of coolant inventory from the primary circuit, and a corresponding pressure decrease. This accident may potentially cause the core to uncover. This presents a potential challenge to the fuel integrity due to core heat-up and may also impact the containment integrity due to large mass and energy release.

13. The 2A-LOCA affecting the coolant loops represents the largest postulated breach of the primary coolant circuit. Consideration of this fault scenario is included as part of the safety submissions supporting the EPR design. However, the transient analysis and/or structural integrity treatment of this fault scenario may be subject to different regulatory considerations depending upon the national approaches, expectations and requirements.

5. BACKGROUND

14. The subject of the 2A-LOCA analysis within the EPR design safety documentation has been the subject of discussion within the A&T Technical Expert Sub Group.

15. This is of particular interest to the analysis relating to the EPR design and the supporting safety case, which is quite different from the traditional methods used in operating Pressurised Water Reactors (PWR). The international regulators have therefore decided to cover this aspect of the design in this technical paper.

16. This aim of this document is to:

- highlight differences of 2A-LOCA analysis method used in the different EPR designs, if any;
- present the position of the participating regulators and their technical support organisations (TSO) relating to the treatment of 2A-LOCA; and
- exchange regulatory practice in the assessment of 2A-LOCA analysis methodology.

6. EPR DESIGN STRATEGY FOR DOUBLE ENDED GUILLOTINE FAILURE (2A-LOCA)

17. A guillotine break in the main piping of the primary circuit hot or cold legs has traditionally been the design basis scenario to determine the specification for emergency core cooling systems. The effect is a rapid depressurisation of the primary circuit, which converts the coolant to a mixture of steam and water droplets and expels it from the primary circuit. The depressurisation of the vessel upper head is slightly slower than the rest of the circuit and the flow from the upper head helps to prolong core cooling for a short duration, of the order of a few seconds.

18. The function of the engineered safety systems called upon in this fault is to refill the reactor vessel and reflood the core before fuel damage occurs. Release of radionuclides in this event can be limited provided that the fuel can be demonstrated to remain within the acceptable thermal limits.

19. Plant designers have identified a high integrity component envelope which excludes consideration of failures of the main primary circuit pipework within the Plant Condition Category (PCC) design basis. However, a study of a guillotine failure has been made within their “specific studies” to demonstrate the capability of the design to withstand the fault and to justify that the fault is successfully protected. Such studies are carried out in support of the “defence in depth” principle so as to provide additional confidence in the design of systems and components to demonstrate that there is no cliff edge effect associated with such scenarios.

20. This analysis provides the demonstration that the emergency cooling systems are functionally capable of responding to the fault and therefore the 2A-LOCA does not contribute to the plant’s risk of large radiological releases.

21. The frequency of such occurrence, and structural integrity arguments relating to the highest reliability components allow this scenario to be modelled using less onerous assumptions than those deployed within the design basis analysis, depending upon national regulatory

expectations. The objective is to demonstrate that a coolable geometry is maintained in the fuel assemblies and that the amount of hydrogen released into containment does not present a risk to the integrity of the containment structure.

22. These design requirements transpose directly to constraints on cladding surface temperature required to prevent excessive cladding oxidation, but analysis has also been able to demonstrate that few, if any, of the fuel pins would be expected to fail, or lead to the loss of coolability. This analysis demonstrates that core/fuel geometry will remain acceptable.

23. However, the EPR supporting analysis is based on a number of generic core parameters, which may be subject to change by the site specific operating strategy. It is therefore not evident that the site specific analysis would lead to the same results as those obtained with the generic core parameters. In addition to the specific studies demonstrating acceptability of the consequences of such an event, the structural integrity claims and the specific design, manufacture, inspection and maintenance of the primary circuit welds and pipes are intended to provide improved confidence over the previous designs.

24. Furthermore, it is acknowledged that the 2A-LOCA scenario has been the subject of different approaches in different countries regarding the mechanical analysis of the vessel internals and fuel under hydrodynamic and thermo-hydraulic loadings resulting from the break.

6.1 CODES USED TO SUPPORT THE ANALYSIS

25. The calculations representing 2A-LOCA are in general performed using the CATHARE computer code. The code is capable of predicting the plant performance on a best estimate basis with due allowance for modelling uncertainty. In this scenario, the release of water and steam from the reactor coolant circuit into the containment building results in an increase in containment temperature and pressure. The CONPATE lumped parameter analysis code has been utilised to examine the environmental conditions within the containment. The coupling of the codes allows the provision of the back pressure and the calculation of the release of water and steam from the primary circuit.

26. These analyses are performed to demonstrate that the fuel performance criteria, containment pressure and temperature remain within the overall design limits.

7. REGULATORY BASIS AND SUPPORTING ANALYSIS

27. This postulated initiating event is likely to be outside the design basis for the EPR design. This scenario is however used to determine the effectiveness of the safety protection systems. As such the international regulators consider that investigations are necessary to justify the safety claims on the protection system and likely consequences from such scenarios. The participating regulators have therefore considered this aspect of the design and where appropriate, conducted independent confirmatory analysis. The following subsections provide the regulatory basis of the participating countries.

7.1 CHINA:

28. China's regulatory guide on postulated initiating events (PIEs) leading to design basis accidents (DBA) (Safety Assessment and Verification for Nuclear Power Plants HAD102-17-2006) requires that "*it should be noted that some of the accident initiators that have been treated historically as DBAs may have a frequency that is lower than* 10^{-5} *per year.*

This may be the case for PIEs such as a large break LOCA for plants designed and built to modern standards. The regulatory rules, however, may still request that such PIEs be considered in the category of DBAs."

29. This requirement is consistent with the IAEA's Safety Assessment and Verification for Nuclear Power Plants No. NS-G-1.2.

30. Due to the Break Preclusion (BP) concept applied in the design of TAISHAN, 2A-LOCA is not considered a DBA, but according to the requirements of Chinese regulatory guidance and the design practice of other PWRs, NNSA/NSC advised TNPJVC to consider complementing the 2A-LOCA study with additional sensitivity studies utilising the DBA methodology.

31. The results of this study have been analyzed in the light of the acceptance criteria of the design of safety injection performance in 10 CFR 50.46, requiring:

- The peak cladding temperature must remain lower than 1200°C.
- The maximum cladding oxidation must remain lower than 17% of the cladding thickness.
- The maximal hydrogen generation must remain lower than 1% of the amount that would be generated if all the active part of the cladding had reacted.
- The core geometry shall remain coolable.
- The long term core cooling shall be ensured, i.e. the calculated core temperature shall be maintained at an acceptable low value and decay heat shall be removed.

32. The additional report supporting the TAISHAN design concluded that:

- The resulting Peak Clad Temperature (PCT) exceeds the related 1200°C criteria (10 CFR 50.46) using the Deterministic Realistic Methodology (DRM) approach in an analysis performed by TNPJVC. The revised approach of best estimate plus uncertainty performed by TNPJVC showed that the PCT criterion is met.

33. In the TAISHAN EPR design, the precautions limiting the 2A-LOCA occurrence are:

- Austenitic stainless steels are used for the parts of the RCS in contact with the primary coolant because of their high resistance to corrosion by primary water at the service temperature and in conditions of cold shutdown. Precautions are taken to avoid localised corrosion, including conditioning of the primary coolant and appropriate chemical composition of materials.
- Concerning the pitting, the chloride content and oxygen content of the primary coolant are controlled to avoid this kind of corrosion in service conditions. This conditioning of the primary coolant also improves the stainless steel resistance regarding corrosion cracking. The risk of breaks by corrosion on the RCS is therefore reduced.
- In addition, the break preclusion concept has been applied to the RCS main coolant lines. It consists of implementation of design and manufacturing provisions, demonstration of pipe tolerance to large defects, and application of surveillance provisions during operation. As a consequence, the risk of complete guillotine rupture of a main coolant line is highly reduced.

34. Although, for the current position in the Final Safety Analysis Report submitted by TAISHAN, 2A-LOCA Mass and Energy Release (MER) and Press. & Temp. analysis has not been considered within the DBA category, but instead is covered within a specific study performed using best-estimate assumptions for initial and boundary conditions, no single failure nor preventive maintenance, and no Loss Of Offsite Power.

35. NSC asked TAISHAN to perform additional 2A-LOCA calculations giving consideration to uncertainties on initial and boundary conditions. Based on the conclusion of these analyses, the reviewers accepted the conclusion of the safety case.

7.2 FINLAND:

36. Finland's regulatory guide YVL 1.0 which is used in licensing of OL3 and current guide YVL B.5 requires, that "*the emergency cooling system capacity must be dimensioned so that it is sufficient to compensate for a complete sudden break in the largest pipe in the primary circuit*". A break in the largest pipe in the primary circuit, the main coolant line, is a Class 2 (PCC-4) postulated accident.

37. Acceptance criteria for the Class 2 postulated accidents are given in Regulatory Guide YVL 6.2 (and current guide YVL B.4). For example, the maximum cladding temperature during an accident shall not exceed 1200ºC, no melting shall occur in the control rods, and structural deformations in fuel rods, fuel assemblies, control rods or reactor internals shall not obstruct the movement of control rods in the reactor.

38. 2A-LOCA core cooling analysis has been analysed with two methods; best estimate plus uncertainty (BEPU) analysis and conservative method. Guide YVL 2.2 does not allow use of BEPU analysis method. That is why conservative "bounding" analysis has also been adopted. Current guide YVL B.3 allows the use of BE methods in transient and accident analysis.

39. For the initial FSAR analyses, 2A-LOCA with the break in cold leg is studied with the following failure criteria:

- The most penalising single failure (SF) is assumed at the swing check valve in cold leg (one complete SIS train is unavailable: Medium and Low Head Safety Injection and accumulator).
- The preventive maintenance (PM) of 1 emergency diesel is the most penalizing configuration because 1 active SIS train (1 MHSI pump + 1 LHSI/RHR pump) and 1 EFWS pump are thus unavailable
- LOOP is penalising because of application of the PM principle.

40. Assumption of cold leg break and chosen failure criteria could be conservatively assessed, when considering:

- Break in piping assigned in the break-preclusion category
- Non-consideration of whip restraints which would limit the break area (note that there are no whip-restraints for KONVOI or EPR sister plants)
- Single failure to open the high-reliable swing check valve which is subject to full accumulator pressure (46 bar).

41. The results from the current FSAR analyses are within the acceptance criteria and STUK does not have any open questions to these. However, AREVA has updated the 2A-LOCA

analyses that take into account the as-built steel masses inside the containment. The preliminary analysis results for peak cladding temperature may exceed the acceptance criterion 800°C for Rod Control Cluster Assembly temperature and are expected to exceed the acceptance criterion 1200°C for fuel cladding in deterministic bounding case.

42. AREVA and licensee have re-analysed the methodology used, and argue that during a 2A-LOCA scenario, the swing-type check valve in the SIS injection line experience high pressure differential, therefore its failure to open is over-conservative. AREVA and licensee therefore have proposed that the most penalising plant state will assume a single failure (SF) of 1 emergency diesel, and the preventive maintenance (PM) of 1 emergency diesel. The results from the analyses with modified failure criteria are within the acceptance criteria. STUK has approved the modification of single failure methodology.

43. Confirmatory analyses of 2A-LOCA have been done several times during the project: first analyses were made during review of construction license application and the latest in light of the findings of AREVA concerning effect of containment pressure. The results of these confirmatory analyses have also shown that acceptance criteria are fulfilled. In these analyses several different sensitivities were studied; for example failure assumptions, containment pressure, etc.

44. Regarding the mass and energy release (MER) aspect, the 2A-LOCA break is considered to ensure that the containment withstands the largest break on main coolant pipes and that the in-containment safety relevant equipment remains functional under the resulting ambient conditions. The study is performed following DBA rule to maximize MER into the containment. Furthermore, mechanical analysis of the vessel internals and fuel assemblies mechanical structure under thermo-hydraulic 2A-LOCA loadings is provided to demonstrate the structural integrity, the control rod drop and the core coolability. This mechanical analysis is done for the primary break limited with piping restrains.

45. In summary, the results from the current OL3 2A-LOCA FSAR analyses are within the acceptance criteria of the Class 2 postulated accidents and STUK does not have any open questions to these.

7.3 FRANCE:

46. The pressurized water reactors are designed according to the defence in depth principle. Measures are taken to avoid occurrence of incidents or accidents, and to limit their consequences if the incidents or accidents occur despite these measures. The occurrence of accident initiating events is therefore postulated in the safety analysis report in order to define the measures to limit their consequences.

47. The break preclusion principle leads to the exclusion of postulating the rupture of a primary circuit pipe, relying on implementation of specific requirements for the design, manufacturing, in-service monitoring and inspection of these components. These requirements, if properly applied, lead to reduce with a high level of confidence, the probability of occurrence of such a scenario.

48. The break preclusion design approach is applied on the main coolant piping for Flamanville EPR. This approach complies with the “Directives techniques” (German and French Technical Guidelines) for the design and the construction of the new PWRs.

49. Despite the application of the break preclusion principle, the doubled-ended guillotine break of the main coolant line (2A-LOCA, 1A area 4776 cm^2) is considered in the safety justification for Flamanville EPR.

50. Regarding the mass and energy release aspect, the 2A-LOCA break is considered to ensure that the containment withstands the largest break on main coolant pipes and that the in-containment safety relevant equipment remains functional under the resulting ambient conditions. The study is performed following DBA rules to maximize MER into the containment.

51. Regarding the core cooling aspect, the 2A-LOCA is treated as a "specific study", whereas the PCC-4 studies are limited to doubled-ended guillotine break of main primary connected pipes (1A area 390 cm^2 for safety injection line and 840 cm^2 for pressurizer surge line).

52. This "specific study" is performed with the same code and method as for the PCC-4 LOCA: realistic CATHARE 2 code and DRM which aims at penalizing the key parameters, while keeping the model response as close as possible to transient realistic physics. The same LOCA criteria as for the PCC-4 LOCA are considered. However, unlike PCC-4 LOCA studies, specific assumptions are considered, such as best-estimate values for initial and boundary conditions, no single failure nor preventive maintenance, and no Loss Of Offsite Power (LOOP).

53. The objective of the "specific studies" is to ensure that there is no cliff-edge effect associated to the very low probability concerned scenarios. For 2A-LOCA in particular, the core coolability has to be ensured, even in the case of this very low probability scenario.

54. The core coolability relies on two aspects: the fuel rods cooling during core dewatering and reflooding thanks to emergency cooling system and the mechanical strength of vessel internals and assemblies that enable efficient shutdown rods insertion, conservation of geometrical core structure and efficient distribution of emergency cooling system water.

55. In summary, regarding the fuel rods cooling, the results of EPR safety demonstration show that emergency cooling system is correctly sized for this scenario. The use of specific assumptions is considered acceptable, especially since the usual LOCA criteria are met.

56. Furthermore, no mechanical analysis of the vessel internals and fuel assemblies mechanical structure under thermo-hydraulic 2A-LOCA loadings is provided to demonstrate the structural integrity, the control rod drop and the core coolability. Rather, it is assumed that an appropriate choice of realistic assumptions with regard to break assumptions (break opening time mainly) may indeed allow to prove the case.

7.4 SWEDEN:

57. For the current operating LWRs, LB LOCA is considered to be DBA event and in H4 event class (PC-5, Condition 4), as a postulated initiating event.

58. Regulation is currently under revision (to also cover new build reactors) and it's under consideration to place (or to apply for) 2A LB LOCA in H5 event class, if the occurrence could with high probability be unlikely ($<10^{-6}$), by applying proven methods as LBB and/or Break Preclusion etc. H5 event class – Very unlikely events (not DBA event).

59. It is to be noted that at this stage, SSM has not reviewed any formal application based on the EPR design. Consideration may be given to the relevant regulatory requirements in the future, as appropriate.

7.5 UK:

60. The safety submission provided to the Office for Nuclear Regulation (ONR) as part of the Generic Design Assessment (GDA) of the EPR design includes the analysis of a double-ended guillotine break of the main coolant line as a ‘specific study’. Such a break was claimed to be precluded, as the main primary circuit pipework components have been designated as High Integrity Components (HIC); and therefore excluded from the design basis. This scenario was however studied under the principle of defence in depth, to ensure there are no cliff-edge effects and to justify that the scenario is successfully protected; applying less onerous assumptions than would typically be expected for a DBA study.

61. The general Framatome approach to selection of LOCA faults for assessment within and outside the design basis is considered reasonable, provided that the integrity claims for the main pipework can be substantiated. However, analysis of the worst conceivable break configuration was considered to demonstrate the design provides additional assurance that plant risk is not unduly sensitive to the pipe structural integrity arguments. Furthermore this analysis provides evidence for substantiating the evaluation of plant risk and designing safety systems.

62. ONR assessed the 2A-LOCA analysis from a fault studies perspective against the relevant ONR Safety Assessment Principles (SAP) during GDA. The ONR SAPs expect a demonstration that no sudden escalation in risk occurs for faults excluded from supporting analysis within the design basis. The assessment concluded that the expectations of ONR set against these principles had been met and that the risk from 2A-LOCA faults was As Low As Reasonably Practicable (ALARP).

63. The analysis of core cooling in this scenario was the subject of ONR review in some detail because the case makes the argument that the mean rod in the lead assembly will remain below cladding temperatures likely to cause clad failure by ballooning.

64. In addition, the issue of depressurisation forces on reactor internals was considered, but detailed analysis of spacer-grid impact forces was not made because it was considered that, provided the fuel does not balloon, there is not a significant risk of loss of coolable geometry within the fuel. ONR also judged that the stiffness of the EPR heavy reflector was beneficial compared to existing PWR designs and therefore this was not an area that was sampled in its assessment.

65. The analysis of a guillotine failure of the main primary-circuit pipework initiating event supporting the GDA submission was based on an assumption that the initial plant condition was close to normal operating conditions and unlikely to lead to any additional failures of safety injection systems, although minimum safety injection rates were assumed.

66. In the event of a 2A-LOCA, core uncovery does occur, but the emergency core cooling system is designed to reflood the fuel before significant damage occurs. The GDA analysis demonstrates that extensive fuel failures (clad burst) in this event are unlikely and hence that the core will remain coolable.

67. ONR therefore carried out some independent calculations to determine the likelihood of a loss of coolable geometry, and confirmed that the expected flow blockage would not be

penalising. In response, Framatome performed additional analysis using best estimate method which demonstrated cladding temperatures remain sufficiently low that burst is avoided in this scenario.

68. In the period since GDA was completed, development of site specific fuel cycle management and the proposed "operational flexibility" requirements have resulted in increased predictions of core peaking factors. It is therefore not evident that the analysis above would lead to the same results with the revised factors taken into account. As such it is the designation of the cold leg and nozzle welds as HIC which currently provides confidence that the 2A-LOCA is not a significant concern for the UK-EPR.

69. However, in recent additional scoping calculations using updated containment parameters, the reactor designers have not identified significant differences in fuel performance in such a scenario. The impact of updated site specific containment parameters on fuel performance in such scenario will be evaluated as the site specific analyses are developed to support future commissioning safety submissions.

8. KEY DESIGN DIFFERENCES

70. The key design differences and analytical methods used in the evaluation of the 2A-LOCA are presented in Appendix A.

9. LESSONS LEARNT

71. The regulators note that this scenario is a complex and challenging sequence to analyse in the safety demonstration for the EPR, due to the increased size of the core, and as such a number of confirmatory analyses have been carried out to gain confidence in the outcome of the analyses.

72. The reactor design with the associated core design and power has required development of specific methods to address this challenging aspect of the design, which has been traditionally considered within the design basis framework. The reactor designer and the licensees have therefore reconsidered this scenario, incorporating additional design measures to lower the predicted frequency of this event. The supporting complex analysis may therefore be performed utilising less conservative assumptions as the predicted frequency assigned to this scenario is low.

73. While the regulators consider this scenario to be infrequent, new approaches may need to be developed to reduce the uncertainty associated with the potential consequences within the safety demonstration of such large reactors.

74. The regulators also consider that the development of methodologies and independent confirmatory analyses has helped to better understand the potential uncertainties within the analyses. As such, this learning could be deployed to support the analysis of such complex scenarios in any future benchmarking.

10. CONCLUSION

75. This technical paper has discussed the treatment of the 2A-LOCA analysis method for different EPR designs, and the position of each participating country. The regulators have therefore taken the opportunity to compare the key design parameters, assumptions and initial conditions used in the safety demonstration.

76. The participating regulators acknowledge that this initiating event has been the subject of different approaches and methodologies in different countries, depending upon this event being treated as a design basis event or a specific study in support of the safety submissions.

77. The regulators note that the reactor designer and the licensees have developed their approach to this potential initiating event using established codes and methods to demonstrate the plant behaviour and substantiate the arguments presented in the supporting safety submissions.

78. The regulators have performed independent assessments of the safety submissions and have carried out, if appropriate, confirmatory analysis to develop a view on the adequacy of the safety justification, and provision of defence in depth supporting the EPR design for the relevant phenomena post LOCA.

79. The regulators also consider that the development of methodologies and independent confirmatory analyses has helped to better understand the potential uncertainties within the analyses. As such, these could be deployed to support the analysis of such complex scenarios in any future benchmarking. However, the regulators consider that the safety submissions supporting the EPR design include a reasonably adequate substantiation of conformance with safety criteria.

80. In summary, the participating regulators consider that the work carried out by the reactor designer or the licensees demonstrates conformance with safety criteria following a double-ended Large Break LOCA, and that this initiating event has been addressed within the safety submissions supporting the EPR reactor design.