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General Nuclear System Ltd.

UK HPR1000 GDA Project

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Preliminary Safety Report
Chapter 17
Structural Integrity

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17.1 List of Abbreviations and Acronyms

ALARP	As Low As Reasonably Practicable
CGN	China General Nuclear Power Corporation
ENIQ	European Network for Inspection and Qualification
GDA	Generic Design Assessment
HIC	High Integrity Component
HPR1000 (FCG3)	Hua-long Pressurized Reactor under construction at Fangchenggang nuclear power plant unit 3
IAEA	International Atomic Energy Agency
ISI	In-Service Inspection
KIF	Fatigue Monitoring System [FMS]
KIR	Loose Parts and Vibration Monitoring
LBB	Leak Before Break
LPMS	Loose Part Monitoring System [LPMS]
NDT	Non Destructive Test
NNSA	National Nuclear Safety Administration
ONR	Office for Nuclear Regulation
PCSR	Pre-Construction Safety Report
PSR	Preliminary Safety Report
PWR	Pressurized Water Reactor
RCP	Reactor Coolant System [RCS]
RCPB	Reactor Coolant Pressure Boundary
RP	Requesting Party
RPV	Reactor Pressure Vessel
RVI	Reactor Pressure Vessel Internals
SAPs	Safety Assessment Principles
SCC	Stress Corrosion Cracking
SIC-1	Structural Integrity Class 1

SIC-2	Structural Integrity Class 2
SIC-3	Structural Integrity Class 3
TAGSI	Technical Advisory Group on Structural Integrity
UK	United Kingdom of Great Britain and Northern Ireland
UK HPR1000	The UK version of the Hua-long Pressurized Reactor
VMS	Vessel Vibration Monitoring System [VVMS]

System codes (XXX) and system abbreviations (YYY) are provided for completeness in the format (XXX [YYY]), e.g. Reactor Coolant System (RCP [RCS]).

17.2 Introduction

The structural integrity demonstration is an important aspect of ensuring nuclear facility safety. As one of the critical technical fields, this has been closely focused on by the United Kingdom of Great Britain and Northern Ireland (UK) Generic Design Assessment (GDA). In UK, according to the Safety Assessment Principles (SAPs) in Reference [1], for the metallic components and structures that have a significant effect on nuclear safety, safety cases must be provided to demonstrate the structural integrity of these items within the overall plant design lifetime.

The Requesting Party (RP) recognised the potential differences between the structural integrity demonstration of Hua-long Pressurized Reactor under construction at Fangchenggang nuclear power plant unit 3 (HPR1000 (FCG3)) and the requirements of the UK Regulatory authority. For example, for the metallic components and structures with the highest reliability requirements, the RP must prove that their gross failure possibility is so low that the failure risk can be discounted. For the components and structures with general reliability requirements, depending on their impact on nuclear safety, the structural integrity demonstration for such components will be based on compliance with corresponding nuclear or non-nuclear design codes and standards. The failure risk can be controlled at the level of both tolerable and As Low As Reasonably Practicable (ALARP) over the plant design lifetime.

The design of the UK version of Hua-long Pressurized Reactor (UK HPR1000) will be based on the HPR1000 (FCG3), which has successfully passed the review of the National Nuclear Safety Administration (NNSA) in China. The structural integrity of the metallic components and structures of HPR1000 (FCG3) is demonstrated through the compliance of RCC-M in Reference [2], RSE-M standards in Reference [3] and some Chinese regulatory requirements. This method has also been implemented in a number of Chinese Pressurized Water Reactors (PWR) to ensure safe and reliable operation of the plant. To achieve the expectations and requirements of the UK Regulatory authority for UK HPR1000, the RP will combine relevant good practices of the structural integrity methodology adopted in UK, including the lessons learned from other GDAs, to demonstrate the structural integrity of the metallic components and structures from the perspectives of good design, manufacture, tests, inspection, failure analysis and fore-warning of failure, and to ensure nuclear facility safety.

The structural integrity assessment supports the following high level safety objectives in the areas of Nuclear Safety – Protection of the workers and the Public and Radiological & Environmental Protection, Security & Industrial Safety:

- The design and intended construction and operation of UK HPR1000 will protect the workers and the public by providing multiple levels of defence to fulfil the fundamental safety functions.
- The design and intended construction and operation of UK HPR1000 will be

developed to reduce, so far as is reasonably practicable, the impact on the workers, the public, and the environment.

This chapter will demonstrate the following:

- Appropriate methods that will be adopted for the assessment of the structural integrity of metallic components and structures.

The design of UK HPR1000 will be described in detail in the GDA Pre-Construction Safety Report (PCSR).

This chapter introduces how structural integrity requirements are considered in the design of HPR1000 (FCG3), as well as the activities related to the structural integrity demonstration of UK HPR1000.

In addition, the chapter also describes the methodology for the structural integrity demonstration of metallic components and structures in the nuclear island for UK HPR1000.

17.3 Structural Integrity Demonstration for HPR1000 (FCG3)

The Philosophy of structural integrity of nuclear facilities which are important to safety in HPR1000 (FCG3) is demonstrated through the compliance of RCC-M, RSE-M standards and some Chinese regulatory requirements. This practice had accumulated rich engineering experiences in China General Nuclear Power Corporation (CGN) precedent nuclear plants and been verified a practical and effective method.

This method of structural integrity demonstration for HPR1000 (FCG3) roughly described the following. Firstly the metallic components and structures are classified based on the categorisation and classification scheme recommended by International Atomic Energy Agency (IAEA) safety standard SSG-30 in Reference [4], then appropriate nuclear codes (in some cases, recognised industrial codes) are applied according to the safety class (including function class and barrier class, see Preliminary Safety Report (PSR) sub-chapter 4.7 for details of categorisation and classification) and rigorously carry out relevant activities of design, construction and operation as per code requirements commensurate with the respective code level to ensure the structural integrity of each metallic components and structures.

In accordance with RCC-M codes, the design of these metallic components and structures considers the most rigorous operating conditions to ensure the safety of equipment design. In addition, defects generated during operation are recorded and assessed based on related procedures and rules to ensure the structural integrity. The following sections present the structural integrity consideration of HPR1000 (FCG3) from the perspectives of applicable codes and standards, design, materials, manufacture, testing, installation, pre-service and in-service inspections, operation, monitoring and analysis.

17.3.1 Applicable Codes and Standards

The design, manufacture, inspection, testing, installation and operation of nuclear island equipment of HPR1000 (FCG3) are mainly based on RCC-M 2007, RSE-M 2010 and 2012 Addendum, and of Steam Generator are based on ASME 2007 and 2008 Addendum in Reference [5]. The major codes and standards for barrier class 1 (B-SC1) components are listed in chapter 4 table T-4.8-1, while the major codes and standards for barrier class 2 (B-SC2), barrier class 3 (B-SC3), function class 1 (F-SC1) and function class 2 (F-SC2) components are listed in chapter 4 table T-4.8-2.

17.3.2 Design

During the components design stage, various factors associated with the design have been considered including load conditions, inspection accessibility, component material selection, weld arrangement, structure design and analysis.

Based on the requirements of RCC-M, HPR1000 (FCG3) has selected a conservative load combination approach. Postulated events which based on conservative predictions are used and they cover the entire component service life under different operating conditions.

In the stage of structure design of components, the compatibility with surrounding environments and interfaces, proven and good structure formations, material strength and degradation, maturing formations and methods of weld joint, the accessibility of Non Destructive Test (NDT) and existing proven engineering experiences have been comprehensively considered for structural integrity.

The weld design of components and structural parts in HPR1000 (FCG3) has considered weld material requirements, non-destructive examination requirements, weld quality control, weld type and structure formation and other factors, and eliminated welds from stress concentration areas and geometrical discontinuous regions, in order to support equipment structural integrity in plant operating conditions.

Periodic In-Service Inspection (ISI) is an important means to ensure safe operation of nuclear facilities. The inspection accessibility and route have been considered in the design process to simplify and reduce inspection workload, and also to reduce the exposure dose undertaken by inspection operators.

17.3.3 Materials

Based on the requirements of RCC-M, the material selection for the HPR1000 (FCG3) metallic components and structures has considered the behaviour and function of the equipment in the manufacturing, operation, inspection and maintenance stages, selected existing proven materials with good engineering experience, and avoided damage occurred in manufacture and installation, so that the structural integrity of components has been ensured. The materials manufacture process has been recorded based on related procedures to ensure evidence traceability. Furthermore, the corresponding procedures are also available for non-conformity items.

The compatibility with reactor coolant has been considered in the structural material selection. For all ferritic low alloy steels and carbon steels used for main pressure-retaining components, a corrosion-resistant weld-deposited cladding covers the steel surface that is in contact with reactor coolant. The safe ends of ferritic low alloy steel nozzles and their connecting welding seams (including buttering) used stainless steel forging and nickel based alloy welding materials that have strong stress corrosion resistance.

All austenitic stainless steels of the Reactor Coolant System (RCP [RCS]) and components are required to be transported, stored and cleaned based on the design regulations during manufacturing, installation and tests, in order to minimize ferritic contamination and the possibility of Stress Corrosion Cracking (SCC). All austenitic stainless steels are delivered in the solid solution heat treatment condition. To avoid austenitic stainless steel sensitization and to prevent intergranular corrosion, very low carbon stainless steel is widely used in nuclear island equipment. For other austenitic stainless steel, the intergranular corrosion test shall be carried out during the raw material manufacturing stage according to the requirements of RCC-M.

For the welding materials within the Reactor Coolant Pressure Boundary (RCPB), the welding materials for ferritic base material connections shall meet the requirements of RCC-M S2000, and relevant tests and qualifications on the welding materials comply with the requirements of RCC-M S2000 and S5000. The welding material for austenitic stainless steel base material connections shall meet the requirements of RCC-M S2000, and tests and qualifications on the welding material are conducted based on the requirements of RCC-M S2000 and S5000. The welding materials used to connect nickel-chromium-iron alloy with the same base materials, as well as the welding materials used to connect with ferritic base materials or austenitic base materials shall meet the requirements of RCC-M S2000, and tests and qualifications on the welding material shall follow the requirements of RCC-M S2000 and S5000.

17.3.4 Manufacture and Installation

The manufacture of components and structural parts in HPR1000 (FCG3) has implemented the requirements of RCC-M Section I, Subsections B, C, D, G and H.

Inspections and tests in the manufacturing process are in compliance with the requirements of RCC-M Section III. These examinations include the examinations in manufacture and installation, as well as the examinations after the final stress relieving heat treatment. Inspection methods include the ultrasonic examination, radiographic examination, liquid penetrant examination, magnetic particle examination, eddy current examination and visual inspection.

In the manufacture process, welding requirements comply with RCC-M Section IV. Welding materials are qualified as per RCC-M S5000 and accepted, according to RCC-M

S2000 and also corresponding welding material specifications. Before products are welded, the welding process shall be qualified according to the requirements of RCC-M S3000 and corresponding welding process qualification documents. All welds shall be completed by qualified welders or welding operators. Before welding, the welding personnel shall have obtained welding qualification certificates to ensure that the welding process meets manufacture requirements. The welder's qualification shall meet the requirements of RCC-M S4000. Product welding and weld-related inspections shall be conducted according to the regulations of RCC-M S7000.

Component cleanness and inspections in the manufacture process shall meet the requirements of RCC-M F6000. To facilitate equipment storage and transportation, related surfaces are protected according to the requirements of RCC-M F5300.

Component package, transportation and storage shall meet the requirements of RCC-M F6000. Climate conditions are particularly considered in advance during storage and transportation. Tools and spare parts shall be packed separately using water-proof materials, and delivered with the components.

On-site equipment installation and commissioning are in line with related technical documents and procedures. Implementation methods are developed based on mature and reliable engineering experience of the same type of Pressurized Water Reactor (PWR) units. Manufacture and installation process inspections are carried out by specific quality assurance departments and related organizations.

17.3.5 Pre-service and In-service Inspection and Testing

The components and structures of HPR1000 (FCG3) are carried out pre-service and in-service inspection and testing according to the requirements of RSE-M codes.

Component accessibility during pre-service and in-service inspections has been fully considered in design stage. In reducing the personnel operational dose during in-service inspections, a large number of remote control devices and equipment will be used to perform inspections. Equipment involved in pre-service and in-service inspections is qualified based on regulation and standard requirements and relevant procedures are produced to ensure the compliance of the requirements. Before in-service inspections, the capability of key inspection methods shall be verified to confirm that the personnel, equipment and procedures involved are capable of detecting defect size limits that are stipulated in regulations. Margin should be set in accordance with the agreed acceptance criterion for the defect size specified in the relevant design codes.

17.3.6 Operation

In HPR1000 (FCG3), components and structures that have an important impact on nuclear safety will be operated and controlled within defined limits and under the allowable operating conditions over the plant entire service life. Appropriate safety margins have been allocated in the design and maintenance activities have also been considered to ensure structural integrity of the components over the service lifetime.

Strict control requirements for water chemistry in the reactor coolant system, especially an upper limit for chloride and oxygen concentration in reactor coolant, are implemented to reduce the corrosive environment to ALARP level. During the operating process, hydrogen is added to suppress the generation of oxygen through radiolysis. Laboratory tests and operational experience of similar types of plant have proved that these control measures are effective. Operational practices of earlier PWR plants also indicate that by implementing these measures, no intergranular corrosion occurs on severely sensitized stainless steel which is in contact with coolant for a long time. Detailed descriptions of reactor water chemistry are presented in chapter 21.

For the concern of irradiation embrittlement of the low alloy steel in the active core region, irradiation monitoring capsules are positioned at the outside surface of the Reactor Pressure Vessel Internals (RVI) barrel and specimens will be retrieved and tested periodically. The purpose is to monitor the neutron damage or embrittlement level of the Reactor Pressure Vessel (RPV) affected region during the operating process, and to ensure that RPV will maintain appropriate structural integrity.

17.3.7 Monitoring

The key monitoring systems that provide operating status related to structural integrity of metallic components and structures in HPR1000 (FCG3) are fatigue monitoring system (KIF [FMS]), Loose Parts and Vibration Monitoring (KIR) and the leakage detection system.

The KIF [FMS] system provides fatigue load monitoring of the highly stressed components which is important in ensuring long term reliability and safety of the plant by checking that the design load assumptions are met. The KIF [FMS] system can collate real life fatigue data to be used as the input to fatigue evaluations.

The KIR system has two main sub-systems, i.e. Loose Part Monitoring System (LPMS) and Vessel Vibration Monitoring System (VMS [VVMS]). The function of the LPMS is to detect and locate loose parts in the RCP [RCS] during reactor operation in order to prevent potential damage to the Steam Generator tubes or to the RVI. The function of the VMS [VVMS] is to monitor in-service vibration response of the RPV and RVI, which is useful to detect mechanical deterioration.

The leakage detection system in HPR1000 (FCG3) is used to detect the leakage occurred in the reactor coolant pressure boundary and main steam line (inboard containment), evaluate the leakage rate, locate the leakage position, and provide evaluation and pre-warning for safety operation of nuclear power plants. Leakage monitoring uses level, flow, temperature, humidity measurements. Leakage monitoring consists of identifiable leakage and unidentifiable leakage.

17.3.8 Analysis

Detailed stress analysis and assessments have been performed for components and structures in HPR1000 (FCG3) covering different failure modes. The loadings include operation pressure, temperature, flow rate (including fluctuation) and dead weight, seismic aspects, pipe break etc. The elastic analysis method or simplified elastic-plastic analysis method is used to analyse the design condition, normal and upset conditions, emergency condition, fault condition and hydro-test condition based on RCC-M Subsections B, C, D, G and H. Fracture analysis is conducted based on the RCC-M Appendix Sub-section Z. The data of the table in Sub-section Z is used to confirm the load limits of the analysis and assessments. High stress locations, such as discontinuities and nozzles, will be analysed detailed. RCC-M components will comply with the requirements of RCC-M codes.

The dynamic analysis methodology has been applied to main systems and equipment, such as primary system and RPV. The dynamic effects due to seismic and pipe breaks are assessed, and subsequently the loadings for stress analysis are obtained. The Leak Before Break (LBB) technology has been applied to the primary loop pipe (hot leg, cold leg and transition section), and surge pipes. LBB exhibits the leak behaviour in the event of a through-wall defect developing, and LBB is one of defence in depth methods. The LBB technology mainly follows the requirement of SRP3.6.3 (2007 version) in Reference [6] published by NRC, USA, and refer to the content of relevant chapters, Section III, NUREG-1061 in Reference [7].

RCC-M Appendix ZG has been adopted to carry out the fast fracture assessment of the primary equipment. The analysed zones cover neutron irradiation embrittlement zone, important weld zone and other positions where a crack is likely to be initiated.

17.3.9 Quality Assurance

The quality assurance of HPR1000 (FCG3) during design, procurement, fabrication and inspection are implemented in accordance with the requirements which are identified in sub-chapter 20.6.

17.4 UK HPR1000 Structural Integrity Methodology

The structural integrity demonstration of HPR1000 (FCG3) had been presented in the sub-chapter 17.3. The gaps between the current practices of HPR1000 (FCG3) and the requirements of the UK Regulatory authority have been identified. This sub-chapter will present a proposed methodology of UK HPR1000 structural integrity demonstration and the rest of gaps will be described in subsequent sub-chapter 17.5.

The structural integrity demonstration of UK HPR1000 covers the metallic components and structures of the nuclear island such as pressure vessels, coolant circuits, pipework, core support, pumps, valves, storage tanks, pressure boundary penetrations and the steel liners of concrete containments but excludes the concrete structures.

This sub-chapter introduces the proposed structural integrity classification method to be adopted for UK HPR1000 and presents the approach to the demonstration of the structural integrity for components included.

17.4.1 Proposed Structural Integrity Classification Method for UK HPR1000

HPR1000 (FCG3) safety classification is determined based on IAEA SSG-30. Detailed classification methods for HPR1000 (FCG3) refer to sub-chapter 4.7.

In order to demonstrate consistency with the Office for Nuclear Regulation (ONR) Safety Assessment Principles, certain components are required to justify their reliability beyond the normal design code requirements. For UK HPR1000, it is proposed that the classification method for metallic components and structures is refined to include component classes of High Integrity Component (HIC).

a) High Integrity Component (HIC)

HIC is assigned to the components whose failure is intolerable and for which no protection is provided or protection provision is not reasonably practicable. Components that require the highest reliability such as the RPV will be classified as HIC.

b) Structural Integrity Class 1 (SIC-1)

SIC-1 is assigned to the components and structures whose failure could cause limited core damage. There should be at least one line of protection. The integrity claim for such components will be mainly based on compliance with recognised nuclear design code requirements.

c) Structural Integrity Class 2 and Class 3 (SIC-2 and SIC-3)

SIC-2 or SIC-3 are assigned to the components and structures whose failure does not result in core damage. There should be at least two lines of protection with diversity. The integrity claim for such components will be mainly based on compliance with appropriate design codes and standards.

17.4.2 Approach to the Demonstration of Structural Integrity

The approach to demonstrate structural integrity of the HPR1000 (FCG3) design is to develop a safety case that gives confidence in the reliability of the metal components. A properly constructed safety case will be consistent with the defence in depth principle. For some high reliability components, it is not possible to provide defence in depth through physical means. Defence in depth for such components will be demonstrated through a multi-legged safety case. The following sections present the safety case approach for the component classes described in section 17.4.1.

17.4.2.1 Structural Integrity Demonstration for HIC

The safety case approach presented below for HIC components is consistent with the recommendation by the Technical Advisory Group on Structural Integrity (TAGSI) in Reference [8].

For HIC components, physical redundancy and diversity are not practicably achievable. Defence in depth is demonstrated through the application of appropriate experience, testing, analysis and monitoring addressed in a multi-legged safety case:

a) Leg 1: Design and Manufacture

Based on the existing engineering (manufacturing, construction and operation) experience and proven track records, provide arguments and evidences to demonstrate the high reliability and avoidance of defects and support the claim of good design and manufacture.

b) Leg 2: Functional Testing

Provide arguments and evidences to demonstrate the functionality of the component through testing such as the proof pressure test.

c) Leg 3: Failure Analysis

Provide arguments and evidences to demonstrate tolerance to defects and through-life degradation mechanisms over the design life of the plant using the current best scientific understanding. This exceeds typical design code requirements by recognising that flaws may be present and establishing tolerance to them. Material properties testing, such as tensile and toughness test, will be tested for HIC components if needed.

d) Leg 4: Forewarning of Failure

Provide arguments and evidences to demonstrate that in-service inspection, leakage monitoring, transient monitoring, irradiation surveillance etc. will be in place, and commit to take future actions on gaining new information to effectively forewarn of failure.

A detailed structural integrity program will be developed in the next GDA steps to provide as far as possible separate independent evidences to support these legs of safety case.

17.4.2.2 Structural Integrity Demonstration for SIC-1

The demonstration for the structural integrity of components and structures classified as SIC-1 will be based on the arguments and evidences that recognised nuclear design codes have been followed for the design and manufacture of the SIC-1 components. The demonstrating code compliance with claims and arguments structure will be established for this component class.

17.4.2.3 Structural Integrity Demonstration for SIC-2 and SIC-3

The structural integrity demonstration for components and structures classified as SIC-2 or SIC-3 shall conform to the requirements of the relevant design codes and standards applicable for this component class. The demonstrating code compliance with claims and arguments structure will be established for this component class.

17.5 Structural Integrity Activities for the Next Steps of GDA

This sub-chapter covers the current understanding of Structural Integrity activities required in the following GDA steps. Relevant work plan will be generated and agreed with ONR at the appropriate GDA steps.

17.5.1 Gap Analysis

The structural integrity demonstration of metallic components and structures in HPR1000 (FCG3) presented above, which have passed the review of NNSA in China, is based on the classification system of IAEA and relevant requirements of RCC-M and RSE-M to demonstrate that failure risks of nuclear facilities remain within design limits over the overall plant service lifetime. However, through a preliminary gap analysis, the RP recognized that there are potential differences between the current practice in China and the ONR requirements. These differences are:

a) The gaps between the current versions of codes used in HPR1000 (FCG3) and the more recent versions of codes for UK HPR1000.

b) The structural integrity classification of HPR1000 (FCG3) is potentially different from the expectations of ONR.

c) The demonstration of the structural integrity for the metallic components and structures with the highest reliability requirements is different from the multi-legged safety case approach that ONR expects.

d) The fracture assessment method for the components with cracks assumption for HPR1000 (FCG3) primary equipment has adopted RCC-M methods, which is different from R6 methods traditionally used in UK for HIC components.

e) The fracture toughness test of material of HIC components is required in UK GDA context.

f) Independent third-party inspections in manufacture stage of HIC components will be done to confirm that processes and procedures are being followed.

The RP will conduct work required to address the gaps in order to meet the ONR expectations.

17.5.2 Further Tasks for the Next-steps of GDA

Based on the differences described in section 17.5.1, UK HPR1000 will subsequently complete the following structural integrity tasks.

a) Applicable standards and version

The standards and version applicable to the structural integrity demonstration of UK HPR1000 is being carried out relevant gap analysis against the current latest versions.

b) Programme for Structural Integrity Classification

1) Define structural integrity classification process,

2) Systematically classify relevant components and structures based on the safety classification method,

3) Identify specific assessment requirements for the structural integrity demonstration for different classes of components.

c) Programme for Defect Tolerance Assessment

On the basis of the on-going fast fracture analysis and assessment of HPR1000 (FCG3), derive a programme for defect tolerance assessments by following R6 procedure to demonstrate avoidance of fracture of HIC components.

d) Inspection Assessment

At the end of manufacturing stage, the NDT of HIC welds will be qualified according to the European Network for Inspection and Qualification (ENIQ)-based Methodology. The RP will develop an inspection qualification programme to prove the effectiveness of NDT method of HIC components. The detail will be addressed through the Nuclear Site Licensing Phase which is outside the scope of GDA.

e) Fracture toughness test of material

The fracture toughness test of material of HIC components will be considered and implemented at the stage of product manufacture in UK HPR1000. The detail will be addressed through the Nuclear Site Licensing Phase which is outside the scope of GDA.

f) Methodology of construct component safety cases

Establish an initial programme for conducting safety cases of the structural integrity of HIC components and structures based on the multi-legged approach recommended by TAGSI and precedent GDA good practices.

g) Programme for Third-party Inspection

Develop a preliminary plan for conducting manufacture and installation relevant inspections of HIC components and structures to meet the requirements and content of the third-party inspections. The detail will be addressed through the Nuclear Site Licensing Phase which is outside the scope of GDA.

17.6 Conclusions

This chapter briefly describes the scope, objectives, classification method, corresponding demonstration of safety case approach for the structural integrity of metallic components and structures for UK HPR1000. The RP has started to undertake a gap analysis to establish gaps between HPR1000 (FCG3) structural integrity demonstration practices and the ONR’s expectations and requirements. The RP will conduct the tasks required in the next GDA steps to enable UK HPR1000 structural integrity demonstration to meet the regulatory requirements and standards in UK.

17.7 References

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