## Revision Log

| Revision | Description of Changes |
|---|---|
| 0 | Initial Issue. |

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## Executive Summary

Holtec is anticipating a future exemption request to be submitted relating to 10 CFR 50.46 applicability to aspects of the SMR-160 design in support of a future licensing application under 10 CFR 50. This report documents the potential items to be used in justifying the exemption, pertaining to the NRC regulations governing postulated Loss of Coolant Accidents (LOCAs) for the SMR-160 Reactor Coolant System (RCS). This report lists these items in a 'Table of Contents' format which will be used to develop a report containing the full justification for the exemption request. The design documents and NRC correspondence used to develop this report are listed in the Reference section.

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## Table of Contents



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# 1.0 PURPOSE

The purpose of this report is to capture and document the potential items that will be used to assist in justifying an exemption to the NRC regulations governing postulated Loss of Coolant Accidents (LOCAs) for the SMR-160 Reactor Coolant System (RCS). This report lists these items in 'Table of Contents' format which will be used to develop a report containing the justification for the exemption request.

# 2.0 METHODOLOGY

The list of items for the exemption justification were collected through a systematic approach of reviewing the SMR-160 design documentation and prior correspondence (public meetings, teleconferences, informal discussions, requests for additional information, audits, etc.) with the NRC staff during the SMR-160 pre-application activities. In addition to this, other recent exemption requests were reviewed to ensure consistency with the structure, format, content, and justification methodology.

# 3.0 EXEMPTION JUSTIFICATION ITEMS LIST

The potential LOCA exemption justification items are listed in a 'Table of Contents' format below:

**1.0 Introduction and Request**
- **1.1 Executive Summary**
- **1.2 Introduction -** Purpose, Scope, Staff Position and Background
- **1.3 Regulatory Requirements**
- **1.4 Exemption Sought**
- **1.5 Effect on SMR-160 Regulatory Compliance**

**2.0 Justification for Exemption**

**2.1 SMR-160 RCS and Subject Locations**
- Description of SMR-160 Design (including RCS and ECCS Systems)
- Discussion on 'Unique' Design Aspects (Configuration, Shape, and Size)
- Discussion on Criteria and Selection Methodology of Break Locations and Break Sizes
- Discuss the Application of Break Exclusion and Application to the SMR-160 Design

**2.2 Industry Operating Experience and Design Comparisons**
- Discussion on Applicable Operating Experience (Nuclear and Non-Nuclear)
- Discussion of Differences in SMR-160 Design from Operating Fleet Which Could Affect the Potential Likelihood of Failures and the extent of the Failures (Break Size)

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## 2.3 Technical Basis

### 2.3.1 Systems Design

Discussion of Applicable ASME Codes for the SMR-160 Design (including specifics for the Subject Locations)

- Include Detailed Descriptions and Drawings for the Subject Locations
- This discussion will specify and commit to the applicable code criteria for Construction (including design) and pre-service and in-service inspections, the frequency of these inspections and acceptance criteria required for the subject locations and their welds. (Note: This discussion will show a gap analysis of the vessel and pipe ASME Code requirements for construction, and pre-service and in-service inspection activities. It will also include committing to the more conservative option for the subject locations and their welds for both construction and inspection activities.)

Discussion of BPV Code Design by Analysis

- Load combinations considered
- Include an illustrative analysis package

Discussion and Table Including Primary Stress Intensity Limits for the Subject Locations and Their Welds

Discussion of SSC classification system application to the RCS

### 2.3.2 Mechanical Design

Descriptions and Drawings for the Subject Locations

- Include material labels for the RCS and Subject Locations

Discussion of the Forging Process for the RCS vessels and Subject Locations

- Include comparisons of the forgings for the SMR-160 design subject locations to proven forging methods for currently in-service reactor pressure vessels (RPVs).

Discussion of System Structural Layout

- Include all structural support elements, spacing, design considerations, and configurations for the RCS and Subject Locations

Discussion of Nondestructive Examination for Fabrication, Preservice and Inservice

- This discussion will include inspection accessibility to achieve 100 percent volumetric examination coverage of welds and adjacent base materials, the inspection methods, applicable acceptance criteria, and qualification requirements. Note: A commitment will be made to the volumetric examination of the required volume as defined per the ASME BPV Code. Information will be provided that identifies the locations of the inspections and makes a commitment that inspections will occur on those portions of the welds which fall into the required examination category and examination item similar to IWB-2500 of the ASME BPV Code, Section XI.

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### 2.3.3 Material Design

Discuss the Materials of Construction for the Subject locations

- Include description and drawings for base and weld materials, material properties, material types, material processing, etc. for the subject locations.

Discussion of Weld Specifics (Weld Design, Geometries, and materials, including cladding) for Subject Locations

Discussion of the Fabrication of Materials (including Welding Methods, Weld Residual Stresses and Analysis, Weld Controls/Qualifications, Post Weld Heat Treatment)

- Include a discussion on the similarities and differences of the proposed welds from currently operating plants and their welds. Note: This discussion will also include a potential commitment to performing items like post weld heat treatment, even if they are allowed to be exempted by the code, to build in additional conservatism and margin for safety. Also, consider including FEA calculations for WRS due to forming processes used and evaluated by fracture mechanics.

Discussion of Material Environment at the Subject Locations (including water chemistry controls, stagnant locations, large heat sinks affecting residual stresses, etc.)

- This discussion will include the steam generator (SG) Riser weld locations because of the length of the seamless forging and the potential for them to experience loadings from pressure and temperature differentials, and other environmental conditions (i.e., primary water [temperature and chemistry] on one side of the riser with secondary water [temperature and chemistry] on either side of the riser).

Discuss the Potential Leakage and Failure and Degradation Mechanisms for the Subject Locations

- Discussion of Brittle Fracture and Prevention
- Discuss Potential Concerns with Stress Corrosion Cracking. Include discussion of RG 1.44 and EPRI and industry guidance on water chemistry, and minimizing applied and residual stresses in the subject locations to reduce possibility of SCC)
- Discuss Potential Fatigue Issues with the Subject Locations
- Discuss Potential Water Hammer Conditions
- Discuss Potential Thermal (Aging) and Hydrogen Embrittlement of the Subject Locations. Note: Thermal may not apply if not cast materials. For hydrogen, specify that industry guidance will be followed to prevent issues during welding.

Discussion of Fracture Mechanics Analyses and Methodology (include acceptance criteria supporting extremely low likelihood of leakage or structural failure) for Subject Locations

- Discuss both deterministic and probabilistic fracture mechanic analyses (methodologies and acceptance criteria) that demonstrate sufficiently low likelihood of failure. This discussion will also ensure

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PIF to SG welds, SG Riser section welds, and SG Riser to tube sheet welds are discussed. Other items discussed in this section include the subject location's material nil ductility temperature, shifts in reference transition temperature due to quench/temper, irradiation, time at temperature. NDE will be used to show how small a defect can be identified.

- Performance of fracture mechanics analysis as per ASME Section III Appendix G

**2.3.4 Probabilistic Risk Analysis (PRA) for Design Basis Accident (DBA) Break Size**

Discussion of PRA Modeling Assumptions and Conclusions

Criteria and Assumptions for Assessing Potential Break Consequences at the Subject Locations

- Include a discussion on the determination of criteria and assumptions for DBA, Special Events, and BDBAs, and the determination of thresholds using a combination including but not limited to break frequency, initiating event, crack growth rate, inspections frequencies, joint/weld design.

Identification and Selection of Potential Break Locations and Break Sizes

- Include Discussion of Subject Locations for Potential 10 CFR 50.46 Design Basis Analysis Exclusion (Note: This discussion will include quantitative analysis (and PRA driven results) to support the SMR-160 qualitative justifications.)

Discussion of Break Probability for the Full Spectrum of Break Types and Locations

Discussion of Initiating Event Frequency (based on Break Probability) at the Subject Locations

Description of Thermal Hydraulic Analyses Used to Support PRA CDF Calculations

Discussion on Defense-In-Depth (DID) Design and Mitigation Capabilities for the Full Spectrum of Break Types and Locations. Discuss DID for Each of the Three Barriers (Fuel Cladding, RCPB, and Containment) for Potential Failures at the Subject Locations

- Include a discussion of the redundancy, reliability and system performance capabilities for each layer of DID and mitigation strategy, this includes all passive safety systems and features. Also, include a discussion with specifics as to what design features, criteria, methods, programs, and commitments will be met by a future applicant to analyze, detect, or monitor for leak detection, isolation and containment capabilities for components connected to the RPV, the SG and penetrating containment.

**2.3.5 Deterministic Analysis of DBA LOCAs**

Discussion of LOCA RELAP Modeling for the SMR-160 Design

- Include assumptions and conclusions

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DID and Mitigation for Potential Failures at the Subject Locations
Discuss DID for Each of the Three Barriers (Fuel Cladding, RCPB, and Containment) for Potential Failures at the Subject Locations
- Include a discussion of the redundancy, reliability and system performance capabilities for each layer of DID and mitigation strategy, this includes all passive safety systems and features. Also, include a discussion with specifics as to what design features, criteria, methods, programs, and commitments will be met by a future applicant to analyze, detect, or monitor for leak detection, isolation and containment capabilities for components connected to the RPV, the SG and penetrating containment.

Discussion on Related Regulations, Applicable Containment and Dose Requirements for RCPB
- Include a discussion of 10 CFR 50.34(a)(1(ii) for allowable dose consequences for postulated accidents and GDCs 50 through 57 for containment requirements.

**2.3.6 Probabilistic Analysis of BDBA LOCAs**

Discussion of PRA Modeling Assumptions and Conclusions

DID and Mitigation for Potential Failures at the Subject Locations
Discuss DID for Each of the Three Barriers (Fuel Cladding, RCPB, and Containment) for Potential Failures at the Subject Locations
- Include a discussion of the redundancy, reliability and system performance capabilities for each layer of DID and mitigation strategy, this includes all passive safety systems and features, and non-safety related systems that can be used to mitigate the spectrum of special events and BDBAs. Also, include a discussion with specifics as to what design features, criteria, methods, programs, and commitments will be met by a future applicant to analyze, detect, or monitor for leak detection, isolation and containment capabilities for components connected to the RPV, the SG and penetrating containment.

Analysis of SMR-160 Design Capability to Mitigate Breaks Larger than those Excluded from 10 CFR 50.46 Design Bases Analyses

**2.3.7 Operations, Procedures and Programs**

Discuss Applicable Technical Specifications and Operator Actions Used to Address the Full Spectrum of Potential Breaks

Discuss the application of 10 CFR 50 Appendix J Leakage Rate Testing for RCS Isolation Valves

Discuss Operational Programs and Procedures Used for the Identification of Potential Issues with RCPB Integrity
- This will include vibration conditions or a description of a comprehensive vibration assessment program (CVAP) for the Subject Locations as described in RG 1.20. Note: The NRC staff will need to review a future applicant's evaluation of potential vibration induced failure and degradation mechanisms and establishment of a CVAP.

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Discuss Design Features and Operational Procedures to Preclude Steam and Water Hammer Conditions and Loads (include interconnecting systems)

- Include discussion of leakage detection and monitoring system that will be employed to detect any leakage at the subject locations and their welds. Also discuss potential technical specifications (TSs) involving leakage, including actions to ensure prompt shutdown to reduce pressure and minimize potential large break LOCA (LBLOCA) at the subject locations satisfying 10 CFR 50.36 requirements. Note: Review RG 1.45, Guidance on Monitoring and Responding to RCS Leakage. The NRC staff will need to review a future applicant's leakage detection program plan and related TSs.

Discuss Additional Operator Actions, Automatic Actions, Other Design Capabilities (including non-safety related systems and features)

**3.0 Regulatory Basis**

**3.1 Criteria of 10 CFR 50.12 Specific Exemptions**

**4.0 Conclusions**

**Note:** As discussed with the NRC staff, each section above will be evaluated for the inclusion of specific analysis methodology, acceptance criteria, conditions and limitations where appropriate (i.e., for the subject locations, welds, the materials, inspection activities, leakage monitoring, fatigue, water chemistry, programs and procedures, etc.). Also, each section will discuss, where appropriate, the potential need for the NRC to review a future's applicant's program, procedures, evaluations, and other supporting documentation for the exemption justification to remain valid.

# 4.0 CONCLUSIONS

As stated in the Executive Summary, this report captures and documents all the potential items that will be used to assist in justifying an exemption to the NRC regulations governing postulated LOCAs for the SMR-160 RCS. This report will be shared with the NRC staff and used, along with NRC staff feedback on this report, to develop a comprehensive LOCA exemption justification report.

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## 5.0 REFERENCES


[1] ML22235A111, 08/31/2022 Preapplication Meeting with Holtec International, LLC, regarding Loss-of-Coolant Accident Analyses to support the Construction Permit for the Holtec SMR-160 Design

[2] ML22236A529, SMR, LLC Preapplication Meeting Materials for August 31, 2022 (Project No. 99902049)

[3] HI-2201064, Elimination of Large Break Loss of Coolant Accident (LOCA) and Establishment of LOCA Acceptance Criteria for SMR-160, Revision 2 (including Revision 3 edits made as a result of NRC RAIs prior to LTR withdrawal)

[4] ML22228A024 and ML22018A171, Withdrawal of SMR, LLC, SMR-160 Topical Report: Elimination of Large Break Loss of Coolant Accident (LOCA) and Establishment of LOCA Acceptance Criteria

[5] ML22028A085 and ML21263A245, Regulatory Audit Report of the Holtec SMR-160 Topical Report HI-2201064 Elimination of Large Break Loss of Coolant Accident (LOCA) and Establishment of LOCA Acceptance Criteria, Revision 2

[6] ML21364A119 and ML22028A023, November 23, 2021, Summary of the Public Meeting to Discuss the Holtec Small Modular Reactor, SMR-160, Topical Report: "Elimination of Large Break LOCA and Establishment of LOCA Acceptance Criteria"

[7] ML21230A134, Holtec International – Response to Request for additional Information (RAI) on LOCA Criteria

[8] ML21218A134, Enclosure 2: Response to Request for Additional Information 9846 (eRAI 9846)

[9] ML21218A132, SMR, LLC – Response to Request for Additional Information (RAI) 9846

[10] ML21123A187, 2021/05/03 Holtec SMR-160 RAI – Final Holtec RAI_9832 4-32-21R1

[11] ML21116A103, 2021/04/26 Holtec SMR-160 RAI – Request for Additional Information 9832 (eRAI 9832)

[12] ML22243A010, Summary of the August 31, 2022, Public Meeting

[13] ML21202A235, Summary of July 13, 2021, Public Meeting

[14] ML21180A465, Summary of the June 16, 2021, Public Meeting

[15] ML21117A417, Summary of the April 21, 2021, Public Meeting

[16] ML21056A022, Summary of the February 17, 2021, Public Meeting

[17] ML21092A159, Summary of the March 31, 2021, Public Meeting


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