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INTERMEDIATE HEAT EXCHANGER (IHX)

ASME STANDARDS TECHNOLOGY, LLC

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ASME CODE CONSIDERATIONS FOR THE INTERMEDIATE HEAT EXCHANGER (IHX)

ASME STANDARDS TECHNOLOGY, LLC

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FOREWORD

This document is the result of work resulting from Cooperative Agreement DE-FC07-05ID14712 between the U.S. Department of Energy (DOE) and ASME Standards Technology, LLC (ASME ST-LLC) for the Generation IV (Gen IV) Reactor Materials Project. The objective of the project is to provide technical information necessary to update and expand appropriate ASME materials, construction and design codes for application in future Gen IV nuclear reactor systems that operate at elevated temperatures. The scope of work is divided into specific areas that are tied to the Generation IV Reactors Integrated Materials Technology Program Plan. This report is the result of work performed under Task 7 titled "ASME Code Considerations for the Intermediate Heat Exchanger (IHX)."

ASME ST-LLC has introduced the results of the project into the ASME volunteer standards committees developing new code rules for Generation IV nuclear reactors. The project deliverables are expected to become vital references for the committees and serve as important technical bases for new rules. These new rules will be developed under ASME's voluntary consensus process, which requires balance of interest, openness, consensus and due process. Through the course of the project, ASME ST-LLC has involved key stakeholders from industry and government to help ensure that the technical direction of the research supports the anticipated codes and standards needs. This directed approach and early stakeholder involvement is expected to result in consensus building that will ultimately expedite the standards development process as well as commercialization of the technology.

ASME has been involved in nuclear codes and standards since 1956. The Society created Section III of the Boiler and Pressure Vessel Code, which addresses nuclear reactor technology, in 1963. ASME Standards promote safety, reliability and component interchangeability in mechanical systems.

Established in 1880, the American Society of Mechanical Engineers (ASME) is a professional not-for-profit organization with more than 127,000 members promoting the art, science and practice of mechanical and multidisciplinary engineering and allied sciences. ASME develops codes and standards that enhance public safety, and provides lifelong learning and technical exchange opportunities benefiting the engineering and technology community. Visit www.asme.org for more information.

The ASME Standards Technology, LLC (ASME ST-LLC) is a not-for-profit Limited Liability Company, with ASME as the sole member, formed in 2004 to carry out work related to newly commercialized technologies. The ASME ST-LLC mission includes meeting the needs of industry and government by providing new standards-related products and services, which advance the application of emerging and newly commercialized science and technology and providing the research and technology development needed to establish and maintain the technical relevance of codes and standards. Visit www.stllc.asme.org for more information.

ABSTRACT

Part I - Review of Current Experience on Intermediate Heat Exchanger

This report will first review the different concepts of intermediate heat exchanger (IHX) that could be envisioned for HTR/VHTR applications in a range of temperatures from 850 to 950°C. This will cover shell-and-tube and compact designs (including the plate-fin concept). The review will then discuss the maturity of the concepts in terms of design, fabricability and component testing. This report will also discuss material candidates for IHX applications and will discuss specific issues that will have to be addressed in the context of the HTR design.

Part II - Recommended Code Approach for Intermediate Heat Exchanger

This report is providing recommendations in terms of Code approach for the Intermediate Heat Exchangers envisioned for High Temperature Gas-Cooled Reactors. The report will address the following:

- Recommend key features of a construction code needed to address the unique issues associated with the VHTR IHX and associated equipment
- Identify the tests which should be required to establish cyclic life or to calibrate design methods
- Identify required in-service inspection and associated NDE
- Review the adequacy of existing ASTM specifications for materials, testing, examination, etc. to determine if any new standards will need to be developed to support IHX design, fabrication, operation or inspection.
- Provide recommendations in terms of Code infrastructure.

PART I

Review of Current Experience on Intermediate Heat Exchanger

1 INTRODUCTION

This report reviews the current experience on various high temperature reactor intermediate heat exchanger (IHX) concepts. There are several different IHX concepts that could be envisioned for HTR/VHTR applications in a range of temperatures from 850 to 950°C. The concepts that will be primarily discussed herein are:

- Tubular Helical Coil Heat Exchanger (THCHE)
- Plate-Stamped Heat Exchanger (PSHE)
- Plate-Fin Heat Exchanger (PFHE)
- Plate-Machined Heat Exchanger (PMHE).

The primary coolant of the NGNP is potentially subject to radioactive contamination by the core as well as contamination from the secondary loop fluid. Intermediate heat exchangers (IHXs) have been proposed as a means of separating the primary circuit of the NGNP or other process heat application from the remainder of the plant in order to isolate the radioactivity and minimize radiation doses to personnel as well as protect the primary circuit from contamination.

2 SCOPE

This report will first review the different concepts of IHX that could be envisioned for HTR/VHTR applications in a range of temperature from 850 to 950°C. This will cover shell-and-tube and compact designs (including the plate-fin concept). The review will then discuss the maturity of the concepts in terms of design, fabricability and component testing (or feedback from experience when applicable). Particular attention will be paid to the feasibility of developing the IHX concepts for the NGNP with operation expected in 2018-2021. This report will also discuss material candidates for IHX applications and will discuss specific issues that will have to be addressed in the context of the HTR design (thermal aging, corrosion, creep, creep-fatigue, etc). Particular attention will be paid to specific issues associated with operation at the upper end of the creep regime.