Design Basis Document / Owner's Technical Specification for Nitrate Salt Systems in CSP Projects

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1. Introduction

One of the principal means of communication among the project owner, the engineering-procurement-construction (EPC) contractor, and the operation and maintenance contractor is the Design Basis Document. The Document is also known as an Owner's Technical Specification. The document describes the basic design parameters for the project, such as the mirror reflector area, the thermal storage capacity, the steam generator duty, and the steam turbine rating. But of equal importance, the document also defines items such as the plant operating modes, transitions between modes, heat transport fluid properties, reflector optical requirements, allowable receiver fluxes, suitable materials, corrosion allowances, valve types, instrument types, heat trace requirements, and heat exchanger fabrication techniques. To a large degree, the Design Basis Documents are generic to the collector technology; i.e., parabolic trough or central receiver.

2. Content

The work proposed concentrates on Design Basis Documents for parabolic trough and central receiver power plants using nitrate salt as the heat transport fluid and the thermal storage medium. The goals are to 1) distill the successful experience with nitrate salt systems from as many commercial projects as possible, 2) provide technical bases for equipment design/selection that an owner can impose on an EPC contractor, 3) compile this information in one location to provide guidance on salt systems that is as broadly applicable to as many projects as possible, and 4) work toward an industry consensus on a Design Basis Document.

3. Previous Work

In 2001, at the completion of the Solar Two project, Bechtel developed a Design Basis Document for a follow-on tower project in Spain [1]. The follow-on project was tentatively identified as Solar Tres. Solar Tres evolved into the Gemasolar project, which was designed, constructed, and is currently under operation by SENER.

In 2010, Abengoa conducted a study for DOE, entitled Development of Molten Salt Heat Transfer Fluid Technology for Parabolic Trough Solar Power Plants [2]. One of the tasks was the development of a plant Design Basis Document.

In 2011, Abengoa conducted a study for DOE, entitled Development of a Baseload CSP - Advanced Nitrate Salt Central Receiver Power Plant [3]. One of the tasks was the development of a plant Design Basis Document.

In 2017, SolarReserve started the development of a Design Basis Document for the Redstone tower project in South Africa. The Redstone project was to be essentially a duplicate of the Crescent Dunes project in Nevada. However, technical and financial problems with the Crescent Dunes project precluded the financial closure of the Redstone project under SolarReserve, and the associated Design Basis Document was never finished.

In 2019, Worley-Parsons, under contract to Solar Dynamics, developed a Design Basis Document for nitrate salt as the heat transport fluid and thermal storage medium in parabolic trough power plants. In a separate

study for Solar Dynamics, Sargent & Lundy developed a Design Basis Document for nitrate salt as the receiver coolant, thermal storage medium, and heat transport fluid in a central receiver power plant.

In 2020, TerraPower started development on a next-generation nuclear power project. The reactor is cooled with sodium, and heat is transferred to a nitrate salt loop for thermal storage and steam generation. The thermal storage system allows the reactor to operate at a continuous output of 100 percent, while permitting the steam turbine cycle to operate at varying loads tailored to the local utility's peak demand periods. In support of the TerraPower program, Solar Dynamics prepared a Design Basis Document for the nitrate salt systems.

Goals

The work will examine the experiences of commercial projects, and propose recommended changes to the current Design Basis Documents to improve the reliabilities and the availabilities of current projects. Many solar projects using nitrate salt as the working fluid have failed to meet their annual energy outputs calculated in the performance models. The sources of the shortfalls are usually not deficiencies in equipment performance or system efficiency; most of the problems can be traced to the plants failing to meet their availability targets.

The goals of the work are to 1) distill the successful experience with nitrate salt systems from as many commercial projects as possible, 2) provide technical bases for equipment selection and design that an owner can impose on an EPC contractor, with the goal of avoiding past mistakes, 3) compile this information in one location to provide guidance on salt systems that is as broadly applicable to as many projects as possible, and 4) work toward an industry consensus on a Design Basis Document.

The draft document will be circulated among interested parties in the CSP industry for review and comment. Given the industry interest in contributing to, and provide comments on, the Best Practices study [4], it is likely that a similar industry interest will be afforded the draft Design Basis Document.

Status

Work on the project is scheduled to begin in May 2022, with preliminary results available at the time of the Conference. However, the point of departure for the work is a compilation and a summary of the 7 Design Basis Documents noted above. As such, there is a significant data base of material available at the start of the work, which should provide meaningful progress over the next 6 months. The proposed paper for the Conference will provide a summary of the key findings at that stage of the review.

References

[1] A. B. Zavoico, "Solar Power Tower Design Basis Document, SAND2001-2100", Sandia National Laboratories, 2001.

[2] "Molten Salt Heat Transfer Fluid Technology for Parabolic Trough Solar Power Plants", DOE Contract DE-FC36-08GO18038, July 2010.

[3] "Development of Baseload CSP - Advanced Nitrate Salt Central Receiver Power Plant", DOE Contract DE-EE0003596, February 2011.

[4] "Concentrating Solar Power Best Practices Study", National Renewable Energy Laboratory Technical Report NREL/TP-5500-75763, June 2020.