CONCENTRATED SOLAR POWER (CSP) CODES AND STANDARDS GAP ANALYSIS
CONCENTRATED SOLAR POWER (CSP) CODES AND STANDARDS GAP ANALYSIS

Prepared by:

Steve Torkildson, P.E.
Consultant

ASME STANDARDS TECHNOLOGY, LLC
Date of Issuance: December 21, 2012

This report was prepared as an account of work sponsored by ASME Pressure Technologies Codes and Standards and the ASME Standards Technology, LLC (ASME ST-LLC).

Neither ASME, ASME ST-LLC, the author, nor others involved in the preparation or review of this report, nor any of their respective employees, members or persons acting on their behalf, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe upon privately owned rights.

Reference herein to any specific commercial product, process or service by trade name, trademark, manufacturer or otherwise does not necessarily constitute or imply its endorsement, recommendation or favoring by ASME ST-LLC or others involved in the preparation or review of this report, or any agency thereof. The views and opinions of the authors, contributors and reviewers of the report expressed herein do not necessarily reflect those of ASME ST-LLC or others involved in the preparation or review of this report, or any agency thereof.

ASME ST-LLC does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a publication against liability for infringement of any applicable Letters Patent, nor assumes any such liability. Users of a publication are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representative(s) or person(s) affiliated with industry is not to be interpreted as government or industry endorsement of this publication.

ASME is the registered trademark of the American Society of Mechanical Engineers.
TABLE OF CONTENTS

Foreword ................................................................................................................................................ v
Abstract ................................................................................................................................................. vi
1 Introduction ...................................................................................................................................... 1
2 System Descriptions......................................................................................................................... 3
   2.1 Dish Systems ............................................................................................................................. 3
   2.2 Linear Systems ............................................................................................................................ 3
       2.2.1 Linear Parabolic Trough Systems ................................................................................ 3
       2.2.2 Linear Fresnel Systems ................................................................................................ 4
       2.2.3 Linear System Heat Transfer ........................................................................................ 4
   2.3 Power Towers ............................................................................................................................ 5
       2.3.1 Power Tower Rankine Cycle Receiver ......................................................................... 5
       2.3.2 Molten Salt Receiver ..................................................................................................... 5
       2.3.3 Power Tower Brayton Cycle Receiver ......................................................................... 6
3 Boiler and Pressure Vessel Code Issues and Gaps .......................................................................... 8
   3.1 Boiler Definitions ...................................................................................................................... 8
       3.1.1 Is a CSP heated device fired? ....................................................................................... 8
       3.1.2 Closed or Open Systems ............................................................................................... 9
       3.1.3 Review of State Boiler Definitions .............................................................................. 9
   3.2 Stirling Engine Receivers Gap Analysis ................................................................................. 13
   3.3 Rankine Cycle Receiver Gap Analysis .................................................................................... 14
   3.4 Molten Salt CSP System Gap Analysis ................................................................................... 16
       3.4.1 Molten Salt Gaseous Phase ........................................................................................ 18
   3.5 Brayton Cycle Receiver Gap Analysis .................................................................................... 18
4 Recommendations .......................................................................................................................... 21
   4.1 Boiler Definition...................................................................................................................... 21
   4.2 Stirling Engine Systems .......................................................................................................... 21
   4.3 Rankine Cycle – Tower Mounted ............................................................................................ 21
   4.4 Rankine Cycle – Linear Receiver Systems (Troughs and Linear Fresnel Collectors) .......... 21
   4.5 Molten Salt Receivers ............................................................................................................. 21
   4.6 Brayton Cycle Receivers ......................................................................................................... 22
5 The Future ...................................................................................................................................... 23
   5.1 ASME CSP Performance Test Code ....................................................................................... 23
   5.2 Other CSP Technologies ......................................................................................................... 23
References ............................................................................................................................................ 24
Appendix A .......................................................................................................................................... 25
Acknowledgements .............................................................................................................................. 28
Abbreviations and Acronyms ............................................................................................................... 29
LIST OF TABLES
Table 1- State Boiler Definitions ................................................................. 10
Table 2 - Elements of State Boiler Definition ............................................. 11
Table 3 - Comparison of Arizona Definition to Solar Technologies ............... 11
Table 4 - Comparison of California Definition to Solar Technologies .......... 11
Table 5 - Comparison of Colorado Definition to Solar Technologies .......... 12
Table 6 - Comparison of Nevada Definition to Solar Technologies ............. 12
Table 7 - Comparison of New Mexico Definition to Solar Technologies .... 12
Table 8 - Comparison of Utah Definition to Solar Technologies ................. 12
Table 9 - Solar Stirling Engine Risks and Mitigation ................................. 14
Table 10 - CSP Rankine Cycle Boiler Risks and Mitigation ......................... 14
Table 11 - CSP Molten Salt System Risks and Mitigation ......................... 17
Table 12 - CSP Brayton Cycle Risks and Mitigation ................................. 19

LIST OF FIGURES
Figure 1 - Parabolic Dish With Stirling Engine ........................................ 3
Figure 2 - Parabolic Trough Collector ...................................................... 4
Concentrated Solar Power Codes and Standards Gap Analysis  

FOREWORD

The report provides an analysis of the ASME codes and standards that apply to Concentrated Solar Power (CSP) technologies to determine the gaps in the codes and standards and where there may be additional codes and standards work required to implement and commercialize CSP.

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 technology. 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

Numerous concentrated solar power (CSP) facilities have been in successful commercial operation for the past 25 years. Recently, government incentives and advances in cost reduction have brought many new players into the field. An accelerated deployment of CSP is currently being seen worldwide. Many of the developing technologies in CSP have failure modes and effects different from those treated by existing boiler and pressure vessel codes. This study is a gap analysis to identify differences between the safety regulation needs of emerging CSP technologies and existing ASME Boiler and Pressure Vessel codes (BPV). Six leading CSP technologies are examined. The safety related failure modes of these systems are identified and compared with existing Code rules to identify gaps in code coverage. Recommendations for actions to close these gaps are proposed.