

# ASME NTB-4-2021

Background Information for  
Addressing Adequacy or  
Optimization of ASME BPVC  
Section III, Division 5 Rules for  
Nonmetallic Core Components



ASME NTB-4-2021

**BACKGROUND  
INFORMATION FOR  
ADDRESSING ADEQUACY  
OR OPTIMIZATION OF  
ASME BPVC SECTION III,  
DIVISION 5 RULES FOR  
NONMETALLIC CORE  
COMPONENTS**

*Prepared by:*

Josina W. Geringer, Oak Ridge National Laboratory  
Timothy D. Burchell, Oak Ridge National Laboratory  
Mark Mitchell, Ultra Safe Nuclear Corporation



Date of Issuance: June 30, 2021

This manuscript was sponsored by the US Department of Energy, Office of Nuclear Energy, under contract DE-AC05-00OR22725 with Oak Ridge National Laboratory, managed and operated by UT Battelle LLC. Neither the United States Government nor any agency thereof, nor any of their employees, 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 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 the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof. The United States Government retains, and by accepting the work for publication, the publisher acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for United States Government purposes.

Neither ASME, ASME Standards Technology, LLC (“STLLC”), the authors, nor others involved in the preparation or review of this publication, 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 or others involved in the preparation or review of this publication, or any agency thereof. The views and opinions of the authors, contributors, and reviewers of this publication expressed herein do not necessarily reflect those of ASME or others involved in the preparation or review of this document, or any agency thereof.

ASME does not “approve,” “rate”, or “endorse” any item, construction, proprietary device, or activity.

ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this publication and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor assume any such liability. Users of a code or standard 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 code or standard.

ASME is the registered trademark of The American Society of Mechanical Engineers.

No part of this document may be reproduced in any form,  
in an electronic retrieval system or otherwise,  
without the prior written permission of the publisher.

The American Society of Mechanical Engineers

Two Park Avenue, New York, NY 10016-5990

ISBN No. 978-0-7918-7458-5

Copyright © 2021

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

All Rights Reserved

**TABLE OF CONTENTS**

Table of Contents ..... iii  
 Foreword .....iv  
 Abbreviations and Acronyms .....v  
 1 INTRODUCTION ..... 1  
 2 CODE APPROACH .....4  
 3 GRAPHITE STRENGTH ..... 14  
 4 CODE VERIFICATION ..... 16  
 5 SUMMARY ..... 22  
 References ..... 23  
 Appendix A: Graphite Core Components Code Development Progress Presented to ASME Section III (2005) ..... 26

**LIST OF TABLES**

Table 1: Comparison of the Behavior of Steels and Nuclear Graphite .....2  
 Table 2: Safety Margins for Core Support Structures (In Tensile Loading) .....8  
 Table 3: Design Allowable Probability of Failure .....9  
 Table 4: Set of Verification Problems (VP) ..... 18

**LIST OF FIGURES**

Figure 1: JAEA Methodology: (a) Design Stress Limit for Core Support Graphite and (b) Fracture Probability Density Function .....6  
 Figure 2: Proposed ASME CE-3550-1 Service Categories and Stress Intensity Levels .....7  
 Figure 3: Illustration of Design Margin .....8  
 Figure 4: Design Allowable Stresses Flowchart for SRC-1 .....9  
 Figure 5: Schematic of Simplified Assessment Methodology (CDF) ..... 10  
 Figure 6: Schematic of Full Assessment Methodology (CDF) ..... 11  
 Figure 7: Weibull Probability Failure Prediction with the Full Assessment Method (PDF) ..... 11  
 Figure 8: Typical Graphite Core Component Design Sequence ..... 12  
 Figure 9: Typical Graphite Core Component Design Sequence (Continued) ..... 13  
 Figure 10: Comparison of Predicted and Experimental Mean Failure Load for Verification Problems ..... 20  
 Figure 11: Comparison of Experimental Mean Failure Load and Code-Allowable Loads for Verification Problems ..... 21