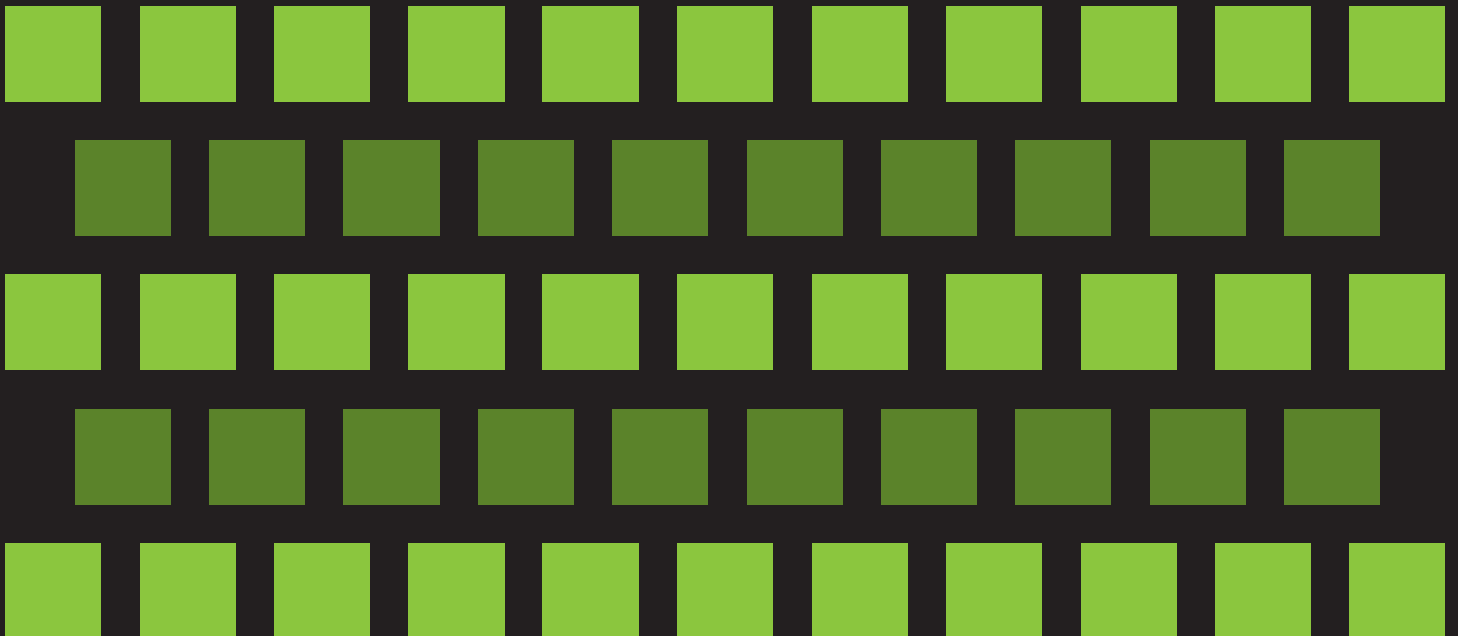


CRITERIA FOR RELIABILITY-BASED DESIGN AND ASSESSMENT FOR ASME B31.8 CODE



STP-PT-048

CRITERIA FOR RELIABILITY-BASED DESIGN AND ASSESSMENT FOR ASME B31.8 CODE

Prepared by:

Maher Nessim
C-FER Technologies



Date of Issuance: June 30, 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.

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.

ASME Standards Technology, LLC
Three Park Avenue, New York, NY 10016-5990

ISBN No. 978-0-7918-3365-0

Copyright © 2012 by
ASME Standards Technology, LLC
All Rights Reserved

TABLE OF CONTENTS

FORWORD	vi
1. PURPOSE	1
2. SCOPE	3
3. DEFINITIONS	4
4. OVERVIEW OF RBDA METHODOLOGY	7
4.1. Implementation Steps	7
4.2. Reliability and Failure Probability	8
4.3. Failure Probability versus Failure Rate	9
4.4. Time Dependence and Effect of Maintenance	10
5. LIMIT STATES	12
5.1. Limit State Categories	12
5.2. Applicable Limit States	13
6. RELIABILITY TARGETS	17
6.1. General	17
6.2. Ultimate Limit State Targets	20
6.3. Leakage Limit States	38
6.4. Serviceability Limit States	40
6.5. Operational Issues	41
7. DEVELOPING A LIMIT STATE FUNCTION	42
8. PROBABILISTIC CHARACTERIZATION OF INPUT VARIABLES	43
9. RELIABILITY ESTIMATION	44
10. IMPLICATIONS OF USING THE APPENDIX	45
10.1. Design of New Pipelines	45
10.2. Maintenance of Operating Pipelines	47
11. EXAMPLE APPLICATIONS	51
11.1. New Pipeline Design	51
11.2. Class Upgrade Deferral	54
12. REFERENCES	58
Acknowledgments	60

LIST OF FIGURES

Figure 1 - Steps Involved in Implementing RBDA.....	7
Figure 2 - Illustration of Load Effect and Resistance Distributions.....	9
Figure 3 - Illustration of Time Dependence and Effect of Maintenance on Reliability	11
Figure 4 - Illustration of the Evaluation Length.....	18
Figure 5 - Reliability Targets for Ultimate Limit States	23
Figure 6 - Risk as a Function of $pPD3$ for a Range of Design Cases.....	25
Figure 7 - Example Population Density Plot.....	26
Figure 8 - Relative Frequency of Unpopulated Areas Around Pipelines.....	27
Figure 9 - A Possible Segmentation Scheme for the Example in Figure 7	28
Figure 10 - Calculation of the Population Density at a Point Along the Pipeline.....	29
Figure 11 - Illustration of the Method of Calculating ρ_i	30
Figure 12 - Example Illustrating the Calculation of a Population Density Graph.....	31
Figure 13 - Illustration of Distributed and Location-specific Limit States	34
Figure 14 - Illustration of Location-specific Limit States Around a Given Point.....	35
Figure 15 - Reported Defect Locations and Governing Evaluation Lengths	36
Figure 16 - Calculated Equivalent Rupture Reliability for the General Reliability Check.....	37
Figure 17 - Calculated Equivalent Rupture Reliability for the Location-specific Reliability Checks ..	38
Figure 18 - Peak Small Leak Rates for the Design Cases as a Function of Wall Thickness.....	40
Figure 19 - Design Factor Comparison Between for RBDA and ASME B31.8	46
Figure 20 - Cost Comparison Between RBDA and ASME B31.8 Designs	47
Figure 21 - Comparison between Failure Rates for RBDA and Current Practice.....	49
Figure 22 - Calculated ULS Reliability versus Target for Segment B.....	53
Figure 23 - Calculated LLS Reliability versus Target for Segment B	53
Figure 24 - LLS Reliability Compared to Target for Status Quo	55
Figure 25 - LLS Reliability Compared to Target for Status Quo	56
Figure 26 - ULS Reliability Compared to Target for Various Class Upgrade Options	57

LIST OF TABLES

Table 1 - List of Applicable Limit States.....51

Table 2 - Population Density and Reliability Targets for Each Pipeline Segment51

Table 3 - Equipment Impact Prevention Measures Assumed for Design Example52

Table 4 - Wall Thickness and Equivalent Design Factors54

Table 5 - Basic and Enhanced Failure Prevention Measures for Equipment Impact.....55

FORWORD

This Criteria Document provides guidance to potential users of the proposed ASME Appendix B31.8R on Reliability Based Design and Assessment (RBDA) by documenting the relevant background information required to fully understand the requirements of the Appendix and to apply them correctly in decision making. The need for a Criteria Document was identified during the process of voting on ASME B31.8 Ballot No. 08-905 as a requirement for further consideration of the RBDA Appendix.

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.