American Nuclear Society

design basis for protection of light water nuclear power plants against the effects of postulated pipe rupture

an American National Standard

published by the

American Nuclear Society

555 North Kensington Avenue

La Grange Park, Illinois 60526 USA

ANSI/ANS-58.2-1988 (W1998)

ERRATUM

ANSI/ANS-58.2-1988 (W1998), Design Basis for Protection of Light Water Nuclear Power Plants Against the Effects of Postulated Pipe Rupture

An error has been identified in Equation D-10 on page 69 of this standard. The last term in equation D-10 is inverted. It should be P_{jc}/P_{oe} as shown below:

(2) In Region 2, for $L_c < L < L_a$, the jet pressure is given by:

$$\frac{P_j}{P_{jc}} = \left(1 - \frac{2r}{D_j}\right)\left\{1 - 2\left(\frac{2r}{D_j}\right)\left[1 - 3C_{Te}\left(\frac{D_e}{D_j}\right)^2\left(\frac{P_{jc}}{P_{oe}}\right)\right]\right\} \qquad \text{(Eq. D-10)}$$

For future clarification, contact the ANS Standards Administrator at standards@ans.org.

November 2014

ANSI/ANS-58.2-1988
Revision of
ANSI/ANS-58.2-1980

American National Standard
Design Basis for Protection of Light Water Nuclear Power Plants Against the Effects of Postulated Pipe Rupture

Secretariat
American Nuclear Society

Prepared by the
American Nuclear Society
Standards Committee
Working Group ANS-58.2

Published by the
American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60525 USA

Approved October 6, 1988
by the
American National Standards Institute, Inc.

American National Standard

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Comments on this standard are encouraged and should be sent to Society Headquarters.

Published by

American Nuclear Society
555 North Kensington Avenue, La Grange Park, Illinois 60525 USA

Printed in the United States of America

Foreword

(This Foreword is not a part of American National Standard Design Basis for Protection of Light Water Nuclear Power Plants Against the Effects of Postulated Pipe Rupture, ANSI/ANS-58.2-1988.)

The piping in nuclear power plants is designed, fabricated and tested to the stringent requirements of the ASME Boiler and Pressure Vessel Code and the ASME Code for Power Piping. As a result, the experience with nuclear plant piping is very favorable. Nevertheless, the Nuclear Regulatory Commission (NRC) requires that nuclear plant safety be based on a defense-in-depth philosophy, and that protection against postulated piping accidents be provided by designing the containment system, emergency core cooling systems, and other protective features against the effects of these postulated accidents. This standard provides guidelines in order to achieve a consistent approach to providing plant protection except that the design of the containment system and emergency core cooling systems is not addressed.

Working Group ANS-58.2 of the standards committee of the American Nuclear Society, was reactivated in February 1984 to incorporate the LBB approach (Section 12) and to review and update the portions of the standard addressing postulated rupture locations and configurations (Section 4) and jet impingement effects (Section 7). In addition, substantial modifications were made to the portions of the standard addressing compartment pressurization effects (Section 8) and flooding effects (Section 10) to reflect developments in American National Standard Subcompartment Pressure and Temperature Transient Analysis in Light Water Reactors, ANSI/ANS-56.10-1987 and American National Standard Design Criteria for Protection Against the Effects of Compartment Flooding in Light Water Reactor Plants, ANSI/ANS-56.11-1988, respectively, since the issuance of ANSI/ANS-58.2-1980. Finally, the entire standard was reviewed and changes made where appropriate for consistency with Sections 4, 7, 8, 10 and 12.

Since the issuance of ANSI/ANS-58.2-1980, the leak-before-break (LBB) approach has been accepted as an alternative to the practice of providing protection against postulated pipe ruptures of arbitrary size. The LBB approach is a mechanistic fracture mechanics method of determining pipe rupture behavior that may be used to either eliminate or reduce the effects that need to be considered at a postulated rupture location.* Currently regulatory authorities have limited the application of the LBB approach to only excluding consideration of dynamic effects associated with pipe ruptures (e.g., pipe whip, missile generation, jet impingement loads, etc.). Recognizing that the technical basis for the LBB approach is sound and its application will probably be extended sometime in the future, this standard presents a consistent technical application of the approach. Where this standard may not agree with current regulatory practice, it is so indicated.

There are four areas where the position provided in this standard is less restrictive than the corresponding current NRC position. First, the NRC requires application of the LBB approach to all points in a given run of pipe including the end points at each anchor. This standard allows application of the LBB approach to any point in a given run of pipe where the rupture locations have been postulated in accordance with the rupture locations criteria of Section 4. Second, at locations where leakage cracks based on the LBB approach have been postulated instead of full-sized circumferential or longitudinal breaks or instead of arbitrarily sized through wall cracks, the NRC currently requires that the evaluation of environmental and flooding effects be based on the

*Information regarding the development of the LBB approach is provided in NUREG-1061, "Report of the U.S. Nuclear Regulatory Commission Piping Review Committee, Volumes 3 and 5, *Evaluation of Potential for Pipe Breaks, and Summary.*"

flow rate from the circumferential break, longitudinal break or through-wall crack being replaced, instead of the flow rate from the leakage crack. Third, the NRC position on the fatigue usage factor basis for postulating break locations is more conservative than this standard (0.1 compared to 0.4). Although the 0.1 fatigue usage factor is considered to be conservative, recent studies have led to a concern relating to the degree of conservatism in the design fatigue curves in the ASME Code that provides the basis of this fatigue usage factor. These curves were developed based on highly polished specimen fatigue tests in air and are shown to be less conservative than when Code allowable fabrication flaws and high temperature water environment are taken into consideration. For the present, the NRC has chosen to retain the fatigue usage factor of 0.1 to bound these concerns. The fourth area pertains to the criteria for postulating intermediate breaks in Class 1 piping not in the containment penetration area. This standard utilizes a higher stress threshold than does the NRC.

Consistent with past practice, this standard does not address event combinations. Specifically, this standard does not provide guidance on the combination of pipe rupture with other events such as water hammer, seismic activity, airplane crashes or acts of sabotage.

Working group ANS-58.2 of the Standards Committee of the American Nuclear Society, had the following membership at the time it developed this standard:

J. N. Fox, Chairman, *General Electric Company*
S. Hou, *U.S. Nuclear Regulatory Commission*
D. A. Peck, *Combustion Engineering, Inc.*
E. R. Johnson, *Westinghouse Electric Corporation*
W. D. Maxham, *Babcock & Wilcox Company*
J. H. Gray, *Sargent and Lundy*
A. Singh, *Electric Power Research Institute*

The members of working group ANS-58.2 wish to express their appreciation to J. M. Healzer from S. Levy, Incorporated for his valuable contribution in reviewing and updating the jet geometry models and evaluation methods described in Appendices C and D, respectively.

The American Nuclear Society's Nuclear Power Plant Standards Committee (NUPPSCO) had the following membership at the time of its approval of this standard.

L. J. Cooper, Chairman
M. D. Weber, Secretary

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F. A. Boorboor	United Engineers & Constructors
W. S. Brown	Westinghouse Electric Corporation
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J. E. Windhorst	Southern Company Services
G. A. Zimmerman	Portland General Electric Company

Contents

Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Postulated Pipe Rupture

1. Introduction

The purpose of this standard is to provide the design basis for the protection of light water reactor nuclear power plants from the following potentially adverse effects of a postulated pipe rupture: pipe whip, pipe internal loads, jet impingement, compartment pressurization, environmental conditions and flooding.[1] Specific guidance for the evaluation of internal fluid system loads other than pipe internal loads, missile generation, emergency core cooling system flow requirements, and containment pressurization is not provided in this standard. Guidance on the design basis for containment pressurization is provided in American National Standard for Subcompartment Pressure and Temperature Transient Analysis in Light Water Reactors, ANSI/ANS-56.10-1987 [1].[2] This standard presents methods for complying with General Design Criterion 4, "Environmental and Missile Design Basis," of Appendix A to Title 10, Code of Federal Regulations, Part 50, "Licensing of Production and Utilization Facilities" [2] and with Title 10, Code of Federal Regulations, Part 100, "Reactor Site Criteria" [3].

Although pipe ruptures could result from random events induced by unanticipated conditions, for any particular piping failure mechanism the actual location of the failure is assumed to be governed by the local conditions of stress and fatigue. Therefore, the point on a given piping run where a rupture would most likely occur would be associated with those points of high relative stress or high relative fatigue usage. These points of high relative stress and high relative fatigue usage can be predicted from anticipated conditions and design loadings. The design rules of this standard are intended to provide protection by postulating pipe ruptures at those locations with the greatest potential for failure under loading conditions associated with specified seismic events and operational plant conditions.

Section 3, Definitions, defines the terms used in this standard. Locations and characteristics of postulated ruptures to be considered are specified in Section 4, Postulated Rupture Locations and Configurations, and requirements for demonstrating adequate protection are specified in Section 5, Protection Requirements.

Section 6, Evaluation of Pipe Whip and Pipe Internal Load Effects; Section 7, Evaluation of Jet Impingement Effects; Section 8, Evaluation of Compartment Pressurization Effects; Section 9, Evaluation of Environmental Effects; and Section 10, Evaluation of Flooding Effects specify the bases and assumptions to be used for determining the potential damage from the effects of pipe whip and pipe internal loads, jet impingement, pressurization of compartments, environmental conditions, and flooding, respectively. A recommended procedure for assessing the potential damage to required systems and components is provided in Section 11, Procedure for Assessing the Potential Damage to Required Systems and Components.

Section 12, Leak-Before-Break Approach, specifies the criteria for the leak-before-break (LBB) approach that may be used to eliminate or reduce the effects that need to be considered at a postulated rupture location.

2. Scope

This standard addresses the design basis for the protection of light water reactor nuclear power plants from the potentially adverse effects of postulated pipe ruptures.

3. Definitions

This section defines terms applicable to this standard.

[1]Guidance on the design basis for missile protection exists in draft form as proposed American National Standard for Plant Design Against Missiles, ANS-58.1; assigned correspondent: W. H. D'Ardenne, General Electric Company, 175 Curtner Ave., San Jose, Calif. 95125.

[2]Numbers in brackets refer to corresponding numbers in Section 13, References.