ASME VVUQ 30.1-2024

Scaling Methodologies for Nuclear Power Systems Responses

AN AMERICAN NATIONAL STANDARD



ASME VVUQ 30.1-2024

Scaling Methodologies for Nuclear Power Systems Responses

AN AMERICAN NATIONAL STANDARD



Date of Issuance: June 28, 2024

This Standard will be revised when the Society approves the issuance of a new edition.

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The standards committee that approved the code or standard was balanced to ensure that individuals from competent and concerned interests had an opportunity to participate. The proposed code or standard was made available for public review and comment, which provided an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

ASME does not "approve," "certify," "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 document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor does ASME 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 representatives or persons affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility for only those interpretations of this document issued in accordance with the established ASME procedures and policies, which precludes the issuance of interpretations by individuals.

The endnotes and preamble in this document (if any) are part of this American National Standard.



ASME Collective Membership Mark

All rights reserved. "ASME" and the above ASME symbol are registered trademarks of The American Society of Mechanical Engineers. No part of this document may be copied, modified, distributed, published, displayed, or otherwise reproduced in any form or by any means, electronic, digital, or mechanical, now known or hereafter invented, without the express written permission of ASME. No works derived from this document or any content therein may be created without the express written permission of ASME. Using this document or any content therein to train, create, or improve any artificial intelligence and/or machine learning platform, system, application, model, or algorithm is strictly prohibited.

The American Society of Mechanical Engineers Two Park Avenue, New York, NY 10016-5990

Copyright © 2024 by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTENTS

Foreword		7
Committe	e Roster	v
Correspondence With the VVUQ Committee		
1	Purpose, Scope, Introduction, and Nomenclature	1
2	Creation of the Adequacy Matrix and Validation Matrix Using Scaled Experimental Facilities	7
3	Scaling History and Types	8
4	Overview and Comparison of H2TS and FSA System Decomposition and Hierarchy	10
5	Concept of Time-Scale Modeling — Dimensionless Groups in Terms of Time Ratios	14
Mandato	ry Appendix	
I	References	20
Nonmand	latory Appendix	
A	Examples of Equations and Dimensionless Groups Used for Scaling Analysis	22
Figures		
1.3-1	Determination of Model Adequacy	2
2-1	Process for Creating Assessment Base for Licensing Purposes: Flowchart	8
3.2-1	Comparison of Elongated Representations of Volumes in LOFT and Semiscale Mod-2A Test Facilities	11
4-1	System Decomposition and Hierarchy for Processes Applied in H2TS	12
4-2	Four Stages of H2TS	13
5.2-1	Subvolumes, V_i , and Control Volume, V	16
5.3.2-1	Changes of System Matrix for FSA During the Duration of NPP Transient	19
A-1.1-1	Control Volume, Transfer Area, Surface and Volume Effects, and State Variable	23
A-3-1	PWR Vessel Pressure Responses for Various Test Facilities in Dimensional Form	29
A-3-2	PWR Vessel Pressure Responses for Various Test Facilities in Dimensionless Form	29
A-5.2-1	Dimensionless Temperature and Its Relationship to Biot Number and the Decay Fractional Change Metric	36
A-5.2-2	Normalized PCT for $0.015 < \Pi_{Bi} < 0.03$	37
Tables		
A-1.1-1	Examples of Derivations of H2TS Dimensionless Groups (Time Ratios)	23
A-2-1	State Variables, Agents of Change, FRCs, and Fractional Changes (Effect Metrics)	26
A-3-1	Definition of Dimensionless Agents of Change and Fractional Rates of Change for Pressure Response Equation	28
A-4-1	Definition of Dimensionless Agents of Change and Fractional Rates of Change for Void Fractions	
	Equation	31

A-5.1-1	Definition of Fractional Rates of Change and Fractional Change Metric for Peak Cladding	
	Temperature Equation	34