

# American Nuclear Society

## reload startup physics tests for pressurized water reactors

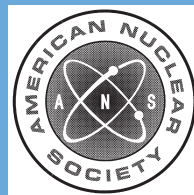
### an American National Standard

**REAFFIRMED**

**August 5, 2016**

**ANSI/ANS-19.6.1-2011; R2016**

This standard has been reviewed and reaffirmed with the recognition that it may reference other standards and documents that may have been superseded or withdrawn. The requirements of this document will be met by using the version of the standards and documents referenced herein. It is the responsibility of the user to review each of the references and to determine whether the use of the original references or more recent versions is appropriate for the facility. Variations from the standards and documents referenced in this standard should be evaluated and documented. This standard does not necessarily reflect recent industry initiatives for risk informed decision-making or a graded approach to quality assurance. Users should consider the use of these industry initiatives in the application of this standard.



published by the  
**American Nuclear Society**  
555 North Kensington Avenue  
La Grange Park, Illinois 60526 USA

ANSI/ANS-19.6.1-2011

**American National Standard  
Reload Startup Physics Tests  
for Pressurized Water Reactors**

Secretariat  
**American Nuclear Society**

Prepared by the  
**American Nuclear Society  
Standards Committee  
Working Group ANS-19.6.1**

Published by the  
**American Nuclear Society  
555 North Kensington Avenue  
La Grange Park, Illinois 60526 USA**

Approved January 13, 2011  
by the  
**American National Standards Institute, Inc.**

## **American National Standard**

Designation of this document as an American National Standard attests that the principles of openness and due process have been followed in the approval procedure and that a consensus of those directly and materially affected by the standard has been achieved.

This standard was developed under procedures of the Standards Committee of the American Nuclear Society; these procedures are accredited by the American National Standards Institute, Inc., as meeting the criteria for American National Standards. The consensus committee that approved the standard was balanced to ensure that competent, concerned, and varied interests have had an opportunity to participate.

An American National Standard is intended to aid industry, consumers, governmental agencies, and general interest groups. Its use is entirely voluntary. The existence of an American National Standard, in and of itself, does not preclude anyone from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard.

By publication of this standard, the American Nuclear Society does not insure anyone utilizing the standard against liability allegedly arising from or after its use. The content of this standard reflects acceptable practice at the time of its approval and publication. Changes, if any, occurring through developments in the state of the art, may be considered at the time that the standard is subjected to periodic review. It may be reaffirmed, revised, or withdrawn at any time in accordance with established procedures. Users of this standard are cautioned to determine the validity of copies in their possession and to establish that they are of the latest issue.

The American Nuclear Society accepts no responsibility for interpretations of this standard made by any individual or by any ad hoc group of individuals. Requests for interpretation should be sent to the Standards Department at Society Headquarters. Action will be taken to provide appropriate response in accordance with established procedures that ensure consensus on the interpretation.

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 60526 USA**

Copyright © 2011 by American Nuclear Society. All rights reserved.

Any part of this standard may be quoted. Credit lines should read "Extracted from American National Standard ANSI/ANS-19.6.1-2011 with permission of the publisher, the American Nuclear Society." Reproduction prohibited under copyright convention unless written permission is granted by the American Nuclear Society.

Printed in the United States of America

## Foreword

(This Foreword is not a part of American National Standard “Reload Startup Physics Tests for Pressurized Water Reactors,” ANSI/ANS-19.6.1-2011.)

It is the intent of this American National Standard to provide guidance for verifying the nuclear characteristics of a commercial pressurized water reactor core. This standard is intended to cover the physics tests that are performed following a refueling or other alteration of the reactor core for which nuclear design calculations are required. This standard provides the minimum acceptable startup physics test program; however, the standard recognizes that additional tests may be required by special design features for a particular core. This standard does not reflect all test programs that have been approved by the U.S. Nuclear Regulatory Commission. This standard specifies the minimum testing required to confirm that the reconstructed core is the same as the designed core.

Compliance with the intent of this standard can be demonstrated by meeting the following requirements:

- (1) Perform the physics tests described herein using an acceptable test method;
- (2) Determine if the test results agree with the predicted results within the previously established test criteria;
- (3) Document the above in accordance with the requirements of Sec. 7 of this standard.

Suggestions for the improvement of this standard are welcome. They should be sent to the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60526.

Following is a summary of changes that were made to the 2005 version:

- (1) The list of acceptable methods for each physics test has been moved to the Appendix;
- (2) The overall bases for performing a startup test program has been added;
- (3) The bases for performing each physics test has been added in the Appendix;
- (4) Several clarifications and editing changes were made.

This standard was developed by Working Group ANS-19.6.1 of the American Nuclear Society, which had the active participation of the following members in preparing the current version:

C. T. Rombough (Chair), *CTR Technical Services, Inc.*

P. D. Adam, *Wolf Creek Nuclear Operating Corporation*  
A. C. Attard, *U.S. Nuclear Regulatory Commission*  
R. A. Borchert, *Millstone Power Station*  
J. D. Brown, *AREVA Corporation*  
J. M. Dever, *AREVA Corporation*  
L. R. Grobmyer, *Westinghouse Electric Corporation, LLC*  
D. B. Kelley, *First Energy Nuclear Operating Company*  
D. K. Powers, *Southern California Edison*  
G. M. Presnell, *Duke Power Company*  
M. C. Prible, *Westinghouse Electric Corporation, LLC*  
P. C. Rohr, *Westinghouse Electric Corporation, LLC*  
K. Sahadewan, *Exelon Nuclear*  
C. P. Stafford, *Arizona Public Service*  
J. D. Wade, *Arizona Public Service*  
D. A. Wellbaum, *Catawba Nuclear Station*

The membership of Subcommittee ANS-19 at the time of its review and approval of this standard was as follows:

D. M. Cokinos (Chair), *Brookhaven National Laboratory*  
C. T. Rombough (Secretary), *CTR Technical Services, Inc.*

A. C. Attard, *U.S. Nuclear Regulatory Commission*  
W. H. Bell, *American Institute of Chemical Engineers Representative (employed by South Carolina Electric & Gas Company)*  
R-T. Chiang, *Areva NP*  
D. J. Diamond, *Brookhaven National Laboratory*  
M. A. Garland, *Oak Ridge National Laboratory*  
J. C. Gehin, *Oak Ridge National Laboratory*  
I. Gould, *Oak Ridge National Laboratory*  
D. R. Harris, *Individual*  
J-I. Katakura, *Japan Atomic Energy Research Institute*  
R. C. Little, *Los Alamos National Laboratory*  
L. Lois, *Individual*  
R. D. Mosteller, *Los Alamos National Laboratory*  
B. Rouben, *Individual*  
E. Sartori, *Individual*  
R. E. Schenter, *Smart Bullets, Inc.*  
A. Weitzberg, *Individual*

Consensus Committee N17, Research Reactors, Reactor Physics, Radiation Shielding, and Computational Methods, had the following membership at the time it reviewed and approved this standard:

T. M. Raby (Chair), *National Institute of Standards and Technology*  
A. Weitzberg (Vice Chair), *Individual*

S. L. Anderson, *Westinghouse Electric Corporation, LLC*  
W. H. Bell, *American Institute of Chemical Engineers*  
(Alt., R. D. Zimmerman, *American Institute of Chemical Engineers*)  
R. R. Brey, *Health Physics Society*  
R. E. Carter, *Individual*  
D. M. Cokinos, *Brookhaven National Laboratory*  
M. L. Corradini, *National Council on Radiation Protection and Measurement*  
B. K. Grimes, *Individual*  
N. E. Hertel, *Georgia Institute of Technology*  
C. Heysel, *McMaster University*  
W. C. Hopkins, *Individual*  
M. A. Hutmaker, Jr., *U.S. Department of Energy*  
A. C. Kadak, *Massachusetts Institute of Technology*  
L. I. Kopp, *Individual*  
P. M. Madden, *U.S. Nuclear Regulatory Commission*  
(Alt., A. Adams, Jr., *U.S. Nuclear Regulatory Commission*)  
J. F. Miller, *Institute of Electrical and Electronics Engineers*  
T. J. Myers, *National Institute of Standards and Technology*  
(Alt., S. H. Weiss, *National Institute of Standards and Technology*)  
D. S. O'Kelly, *National Institute of Standards and Technology*  
J. E. Olhoeft, *Individual*  
R. E. Pevey, *University of Tennessee-Knoxville*  
C. T. Rombough, *CTR Technical Services, Inc.*  
T. R. Schmidt, *Sandia National Laboratories*  
A. O. Smetana, *Savannah River National Laboratory*  
R. Tsukimura, *Aerotest Operations*  
A. R. Veca, *General Atomics*

<b>Contents</b>	<b>Section</b>	<b>Page</b>
	<b>1</b> Introduction .....	1
	<b>2</b> Scope .....	1
	<b>3</b> Definitions .....	2
	3.1 Limitations .....	2
	3.2 Glossary .....	2
	<b>4</b> Relation to other standards .....	3
	<b>5</b> Physics test program and selection criteria .....	3
	5.1 Bases for startup physics test program .....	3
	5.2 Required minimum test program .....	4
	<b>6</b> Test method requirements .....	4
	6.1 General test considerations .....	4
	6.2 Test criteria .....	6
	<b>7</b> Requirements of this standard .....	6
	<b>8</b> References .....	7
	<b>Appendix</b>	
	User's Guide .....	8
	<b>Tables</b>	
	Table 1 Required physics characteristics to be confirmed .....	5
	Table A.1 Typical test criteria .....	10
	Table A.2 Problem identification .....	24
	Table A.3 Supplementary tests for problem identification .....	26

# Reload Startup Physics Tests for Pressurized Water Reactors

## 1 Introduction

In conjunction with each refueling shutdown or other significant reactor core alteration, nuclear design calculations are performed to ensure that the reactor physics characteristics of the new core will be consistent with the safety limits. Prior to return to normal operation, successful execution of a physics test program is required to determine if the operating characteristics of the core are consistent with the design predictions and to ensure that the core can be operated as designed.

This standard specifies the content of the minimum acceptable startup physics test program for commercial pressurized water reactors (PWRs) and provides the bases for each test. Acceptable methods for performing the individual tests are provided in the Appendix.<sup>1)</sup> Alternate methods may be used as long as they are shown to meet the requirements of Sec. 6.

Successful completion of the physics test program is demonstrated when the test results agree with the predicted results within predetermined test criteria. Successful completion of the physics test program and successful completion of other tests that are performed after each refueling or significant reactor core alteration provide assurance that the plant can be operated as designed.

## 2 Scope

This standard applies to the reactor physics tests that are performed following a refueling or other core alteration of a PWR for which nuclear design calculations are required. This

standard does not address the physics test program for the initial core of a commercial PWR.<sup>2)</sup>

This standard specifies the minimum acceptable startup reactor physics test program to determine if the operating characteristics of the core are consistent with the design predictions, which provides assurance that the core can be operated as designed. This standard does not address surveillance of reactor physics parameters during operation or other required tests such as mechanical tests of system components (for example, the rod drop time test), visual verification requirements for fuel assembly loading, or the calibration of instrumentation or control systems (even though these tests are an integral part of an overall program to ensure that the core behaves as designed).

This standard assumes that the same previously accepted analytical methods are used for both the design of the reactor core and the startup test predictions. It also assumes that the expected operation of the core will fall within the historical database established for the plant and/or sister plants.

When major changes are made in the core design, the test program should be reviewed to determine if more extensive testing is needed. Typical changes that might fall into this category include the initial use of novel fuel cycle designs, significant changes in fuel enrichments, fuel assembly design changes, burnable absorber design changes, and cores resulting from unplanned short cycles. Changes such as these may lead to operation in regions outside of the plant's experience database and therefore may necessitate expanding the test program.

---

<sup>1)</sup> The Appendix to this standard is the User's Guide, which provides acceptable methods, guidelines, precautions, suggestions, and typical test criteria for each required test.

<sup>2)</sup> The good practices discussed in this standard should be considered for use in the physics test program for the initial core of a commercial PWR. One test that provides useful information (without additional test time) is the hot-zero-power to hot-full-power reactivity measurement.