

**ASME PTC 31-2011**  
[Revision of ASME PTC 31-1973 (R1991)]

# High-Purity Water Treatment Systems

---

**Performance Test Codes**

**AN AMERICAN NATIONAL STANDARD**



**The American Society of  
Mechanical Engineers**

INTENTIONALLY LEFT BLANK

**ASME PTC 31-2011**  
[Revision of ASME PTC 31-1973 (R1991)]

# High-Purity Water Treatment Systems

---

**Performance Test Codes**

AN AMERICAN NATIONAL STANDARD



**The American Society of  
Mechanical Engineers**

Three Park Avenue • New York, NY • 10016 USA

Date of Issuance: April 9, 2012

This Code will be revised when the Society approves the issuance of a new edition. There will be no addenda issued to PTC 31-2011.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Code. Periodically certain actions of the ASME PTC Committee may be published as Code Cases. Code Cases and interpretations are published on the ASME Web site under the Committee Pages at <http://cstools.asme.org/> as they are issued.

Errata to codes and standards may be posted on the ASME Web site under the Committee Pages to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in codes and standards. Such errata shall be used on the date posted.

The Committee Pages can be found at <http://cstools.asme.org/>. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the appropriate Committee Page after selecting "Errata" in the "Publication Information" section.

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

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 assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed code or standard was made available for public review and comment that provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

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 document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor assumes 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 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.

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  
Three Park Avenue, New York, NY 10016-5990

Copyright © 2012 by  
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS  
All rights reserved  
Printed in U.S.A.

# CONTENTS

Notice .....	v
Foreword .....	vi
Committee Roster .....	vii
Correspondence With the PTC Committee .....	viii
<b>Section 1 Object and Scope .....</b>	<b>1</b>
1-1 Object .....	1
1-2 Scope .....	1
1-3 Test Uncertainties .....	2
<b>Section 2 Description and Definition of Terms— Ion Exchange .....</b>	<b>3</b>
2-1 Definitions .....	3
2-2 References .....	10
<b>Section 3 Guiding Principles .....</b>	<b>12</b>
3-1 Advance Planning for Test .....	12
3-2 General Description of Test Requirements .....	12
3-3 Preliminary Tests .....	12
3-4 Frequency of Observations.....	13
3-5 Duration of Test Runs .....	13
3-6 General Description of Test Procedures .....	13
3-7 Membranes Testing .....	15
3-8 Reverse Osmosis (RO) Operating Performance.....	19
3-9 Membrane Plant Performance Normalization.....	21
<b>Section 4 Instruments and Methods of Measurement .....</b>	<b>24</b>
4-1 Instruments and Methods of Measurement .....	24
4-2 Mechanical Measurements.....	24
4-3 Flowmeter Absence.....	24
4-4 Temperature Measurement .....	24
4-5 Loss of Pressure Measurement .....	24
4-6 Pressure Loss Across a Single Unit/Array or Train of Multiple Units/ Arrays Measurement .....	25
4-7 Pressure Loss Indication Across a Resin Bed Measurement .....	25
4-8 Chemical Measurements .....	25
4-9 Sampling of Water From Influent and Effluent of Water Treatment Equipment .....	25
4-10 Field Sampling of Media .....	26
4-11 Field Measurement of Resin Volume.....	26
4-12 Analysis of Ion Exchange Materials.....	26
4-13 Sampling for Suspended Solids.....	26
4-14 Ion Exchange Operating Capacity .....	27
<b>Section 5 Interpretation of Results .....</b>	<b>29</b>
5-1 Introduction.....	29
5-2 Performance Benchmark .....	32
5-3 Calculations and Analytical Procedures .....	32
5-4 Expression of Specified Performance and Results of Tests.....	32
<b>Section 6 Report of Tests .....</b>	<b>33</b>
6-1 Report of Tests .....	33

<b>Tables</b>		
3-6.1.4-1	Resin Volume Change Chemical Form-to-Form .....	14
3-6.3-1	Ion Exchange System Performance Testing .....	16
3-6.4-1	Chemical Measurements During Ion Exchange System Performance Testing.....	17
3-8.2-1	K-Factor for Reverse Osmosis Calculations.....	20
3-8.2-2	SDI Indices.....	20
4-13-1	Purge Times Required for Representative Sampling .....	27
5-1.1.1-1	Typical Operating Flow Rates Specifications .....	30
5-1.1.1-2	Typical System Flux Rates .....	30
<b>Mandatory Appendices</b>		
I	Regenerant Purity Requirements for Ion Exchange Materials.....	35
II	Suspended Iron Oxide Solids: Membrane Comparison Charts.....	38
<b>Nonmandatory Appendices</b>		
A	Sample Calculations.....	40
B	Causes of Operating Capacity Reduction .....	46
C	Selectivity of Resins.....	47

# NOTICE

All Performance Test Codes MUST adhere to the requirements of PTC 1, General Instructions. The following information is based on that document and is included here for emphasis and for the convenience of the user of this Code. It is expected that the Code user is fully cognizant of Sections 1 and 3 of ASME PTC 1 and has read them prior to applying this Code.

ASME Performance Test Codes provide test procedures that yield results of the highest level of accuracy consistent with the best engineering knowledge and practice currently available. They were developed by balanced committees representing all concerned interests and specify procedures, instrumentation, equipment-operating requirements, calculation methods, and uncertainty analysis.

When tests are run in accordance with a Code, the test results themselves, without adjustment for uncertainty, yield the best available indication of the actual performance of the tested equipment. ASME Performance Test Codes do not specify means to compare those results to contractual guarantees. Therefore, it is recommended that the parties to a commercial test agree before starting the test and preferably before signing the contract on the method to be used for comparing the test results to the contractual guarantees. It is beyond the scope of any Code to determine or interpret how such comparisons shall be made.

# FOREWORD

The ASME Performance Test Codes Committee voted in December 1965 to establish a Test Code Committee for Demineralizers (PTC 31) and later approved as PTC 31 Committee's objective, the development of a Test Code that would define the procedures for the accurate testing of ion exchange equipment for determining level of performance. The name of this Committee was changed at the request of PTC Committee No. 31 from Demineralizers to Ion Exchange Equipment on June 12, 1970.

Most steam generation cycles, either for process application or utility power production, require the use of water treatment equipment. Such equipment may be a simple process application, removing only hardness constituents from water, or may be a relatively complex process employing one or more types of ion exchange resin processes and/or membrane processes each with a high degree of instrumentation and control logic. Additionally, such equipment is employed in virtually all types of nuclear steam generation cycles, processing water containing not only very high concentrations of impurities, but also treating liquids with impurity concentrations in the range of parts per billion to parts per trillion. Because performance of such process equipment directly influences the efficiency and output of steam generation cycles, a Committee was named by The American Society of Mechanical Engineers to draft a revised Performance Test Code for High-Purity Water Treatment Systems. Members of this Committee were selected on the basis that equipment manufacturers, users, and consultants as well as general interest groups were represented. A draft of this Code was distributed in September 2011 for comment and criticism by industry and other interested individuals.

This edition was approved by the PTC Standards Committee on September 2, 2011, and approved and adopted as a Standard practice of the Society by action of the Board on Standardization and Testing on October 7, 2011. It was also approved as an American National Standard by the ANSI Board of Standards Review on November 21, 2011.

# ASME PTC COMMITTEE Performance Test Codes

(The following is the roster of the Committee at the time of approval of this Code.)

## STANDARDS COMMITTEE OFFICERS

J. R. Friedman, *Chair*  
J. W. Milton, *Vice Chair*  
J. H. Karian, *Secretary*

## STANDARDS COMMITTEE PERSONNEL

P. G. Albert, General Electric Co.  
R. P. Allen, Consultant  
R. L. Bannister, *Honorary Member*, Consultant  
J. M. Burns, Burns Engineering Services, Inc.  
W. C. Campbell, Southern Company Services, Inc.  
M. J. Dooley, Sigma Energy Solutions, Inc.  
J. R. Friedman, Siemens Energy, Inc.  
G. J. Gerber, Consultant  
P. M. Gerhart, University of Evansville  
W. O. Hays, *Honorary Member*, Consultant  
T. C. Heil, Consultant  
R. E. Henry, Sargent & Lundy, Inc.  
R. Jorgensen, *Honorary Member*, Consultant  
J. H. Karian, The American Society of Mechanical Engineers  
D. R. Keyser, Survice Engineering  
S. J. Korellis, Electric Power Research Institute

F. H. Light, *Honorary Member*, Consultant  
M. P. McHale, McHale & Associates, Inc.  
P. M. McHale, McHale & Associates, Inc.  
T. K. Kirkpatrick, *Alternate*, McHale & Associates, Inc.  
J. W. Milton, GenOn Energy  
G. H. Mittendorf, Jr., *Honorary Member*, Consultant  
S. P. Nuspl, Consultant  
R. R. Priestley, General Electric Co.  
J. W. Siegmund, *Honorary Member*, Consultant  
J. A. Silvaggio, Jr., Siemens Demag Delaval Turbomachinery, Inc.  
R. E. Sommerlad, *Honorary Member*, Consultant  
W. G. Steele, Jr., Mississippi State University  
T. L. Toburen, T2E3, Inc.  
G. E. Weber, Midwest Generation EME, LLC  
W. C. Wood, Duke Energy  
S. A. Scavuzzo, *Alternate*, The Babcock & Wilcox Co.

## PTC 31 COMMITTEE — HIGH-PURITY WATER TREATMENT SYSTEMS

R. T. Holloway, *Chair*, Holloway Associates  
J. W. Siegmund, *Vice Chair*, Consultant  
A. L. Guzman, *Secretary*, The American Society of Mechanical Engineers  
E. S. Beardwood, Ashland Water Technologies  
W. E. Bernahl, W Bernahl Enterprises  
R. G. Bradley, BWT Systems, Inc.  
D. Dewitt-Dick, Champion Technologies

D. D. Downey, The Purolite Co.  
C. M. Layman, Bechtel Power Corp.  
P. Midgley, Degremont Technologies  
R. M. Morgan, The Dow Chemical Co.  
M. I. Willett, University of Michigan  
K. A. Selby, *Contributing Member*, Water Technology Consultants, Inc.

# CORRESPONDENCE WITH THE PTC COMMITTEE

**General.** ASME Codes are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Code may interact with the Committee by requesting interpretations, proposing revisions, and attending Committee meetings. Correspondence should be addressed to

Secretary, PTC Standards Committee  
The American Society of Mechanical Engineers  
Three Park Avenue  
New York, NY 10016-5990

**Proposing Revisions.** Revisions are made periodically to the Code to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Code. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Code. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal including any pertinent documentation.

**Proposing a Case.** Cases may be issued for the purpose of providing alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee Web page.

Request for Cases shall provide a Statement of Need and Background Information. The request should identify the Code, the paragraph, figure or table number(s), and be written as a Question and Reply in the same format as existing Cases. Request for Cases should also indicate the applicable edition(s) of the Code to which the proposed Case applies.

**Interpretations.** Upon request, the PTC Standards Committee will render an interpretation of any requirement of the Code. Interpretations can only be rendered in response to a written request sent to the Secretary of the PTC Standards Committee. The request for interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his/her request in the following format:

- Subject:** Cite the applicable paragraph number(s) and the topic of the inquiry.
- Edition:** Cite the applicable edition of the Code for which the interpretation is being requested.
- Question:** Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format will be rewritten in this format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not “approve,” “certify,” “rate,” or “endorse” any item, construction, proprietary device, or activity.

**Attending Committee Meetings.** The PTC Standards Committee and PTC Committees hold meetings regularly, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the PTC Committee.

# HIGH-PURITY WATER TREATMENT SYSTEMS

## Section 1 Object and Scope

### 1-1 OBJECT

#### 1-1.1

This Code defines the procedures for the accurate field testing of high-purity water treatment systems for the purpose of determining level of performance. It is based on the use of accurate instrumentation and the best analytical and measurement procedures available.

#### 1-1.2

This Code is recommended for use in conducting acceptance tests of high-purity water treatment systems. If so used, any deviations from Code procedure must be agreed upon in writing. In the absence of written agreement, the Code requirements shall be mandatory.

Upon completion of tests, the report issued should provide all necessary base line data against which all future operational test results can be measured to assess deterioration of performance in the interim.

#### 1-1.3

Before formulating the procedure for testing a specific process or system, the Code on General Instructions PTC 1 should be studied and followed in detail.

#### 1-1.4

The Code on Definitions and Values (PTC 2) defines certain technical terms and numerical constants. Unless otherwise specified in this Code, instrumentation should comply with the sections of Supplements on Instruments and Apparatus (PTC 19 Series).

### 1-2 SCOPE

Only the relevant portion of this Code need apply to any individual case or test under consideration. In some cases the procedure is simple; however, for complex systems or complex modes of system operation, the

procedures and calculations of test results require more involved provisions for testing.

#### 1-2.1

This Code is applicable to the following types of high-purity water treatment systems, which are either used individually or in various combinations depending on requirements of the process:

(a) *membrane equipment* including but not limited to, microfiltration, ultrafiltration, nanofiltration, and reverse osmosis

(b) *ion exchange equipment* including, but not limited to, softeners, dealkalizers, multibed demineralizers, mixed-bed demineralizers, and condensate polishers

(c) *hybrid equipment* including, but not limited to, electrode ionization (EDI) and electro dialysis reversal (EDR).

#### 1-2.2

This Code applies to equipment and systems that are utilized for

(a) the conditioning of makeup, feedwater, and condensate for steam generation

(b) the conditioning of process waters

#### 1-2.3

This Code applies to the performance of high-purity water treatment systems at design, minimum flow rates or maximum flow rates, depending on the purpose of the test, with regard to one or more of the following:

(a) water quality and quantity of influent and effluent

(b) pressure drop, flow, and temperature

(c) startup, shutdown, and lay-up procedure

(d) operating efficiency

(e) media testing

(f) media cleaning and maintenance

(g) chemical purity and solution concentrations

(h) associated chemical equipment