

# Moisture Separator Reheaters

PERFORMANCE  
TEST  
CODES

ASME PTC 12.4–1992

AN AMERICAN NATIONAL STANDARD

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS  
United Engineering Center      345 East 47th Street      New York, N.Y. 10017

Date of Issuance: May 24, 1993

This Standard will be revised when the Society approves the issuance of a new edition. There will be no addenda or written interpretations of the requirements of this Standard issued to this edition.

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 Consensus Committee that approved the code or standard was balance 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 which 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 assume any such liability. Users of a code or standard are expressly advised that the determination of the validity of any such patent rights, and the risk of the 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 issued in accordance with governing ASME procedures and policies which preclude the issuance of interpretations by individual volunteers.

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.

Copyright © 1993 by  
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS  
All Rights Reserved  
Printed in U.S.A.

## FOREWORD

(This Foreword is not part of ASME PTC 12.4-1992.)

Moisture Separator Reheaters (MSRs) were introduced to steam power cycles after the advent of commercial nuclear power. A moisture separator, with no reheat was first added to nuclear power cycles to minimize the low pressure (LP) turbine erosion caused by wet steam prevalent in those cycles and improve turbine cycle performance. Steam reheat was added later to reduce further the quantity of moisture in the steam passing through the LP turbine and to increase further the efficiency of the LP turbine.

The first MSRs were susceptible to many modes of failure. Great technological advances have occurred over the past 30 years with respect to MSR design and operation. These advances increased the reliability and enhanced the performance of the MSR which provided the momentum and justification for MSR upgrades.

During the 1970s and early 1980s an increasing number of utilities were involved in MSR upgrades which included replacing portions of or their entire MSRs. The ASME Board on Performance Test Code was notified in June 1984 that no code existed for the testing and analysis of MSRs. PTC-6 (1982) on steam turbines treated the MSR as an integral part of a turbine generator, which it is when purchased as a package. The Board authorized the formation of a new performance test code committee to develop a code for the treatment of the MSR as a separate component.

A new committee was formed and first met in December 1985. Numerous drafts were developed over the next 4 years, each more detailed than the previous. Upon the completion of appendices containing a set of sample calculations and a complete uncertainty analysis, the draft was released for the industry review in July of 1990. The comment resolution process, completed in April 1991, strengthened the document. The committee was balloted and approved the code draft in July 1991. The Board on Performance Test Codes approved the code in January 1992. This test code has been approved as an American National Standard by the ANSI Board of Standards Review on November 24, 1992.

## **PERSONNEL OF PERFORMANCE TEST CODE COMMITTEE No. 12.4 ON MOISTURE SEPARATOR REHEATERS**

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

### **OFFICERS**

**Samuel J. Korellis**, *Chairman*  
**W. Cary Campbell**, *Vice Chairman*  
**Geraldine A. Omura**, *Secretary*

### **COMMITTEE PERSONNEL**

**Paul G. Albert**, General Electric Co.  
**George L. Amodeo**, Virginia Power  
**Peter Von Böckh**, Ingenierschule Beider Basel  
**W. Cary Campbell**, Southern Company Services  
**H. Gay Hargrove**, Westinghouse Electric Corp.  
**Edwin W. Hewitt**, Condenser & MSR Consultants  
**Walter A. Hill**, ENTERGY  
**Samuel J. Korellis**, Illinois Power  
**Terrance M. Lafferty**, Tennessee Valley Authority  
**Sherrill Stone**, Peerless Manufacturing Co.  
**George T. Wood**, Florida Power & Light  
**Abraham L. Yarden**, Senior Engineering

In addition to the above personnel, the Committee is deeply indebted to Mr. Peter Bird, Mr. Al Smith, Mr. Clement Tam, and Mr. Richard Harwood for their contributions in the development of this Code.

## PERSONNEL OF BOARD ON PERFORMANCE TEST CODES

### OFFICERS

N.R. Deming, *Chairman*  
D.R. Keyser, *Vice Chairman*  
W.O. Hays, *Secretary*

### COMMITTEE PERSONNEL

A.F. Armor  
W.G. McLean  
R.L. Bannister  
G.H. Mittendorf, Jr.  
R.J. Biese  
J.W. Murdock  
J.A. Booth  
S.P. Nuspl  
B. Bornstein  
R.P. Perkins  
H.G. Crim, Jr.  
R.W. Perry  
J.S. Davis, Jr.  
A.L. Plumley  
N.R. Deming  
C.B. Scharp  
G.J. Gerber  
J.W. Siegmund  
P.M. Gerhart  
R.E. Sommerlad  
R. Jorgensen  
J.W. Umstead, IV  
D.R. Keyser  
J.C. Westcott

# CONTENTS

Foreword.....	iii
Committee Roster.....	v
<b>0 Introduction</b> .....	<b>1</b>
<b>1 Object and Scope</b> .....	<b>3</b>
1.1 Object.....	3
1.2 Scope.....	3
1.3 Expected Measurement Uncertainty.....	3
<b>2 Definitions and Description of Terms</b> .....	<b>5</b>
2.1 Nomenclature.....	5
2.2 Definitions.....	5
<b>3 Guiding Principles</b> .....	<b>7</b>
3.1 Preparation for the Test.....	7
3.2 General Test Requirements.....	8
3.3 Test Operating Conditions.....	8
3.4 Test Techniques.....	9
<b>4 Instrumentation and Methods of Measurement</b> .....	<b>13</b>
4.1 General Considerations.....	13
4.2 Measurement of Pressure.....	13
4.3 Measurement of Differential Pressure.....	14
4.4 Measurement of Temperature.....	15
4.5 Measurement of Steam Quality.....	16
4.6 Flow Rate Determinations.....	16
4.7 Measurement of Water Levels.....	24
<b>5 Computation of Results</b> .....	<b>25</b>
5.1 MSR Performance Computation.....	25
5.2 Component Pressure Drop.....	25
5.3 Terminal Temperature Difference.....	25
5.4 Moisture Separator Outlet Quality.....	26
5.5 Reference Values.....	28
5.6 Sensitivity of Deviation from the Reference Value.....	28
<b>6 Test Report</b> .....	<b>29</b>
6.1 Introduction.....	29
<b>Appendices</b>	
A Sample Calculation.....	33
B Measurement Uncertainty Calculations.....	53

**Figures**

3.1	Typical Test Point Locations .....	11
4.1	Water Leg Determination.....	14
4.2	Injection and Sampling Point Locations — MSR Two-Pass Arrangement ..	20
4.3	Injection and Sampling Point Locations — MSR Four-Pass Arrangement..	21
4.4	Typical Installation of Injection and Sampling Points.....	22
4.5	Oxygen Content of Sample .....	23
5.1	Moisture Separator Reheater — Typical Data Point Locations.....	27

**Tables**

3.1	Permissible Deviation of Variables .....	9
5.1	MSR Performance Computations .....	28

# ASME PERFORMANCE TEST CODES

## Code on

# MOISTURE SEPARATOR REHEATERS

## SECTION 0 — INTRODUCTION

### 0.1

A Moisture Separator Reheater (MSR) is a nuclear power plant component located between the high and low pressure turbines. Its purpose is to remove moisture and add superheat to the cycle steam before the steam enters the low pressure turbine. It consumes throttle steam, and may also consume high pressure extraction steam in the heating process. The MSR introduces an additional pressure drop in the turbine expansion while accomplishing these functions. The use of a properly designed and adequately performing MSR will result in a cycle heat rate improvement.

### 0.2

One of the purposes of this test Code is to consider the separate functions of moisture separation and either one or two stages of steam reheat. This proce-

dures can be employed to combine the effects of the performance of the individual MSR components. Therefore, the test results will describe the performance of either individual MSR components or the entire MSR.

### 0.3

PTC 1-1991, the Code on General Instructions, should be studied thoroughly before formulating the procedures for testing an MSR. The Code on Definitions and Values, PTC 2-1980 (R1985), defines technical terms and numerical constants which are used throughout this Code. Unless otherwise specified, instrumentation should comply with the appropriate supplements of the PTC 19 Series of codes on Instruments and Apparatus. PTC 6-1976, Steam Turbines, should be consulted for isolation and verification methods.



## SECTION 1 — OBJECT AND SCOPE

### 1.1 OBJECT

This Code provides the procedures, direction, and guidance for the accurate testing of Moisture Separator Reheaters (MSRs) which includes moisture separating and steam reheating components located between the high pressure and low pressure steam turbine. The purpose of the Code is to determine the performance of the MSR and to provide guidance in the evaluation of its performance effect on the turbine cycle heat rate with regard to:

- (a) Moisture Separator Outlet Quality;
- (b) Reheater Terminal Temperature Difference (TTD) per stage;
- (c) Cycle Steam pressure drop across applicable component(s); and
- (d) Excess heating steam flow.

### 1.2 SCOPE

Requirements are specified by this Code for application on MSR testing in the following areas:

- (a) Pretest arrangements and agreements;
- (b) Instrumentation types and accuracies;

- (c) Instrumentation applications and methods of measurement;
- (d) Testing and calculational techniques; and
- (e) Information contained in the test report.

### 1.3 EXPECTED MEASUREMENT UNCERTAINTY

By satisfying the instrument accuracy criteria specified in Section 4 and complying with the balance of procedural requirements of this Code, a test will generally provide 95 percent or greater confidence that the measurement of the required performance parameters will yield results for which the bounds of the difference between the final test results and the true value is within  $\pm 10.0$  Btu/kW-hr.

Utilizing techniques specified in PTC 19.1, Measurement Uncertainty, the overall measurement uncertainty is based on the prescribed instrument accuracies and example precision indices for MSR testing. An outline of the calculations conducted to establish the expected overall measurement uncertainty value, noted above, is covered in Appendix B. Users of this Code should determine the quality of a Code test by performing a post test uncertainty analysis utilizing PTC 19.1.