

AGA Report No. 7

Measurement of Natural Gas by Turbine Meters

Revised
February 2006

Prepared by

Transmission Measurement Committee



Copyright © 2006 American Gas Association
400 North Capitol Street, NW, 4th Floor, Washington, DC 20001, U.S.A.
Phone: (202) 824-7000 • Fax: (202) 824-7082 • Web: www.aga.org

Catalog # XQ0601

Currently in preview, click buy full version

DISCLAIMER AND COPYRIGHT

The American Gas Association's (AGA) Operating Section provides a forum for industry experts to bring collective knowledge together to improve the state of the art in the areas of operating, engineering and technological aspects of producing, gathering, transporting, storing, distributing, measuring and utilizing natural gas.

Through its publications, of which this is one, the AGA provides for the exchange of information within the gas industry and scientific, trade and governmental organizations. Each publication is prepared or sponsored by an AGA Operating Section technical committee. While AGA may administer the process, neither the AGA nor the technical committee independently tests, evaluates, or verifies the accuracy of any information or the soundness of any judgments contained therein.

The AGA disclaims liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on AGA publications. The AGA makes no guaranty or warranty as to the accuracy and completeness of any information published therein. The information contained therein is provided on an "as is" basis and the AGA makes no representations or warranties including any express or implied warranty of merchantability or fitness for a particular purpose,

In issuing and making this document available, the AGA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the AGA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The AGA has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the AGA list, certify, test, or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance is solely the responsibility of the certifier or maker of the statement.

The AGA does not take any position with respect to the validity of any patent rights asserted in connection with any items which are mentioned in or are the subject of AGA publications, and the AGA disclaims liability for the infringement of any patent resulting from the use of or reliance on its publications. Users of these publications 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.

Users of this publication should consult applicable federal, state, and local laws and regulations. The AGA does not, through its publications intend to urge action that is not in compliance with applicable laws, and its publications may not be construed as doing so.

This report is the cumulative result of years of experience of many individuals and organizations acquainted with the measurement of natural gas. However, changes to this report may become necessary from time to time. If changes in this report are believed appropriate by any manufacturer, individual or organization, such suggested changes should be communicated to AGA by completing the last page of this report titled, "**Form for Suggestion to Change AGA Report No. 7, Measurement of Natural Gas by Turbine Meters**" and sending it to: **Operations & Engineering Services Group, American Gas Association, 400 North Capitol Street, NW, 4th Floor, Washington, DC 20001, U.S.A.**

Copyrights © 2006, American Gas Association, All Rights Reserved.

FOREWORD

This report is published in the form of a performance-based specification for turbine meter for natural gas flow measurement. It is the result of collaborative effort of natural gas users, turbine meter manufacturers, flow measurement research organizations and independent consultants forming Task Group R-7 of AGA's Transmission Measurement Committee (TMC). In addition, comments to this report were made by the Committee on Gas Flow Measurement (COGFM) of the American Petroleum Institute (API).

Research conducted in support of this report and cited herein has demonstrated that turbine meters can accurately measure natural gas and, therefore, should be able to meet or exceed the requirements specified in this report when calibrated and installed according to the recommendations contained herein. Users should follow appropriate installation, use and maintenance of turbine meter as applicable in each case.

This version of AGA Report No. 7 is intended to supersede all prior versions of this document. However, this document does not reference existing turbine meter installations. The decision to apply this document to existing installations shall be at the discretion of the parties involved.

Appendix B of this report contains the equations needed to convert volume measured at actual (line) conditions to equivalent volume at base conditions, or mass. These equations may be used to perform such calculations with any type of positive displacement or inferential meter that registers in units of volume.

ACKNOWLEDGEMENTS

Report No. 7, *Measurement of Natural Gas by Turbine Meters*, was developed by a Task Group of the American Gas Association's Transmission Measurement Committee. Individuals who made substantial contributions to the creation of this document are:

Larry Fraser, Fraser & Associates (Chairman)

Angela Floyd, Panhandle Energy
Dan Peace, Sensus Metering Systems
Mark Pelkey, National Fuel
Alex Podgers, American Meter Co.

Research conducted by Darin George, Ph.D., Southwest Research Institute at the Southwest Research Institute and the Colorado Experimental Engineering Station was instrumental in developing the scientific basis for the provisions of this Report.

Other individuals who contributed to the development of the document are:

Ed Bowles, Southwest Research Institute
Joe Bronner, Pacific Gas and Electric Co.
Jim Bowen, Instromet
Frank Brown, Consultant
Steve Caldwell, CEESI
Cary Carter, Texas Gas Transmission
Craig Chester, Williams Gas Pipeline
Philip DiGiglio, KeySpan Corporation
Chuck French, Gas Technology Institute
Garnet Grudeski, TransCanada Calibrations
Danny Harris, Columbia Gas
Jim Hagler, Great Lakes Gas
Zaki Hassan, Chevron Texaco
Mark Irwin, Controlotron Corp.
John Keating, Consultant
Eric Kehler, Southwest Research Institute
Allen Knack, Consumers Energy
Paul LaNasa, CPL & Associates
John Lansing, Daniel M&C
Rick Ledesma, El Paso Pipeline Group
Brad Massey, Southern Star Central Gas Pipeline
George Mattingly, Consultant
Dannie Mercer, Atmos Energy Corporation
Roy Meyer, Exxon Mobil
Winston Meyer, CenterPoint Energy
Kevin Moir, DTE Energy
John Naber, Daniel M&C
Chris Overgaard, Nicor Gas
Warren Peterson, TransCanada PipeLines
Thanh Phan, Duke Energy
Reese Platzer, Questar Pipeline
King Poon, Thermo Electron Corp.
Dan Rebman, Universal Ensco

Daniel Rudroff, Welker Flow Measurement Systems Inc.
Blaine Sawchuk, Canada Pipeline Accessories
Bill Schieber, Solar Turbines
Tushar Shah, Eagle Research Corporation
Jerry Paul Smith, Consultant
Walt Seidl, CEESI
Karl Stappert, Daniel M&C
John Stuart, Stuart Consulting
Jim Witte, El Paso Pipeline Group

AGA acknowledges the contributions of the above individuals and thanks them for their time and effort in getting this document revised.

Lori Traweck
Senior Vice President

Ali Quraishi, Staff Executive
Engineering Services Director

TABLE OF CONTENTS

DISCLAIMER AND COPYRIGHT.....	III
FOREWORD.....	IV
ACKNOWLEDGEMENTS.....	
TABLE OF CONTENTS.....	VI
MEASUREMENT OF NATURAL GAS BY TURBINE METERS.....	1
1. INTRODUCTION.....	1
1.1 SCOPE	1
1.2 PRINCIPLE OF MEASUREMENT	1
2. TERMINOLOGY	2
3. OPERATING CONDITIONS.....	5
3.1 GAS QUALITY	5
3.2 OPERATING PRESSURES	5
3.3 TEMPERATURES, GAS AND AMBIENT.....	5
3.4 EFFECT OF GAS DENSITY	5
3.5 GAS FLOW RATE CONSIDERATIONS	6
3.6 UPSTREAM PIPING AND FLOW PROFILES.....	6
4. METER DESIGN REQUIREMENTS	7
4.1 CODES AND STANDARDS.....	7
4.2 METER BODY.....	7
4.2.1 Meter Body End Connections	7
4.2.2 Corrosion Resistance.....	7
4.2.3 Meter Lengths and Bores	7
4.2.4 Pressure Tap.....	7
4.2.5 Sealing.....	7
4.2.6 Miscellaneous.....	8
4.3 METER MARKINGS.....	8
4.4 DOCUMENTATION	8
5. PERFORMANCE REQUIREMENTS.....	10
5.1 GENERAL PERFORMANCE TOLERANCES	10
5.2 TEMPERATURE AND GAS COMPOSITION INFLUENCES	11
5.3 PRESSURE INFLUENCES	11
5.4 METER BODY INTERCHANGEABILITY	11
6. INDIVIDUAL METER TESTS.....	12
6.1 INTEGRITY TEST	12
6.2 LEAKAGE TEST	12
6.3 CALIBRATION	12
6.3.1 Calibration Conditions	12
6.3.1.1 Reynolds Number.....	12
6.3.1.2 Density	13
6.3.1.3 Calibration Gases	13
6.3.2 Calibration Guidelines	14
6.3.3 Calibration Configuration	14
6.3.4 Calibration Facilities	14
6.3.5 Calibration Results.....	14

6.3.5.1	Change Gears.....	14
6.3.5.2	K-Factor(s).....	15
6.3.5.3	Meter Factors and Final Meter Factor.....	15
6.3.5.4	Rotor Factors for Dual-Rotor Meters.....	15
6.3.5.5	Meter Verification Test.....	15
6.4	TEST REPORTS.....	16
6.5	QUALITY ASSURANCE.....	16
7.	INSTALLATION SPECIFICATIONS.....	17
7.1	GENERAL CONSIDERATIONS.....	17
7.1.1	Flow Direction.....	17
7.1.2	Meter Orientation and Support.....	17
7.1.3	Meter Run Connections.....	17
7.1.4	Internal Surfaces.....	17
7.1.5	Temperature Well Location.....	17
7.1.6	Pressure Tap Location.....	18
7.1.7	Flow Conditioning.....	18
7.1.7.1	Tube Bundle Type Straightening Vanes.....	18
7.1.7.2	Other External Flow Conditioners.....	18
7.1.7.3	Integral Flow Conditioners.....	18
7.2	RECOMMENDED INSTALLATION CONFIGURATIONS.....	18
7.2.1	Recommended Installation for In-Line Meters.....	19
7.2.2	Optional Installation Configurations for In-Line Meters.....	20
7.2.2.1	Short-Coupled Installation.....	20
7.2.2.2	Close-Coupled Installation.....	21
7.2.2.3	Meter-Integrated Flow Conditioning.....	22
7.2.3	Suggested Installation for Angle-Body Meters.....	23
7.3	ENVIRONMENTAL CONSIDERATIONS.....	24
7.3.1	Temperature.....	24
7.3.2	Vibration.....	24
7.3.3	Pulsations.....	24
7.3.4	Hydrate Formation and Liquid Slugs.....	24
7.4	ASSOCIATED DEVICES.....	24
7.4.1	Filtration and Strainers.....	24
7.4.2	Throttling Devices.....	25
7.5	PRECAUTIONARY MEASURES.....	25
7.5.1	Installation Residue.....	25
7.5.2	Valve Grease.....	25
7.5.3	Over-Range Effects.....	25
7.5.3.1	Run Pressurization.....	25
7.5.3.2	Blow Down Precautions.....	26
7.5.3.3	Flow Limiting Devices.....	26
7.6	ACCESSORY INSTALLATION.....	29
7.6.1	Density Measurement Devices.....	29
7.6.2	Volume Correctors and Instrumentation.....	29
8.	METER MAINTENANCE AND FIELD VERIFICATION CHECKS.....	30
8.1	GENERAL.....	30
8.2	VISUAL INSPECTION.....	30
8.3	CLEANING AND OILING.....	31
8.4	SPIN TIME TEST.....	31
8.5	DUAL-ROTOR METER FIELD CHECKS.....	33
8.6	RETESTING CONSIDERATIONS.....	33

APPENDIX A	A-1
A.1 SINGLE ROTOR TURBINE METERS	A-1
A.1.1 GAS METER DESIGN	A-1
A.1.2 LIQUID METER DESIGN.....	A-2
A.2 DUAL-ROTOR TURBINE METERS	A-2
A.2.1 DUAL-ROTOR DESIGNS	A-2
A.2.2 SECONDARY ROTOR DESIGNS.....	A-5
A.2.3 SECONDARY ROTOR FUNCTIONS.....	A-5
A.3 DUAL-ROTOR METER ELECTRONICS	A-5
APPENDIX B	B-1
B.1 EQUATIONS FOR CALCULATING VOLUMETRIC FLOW	B-1
B.1.1 BASIC GAS LAWS	B-1
B.1.2 FLOW RATE AT FLOWING CONDITIONS.....	B-2
B.1.3 FLOW RATE AT BASE CONDITIONS	B-2
B.1.4 PRESSURE MULTIPLIER	B-2
B.1.5 TEMPERATURE MULTIPLIER.....	B-3
B.1.6 COMPRESSIBILITY MULTIPLIER.....	B-3
B.1.7 EQUATIONS FOR METER RANGEABILITY	B-3
B.1.7.1 Maximum Flow rate	B-3
B.2 EQUATIONS FOR CALCULATING MASS FLOW	B-5
APPENDIX C	C-1
C.1 METER REGISTER READING	C-1
C.2 ELECTRONIC COMPUTATION	C-1
C.3 MECHANICAL INTEGRATING DEVICES	C-1
C.4 PRESSURE, VOLUME AND TEMPERATURE RECORDING DEVICES	C-1
APPENDIX D	D-1
D.1 CHANGE GEARS	D-1
D.2 K-FACTOR(S)	D-2
D.3 METER FACTOR	D-4
D.4 FINAL METER FACTOR	D-8
D.5 ROTOR FACTORS FOR DUAL-ROTOR METERS	10
APPENDIX E	E-1
E.1 REYNOLDS NUMBER AND FLOW RATE MATCHING	E-1
E.2 PRESSURE AND FLOW RATE MATCHING	E-2
E.3 DENSITY AND REYNOLDS NUMBER MATCHING	E-2
E.4 DENSITY AND FLOW RATE MATCHING	E-2
E.5 EXAMPLE CALCULATIONS	E-2
E.5.1 TO MATCH REYNOLDS NUMBERS AND FLOW RATES	E-3
APPENDIX F	F-1
F.1 TESTING IN-LINE	F-1

F.2 TESTING OUT OF LINEF-1
REFERENCE LIST..... REF-1
FORM FOR SUGGESTION TO CHANGE IN THE AGA REPORT NO. 7S-1

Currently in preview, click buy full versi

MEASUREMENT OF NATURAL GAS BY TURBINE METERS

1. Introduction

1.1 Scope

These specifications apply to axial-flow turbine flow meters for measurement of natural gas, typically 2-inch and larger bore diameter, in which the entire gas stream flows through the meter rotor. Typical applications include measuring single-phase gas flow found in production, process, transmission, storage, and distribution and end-use gas measurement systems. Typical use is the measurement of fuel grade natural gas and associated hydrocarbon gases either as pure hydrocarbons or as a mixture of pure hydrocarbons and diluents. Although not within the scope of this document, turbine meters are used to measure a broad range of fluids other than natural gas.

This report does not address the characteristics of electronic pulse signal generating devices within or attached to the meter, although it does address the use of their outputs.

Also not addressed are the characteristics of mechanical or electronic instruments that convert meter outputs from line conditions to base conditions. However, Appendix B does contain the equations establishing the mathematical basis for the conversion process. Although these equations appear in this report, they may be used to convert volume registered by any type of meter.

1.2 Principle of Measurement

Turbine meters are inferential meters that measure flow by counting the revolutions of a rotor, with blades, which turns in proportion to the gas flow velocity. From the geometry and dimensions of the rotor blades and flow channel, for a particular turbine meter size and model, the gas volume at line conditions can be inferred from counting the number of rotor revolutions. The revolutions are transferred into digital readout or electronic signals by some combination of mechanical gearing, generated electronic or optical pulses, or frequency. The accumulated line volume can be converted to base volume at standard or contract conditions by accessory devices. Turbine meters can operate over a wide range of gas and ambient conditions. Their upper flow capacities are established and limited by maximum local internal gas velocities, noise generation, erosion, rotor speed, shaft bearing wear and pressure losses. The maximum flow capacity at line conditions is fixed for a particular turbine meter regardless of the operating pressure and temperature. The maximum base flow capacity increases in accordance with Boyle's and Charles' laws. Minimum flow capacities are limited by fluid and non-fluid drags (i.e., windage and mechanical friction losses, respectively) that cause a particular turbine meter design to exceed the desired or prescribed performance limits.