

# Contents

<b>I</b>	<b>Gas Measurement Fundamentals.....</b>	<b>1.1</b>
	INTRODUCTION .....	1.1
	BASIC CHEMISTRY .....	1.2
	HYDROCARBON PROPERTIES .....	1.4
	THE KINETIC THEORY OF GAS.....	1.5
	GAS LAWS .....	1.18
	EQUATIONS OF STATE .....	1.22
<b>2</b>	<b>Head Meters.....</b>	<b>2.1</b>
	PRIMARY ELEMENTS .....	2.1
	SECONDARY ELEMENTS.....	2.6
<b>3</b>	<b>Turbine Meters.....</b>	<b>3.1</b>
	TURBINE METERS FOR GAS MEASUREMENT .....	3.1
	INSERTION TURBINE METERS.....	3.8
	TURBINE METERS FOR LIQUID MEASUREMENT.....	3.8
<b>4</b>	<b>Other Meters.....</b>	<b>4.1</b>
	DIAPHRAGM METERS .....	4.1
	ROTARY METERS.....	4.3
	VORTEX-SHEDDING METERS .....	4.5
	SWIRL METERS.....	4.6
	VARIABLE-AREA METERS .....	4.6
	TARGET METERS.....	4.6
	MAGNETIC METERS .....	4.6
	ULTRASONIC METERS .....	4.7
<b>5</b>	<b>Orifice Meters .....</b>	<b>5.1</b>
	ORIFICE METER INSTALLATIONS.....	5.1
	GAS FLOW CALCULATIONS FOR ORIFICE METERS .....	5.5
	VOLUME CALCULATIONS USING THE FORMER STANDARD .....	5.8
	PERCENTAGE AND L-10 CHART CALCULATIONS.....	5.15
<b>6</b>	<b>Auxiliary Equipment .....</b>	<b>6.1</b>
	DEW POINT RECORDERS.....	6.1
	TEMPERATURE RECORDERS.....	6.4
	GAS DENSITOMETERS .....	6.4
	LIQUID DENSITOMETERS .....	6.5
	SPECIFIC GRAVITY INSTRUMENTS .....	6.6
	HYDROGEN SULFIDE DETECTORS .....	6.11
	ORIFICE WELL TESTERS .....	6.13
	CRITICAL-FLOW PROVERS AND NOZZLES.....	6.13
	METER PROVERS .....	6.15
	ON-LINE FLOW COMPUTERS .....	6.20

7	Mass Flow Measurement .....	7.1
	TRUE MASS METERS.....	7.1
	INFERENCEAL MASS METERS .....	7.2
	STATIC MASS MEASUREMENT.....	7.5
8	Sampling.....	8.1
	GAS SAMPLING .....	8.1
	LIQUID SAMPLING.....	8.2
9	Operation and Inspection of Measurement Equipment	
9.1	TOLERANCES IN GAS MEASUREMENT .....	9.1
	CAUSES OF CONSTANT ERROR .....	9.5
	CAUSES OF VARIABLE ERRORS.....	9.8
	DETECTING ERRORS WITH A FIELD COEFFICIENT.....	9.10
	PROBLEMS OF HIGH CO <sub>2</sub> IN GAS LIQUID STREAM .....	9.12
	OTHER PROBLEMS AND SOLUTIONS.....	9.12
10	Gas Sales Contracts .....	10.1
	MARKET PERIODS.....	10.1
	FIXED-RATE CONTRACTS.....	10.1
	PERCENTAGE OF PROCEEDS CONTRACTS .....	10.5
	NONSTANDARD CONTRACTS.....	10.5
	GAS-PURCHASING AGREEMENT.....	10.5
	GAS-BALANCING AGREEMENT.....	10.5
	GAS-PROCESSING AGREEMENT .....	10.5
II	Unaccounted-for Gas .....	II.1
	INPUT-OUTPUT POINTS.....	II.1
	PRESSURE BASE .....	II.2
	INCORRECT METER READINGS .....	II.2
	METER-DIAL GEAR RATIOS .....	II.3
	CYCLIC METER READINGS .....	II.4
	TEMPERATURE COMPENSATION.....	II.4
	METER CORRECTIONS .....	II.4
	METER ACCURACY.....	II.4
	LINE BREAKS AND BLOWDOWNS.....	II.5
	REPAIRED LEAKS .....	II.5
	STOLEN GAS.....	II.5
	HEATING VALUE .....	II.5
	CONCLUSION .....	II.5
	Appendix.....	A.1
	Glossary .....	G.1
	Index.....	I.1

# Tables

I.1	Periodic Table of the Elements.....	I.2
I.2	Most Abundant Elements in the Earth's Crust.....	I.3
I.3	Physical Constants.....	I.6
I.4	Physical Constants for Calculations .....	I.13
I.5	Conversion Factors .....	I.14
3.1	Typical Turbine Meter Performance .....	3.3
5.1	Linear Coefficient of Thermal Expansion .....	5.7
5.2	Interpolated Value for $F_p$ .....	5.15
6.1	Physiological Effects of Hydrogen Sulfide .....	6.12
9.1	Effect of Tolerances Used in the Flow Equation.....	9.2
9.2	Effect of Tolerances Applied to Each Variable.....	9.3
11.1	Gas Balance Using Several Pressure Bases.....	11.2



# Figures

1.1	Electronic configuration of the first 20 elements .....	1.3
1.2	The molecular structure of four hydrocarbon fluids .....	1.4
1.3	Supercompressibility factor .....	1.16
1.4	Kinds of pressure .....	1.16
1.5	Temperature scales .....	1.17
1.6	Illustration of Boyle's law .....	1.19
1.7	Illustrations of Charles's law .....	1.20
1.8	Compressibility factors at low reduced pressures .....	1.23
1.9	Compressibility factors for gases near atmospheric pressure .....	1.23
1.10	Pseudo reduced pressure .....	1.24
1.11	Behavior of gas at various temperatures.....	1.25
2.1	Orifice meter installation .....	2.2
2.2	Operation of 5-valve manifold .....	2.3
2.3	A venturi tube.....	2.3
2.4	Lo-Loss tube .....	2.4
2.5	ASME long-radius flow nozzles .....	2.4
2.6	Pitot tube .....	2.6
2.7	Annubar .....	2.6
2.8	A bellows meter .....	2.7
2.9	Static pressure pen linkage .....	2.9
3.1	Turbine meter.....	3.1
3.2	Liquid turbine meter .....	3.9
3.3	Turbine meter system schematic diagram.....	3.11
4.1	Diaphragm displacement meter .....	4.2
4.2	Lobed impeller meter.....	4.3
5.1	Orifice plates .....	5.2
5.2	Square-edge and beveled-edge orifice plates .....	5.3
5.3	Flanged orifice fitting.....	5.4
5.4	Simplex orifice fitting .....	5.4
5.5	Junior orifice fitting .....	5.4
5.6	Senior orifice fitting.....	5.5
6.1	Measuring wheel.....	6.7
6.2	Indicating scale.....	6.8
6.3	Pressurized pycnometer.....	6.9
6.4	Critical-flow prover .....	6.13
6.5	Smith-Matz sonic-flow nozzle.....	6.14
6.6	Unidirectional pipe prover .....	6.17
6.7	Positive-volume tank prover.....	6.19

7.1	Example composite sample calculation .....	7.4
9.1	Excerpt from a clearly written contract .....	9.3
9.2	Partially closed valve upstream of meter tube .....	9.6
9.3	Two ells not in same plane upstream of meter tube.....	9.7
9.4	Percent meter error introduced by liquid in gas .....	9.8
9.5	Effect of nonstandard conditions existing in primary element .....	9.9
9.6	Pressure and temperature curves for measuring hydrate forma- tion.....	9.10
9.7	Corrections required at various temperatures of water in a manometer .....	9.11
9.8	Curve showing needed adjustment for water.....	9.11
9.9	Curve showing needed adjustment for mercury .....	9.11
11.1	Meter not included in gas balance.....	11.2
11.2	Meter dials with different multipliers.....	11.3