

**PIPELINE PUMPING AND  
COMPRESSION SYSTEMS—  
A PRACTICAL APPROACH  
THIRD EDITION**

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Kamal K. Botros  
Thomas Van Hardeveld



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# DEDICATION

We dedicate this third edition again to the memory of our dear friend and colleague, Dr. Mo Mohitpour, who continues to inspire the two authors of this book to share their knowledge and experience in the pipeline industry.



# TABLE OF CONTENTS

<b>Dedication</b>	<b>iii</b>
<b>Preface</b>	<b>xiii</b>
<b>Forewords</b>	<b>xv</b>
<hr/>	
<b>Chapter 1 Introduction to Pipeline Systems</b>	<b>1</b>
1.1 Introduction	1
1.2 Liquid Pipelines System	2
1.3 Gas Pipeline System	4
1.4 Pipeline Safety	6
1.4.1 Process Safety	6
1.4.2 Dependability of Pipeline Systems	11
References	17
<hr/>	
<b>Chapter 2 Liquid Pipeline Pumping System Design</b>	<b>19</b>
2.1 Liquid Pipeline Design	19
2.1.1 Liquid Pipeline Hydraulics	19
2.1.2 Pipe Size and Pump Selection	19
2.1.3 Pipeline System Head Curve	24
2.1.4 Pipeline System Curve Development Example	26
2.1.5 Considerations for System Curves	27
2.2 Pump Station Configuration	28
2.2.1 General	28
2.2.2 Pumps in Series	29
2.2.3 Pumps in Parallel	29
2.2.4 Number of Units	30
2.3 Pump Station Piping Design	34
2.3.1 General Station Design	34
2.3.2 Station Piping Design	38
2.4 Contamination in Liquid Pipelines	44
2.4.1 Contamination Between Products	44
2.4.2 Erosion Due to Solid Contamination	48
2.4.3 DNV RP O501 Erosion Model for a 90 deg Elbow	50

2.5 Terminal Design	52
2.5.1 Terminal Piping Design	52
2.5.2 Overpressure Protection and Surge Relief	55
References	61

---

<b>Chapter 3 Gas Pipeline Compression System Design</b>	<b>65</b>
3.1 Gas Pipeline Design	65
3.1.1 Gas Pipeline Hydraulics	65
3.1.2 Pipeline Optimization with Respect to Compression	65
3.1.3 Pipeline Looping and Compression (Location and Spacing)	69
3.1.4 Hydraulic Simulation	70
3.1.5 Cost of Compressor Operation	73
3.2 Compressor Station Configuration	74
3.2.1 Operating Considerations	74
3.2.2 Types of Compression Equipment	75
3.2.3 Parallel and Series Configuration	76
3.2.4 Number of Units	76
3.2.5 Case Study: NPV Comparison Between Immediate and Deferred Unit Installation	77
3.2.6 Standby Units	78
3.2.7 Environmental Considerations	80
3.2.8 Case Study: Comparison of Different Usage Scenarios for Pipeline Station	81
3.2.9 Compressor Requirements	85
3.2.10 Driver Requirements	86
3.3 Station Layout and Facilities	87
3.3.1 Station Layout	87
3.3.2 Station Piping Layout	87
3.3.3 Scrubbers and Filters	90
3.3.4 Gas Coolers	91
3.3.5 Station and Unit Auxiliary Systems	92
3.3.6 Station and Unit Control Systems	92
3.3.7 Buildings and Weather Protection	95
3.3.8 Safety Systems and Environmental Controls	96
3.3.9 Codes and Standards	96
References	97

---

<b>Chapter 4 Design and Operation of Pumps</b>	<b>99</b>
4.1 Pumps for Liquid Pipeline Stations	99
4.2 Pump History	100
4.3 Centrifugal Pumps	104
4.3.1 Types of Centrifugal Pumps	104
4.3.2 Centrifugal Pump Design	106
4.3.3 Centrifugal Pump Mechanical Seals	109
4.3.4 Centrifugal Pump Nozzle Loading	114

4.4 Positive Displacement Pumps	119
4.4.1 Rotary Pumps	119
4.4.2 Reciprocating Pumps	121
4.4.3 Pulsation Dampeners	124
4.4.4 Other Pump Design Considerations	126
References	129

---

<b>Chapter 5 Performance of Pumps</b>	<b>131</b>
5.1 Introduction to Pump Performance	131
5.2 System Head	131
5.3 American Petroleum Institute Gravity and SG Relationship	133
5.4 Performance of Centrifugal Pumps	137
5.4.1 Pump Performance Curves	137
5.4.2 Centrifugal Pump Coverage Chart	138
5.4.3 Impeller Selection	138
5.4.4 Pump Head-Flow and System Head Flow Curves	140
5.4.5 Centrifugal Impeller Design Theory	141
5.4.6 Specific Speed	143
5.4.7 Impeller Curve Characteristics	145
5.4.8 Affinity Laws	148
5.4.9 Pipeline-Pump Operational Control	148
5.4.10 Pump Power and Efficiency	150
5.4.11 Performance Modifications	150
5.5 Cavitation in Centrifugal Pumps	154
5.5.1 Cavitation Phenomenon	154
5.5.2 Net Positive Suction Head	157
5.5.3 Net Positive Suction Head Available	158
5.5.4 Net Positive Suction Head Required	158
5.6 Centrifugal Pumps and Viscous Liquids	160
5.7 Centrifugal Pump Limits	163
5.7.1 Minimum Flow	163
5.7.2 Temperature Rise	163
5.7.3 Re-Circulation in Centrifugal Pumps	164
5.8 Pump Surge in System Operation	166
5.9 Performance of Positive Displacement Pumps	167
5.9.1 Rotary Pump Performance Chart	167
5.9.2 Pump Power and Efficiency	169
5.9.3 Rotary Pump Slip and Clearance	170
5.9.4 System Head Curves and Rotary Pump Curve	170
5.9.5 Reciprocating Pump Flow Characteristics	171
5.9.6 Reciprocating Pump Acceleration Head	171
5.9.7 Net Positive Pressures	172
5.9.8 Reciprocating Pump Selection	173
5.10 Measurement Units and Conversion Factors for Pumps	175
5.11 Pump and System Design Standards	177
References	178

---

<b>Chapter 6 Design and Operation of Compressors</b>	<b>179</b>
6.1 Introduction to Pipeline Compressors	179
6.2 Reciprocating Compressors	179
6.2.1 General Design	179
6.2.2 Running Gear	181
6.2.3 Frame and Cylinders	183
6.2.4 Capacity Control	187
6.2.5 Valves	187
6.2.6 Packings	193
6.2.7 Bearings and Lubrication Systems	193
6.2.8 Controls and Monitoring	196
6.2.9 Gas Cooling	198
6.2.10 Operation and Optimization	198
6.2.11 Design Standards	203
6.3 Centrifugal Compressors	203
6.3.1 General Design	203
6.3.2 Compressor Internals and Sealing	205
6.3.3 Bearings and Lubrication Systems	209
6.3.4 Sealing System	213
6.3.5 Controls and Monitoring	220
6.3.6 Physical Operation	223
6.3.7 Design Standards	228
6.4 Screw Compressors	229
6.4.1 Screw Compressor Design	229
6.4.2 Screw Compressor Operation	230
6.5 Integrally-Geared Compressors	231
6.5.1 Compressor Design	231
6.5.2 Bearings, Seals and Gears	233
References	234

---

<b>Chapter 7 Performance of Compressors</b>	<b>237</b>
7.1 Introduction to Compressor Performance	237
7.2 Basic Aspects of Performance	237
7.2.1 General	237
7.2.2 Nomenclature	237
7.2.3 Gas Properties	237
7.2.4 Compression Behavior	243
7.2.5 Head	244
7.2.6 Efficiency	244
7.2.7 Flow	245
7.2.8 Power	245
7.3 Performance of Reciprocating Compressors	247
7.3.1 General	247
7.3.2 Flow	247
7.3.3 Power	249
7.3.4 Discharge Temperature	251
7.3.5 Performance Maps	251
7.3.6 Piston Speed	254
7.4 Performance of Centrifugal Compressors	254
7.4.1 General	254
7.4.2 Dynamic Performance Characteristics	254



7.4.3	Selection and Sizing	260
7.4.4	Performance Testing	261
7.4.5	Effects of Mixture Composition on Compressor Performance	262
7.4.6	Compressor Performance Degradation Monitoring	264
7.5	System Characteristics	267
7.5.1	General	267
7.5.2	System Curves	267
7.5.3	Compressor Performance Comparison	270
7.5.4	Operating Limitations	271
7.5.5	Compressor Performance Adjustments	272
7.5.6	Operating Considerations	274
	References	276

---

<b>Chapter 8</b>	<b>Pump and Compressor Drivers</b>	<b>279</b>
8.1	Introduction to Drivers	279
8.2	Gas Turbines	280
8.2.1	Types of Gas Turbines	280
8.2.2	Basic Design of a Gas Turbine	283
8.2.3	Air Intake System	286
8.2.4	Air Compressor Surge	286
8.2.5	Variable Compressor Geometry	287
8.2.6	Anti-icing Systems	288
8.2.7	Exhaust System	289
8.2.8	Bearings and Lubrication System	289
8.2.9	Fuel System	292
8.2.10	Gas Turbine Performance	299
8.2.11	Design Standards	305
8.2.12	Waste Heat Recovery	306
8.3	Electric Motors	307
8.3.1	General	307
8.3.2	Types of Motors	307
8.3.3	Motor Design Considerations	310
8.3.4	Variable Speed Motors	310
8.3.5	Hermetic Compressors	315
8.3.6	Driver Economics	317
8.4	Internal Combustion Engines	320
8.4.1	General	320
8.4.2	Internal Combustion Engine Design	320
8.4.3	Integral Engine/Compressors	322
8.5	Couplings	323
8.5.1	Functions of Couplings	323
8.5.2	Coupling Selection	323
8.5.3	Gear Couplings	325
8.5.4	Flexible Couplings	325
8.5.5	Elastomeric Soft Couplings	327
8.5.6	Steel-Spring Soft Couplings	327
8.5.7	Coupling Standards	329
8.6	Comparison Between Drivers and Driven Equipment	330
8.6.1	General Factors	330
8.6.2	Advantages and Disadvantages of Gas Turbines	330

8.6.3 Advantages and Disadvantages of Electric Motors	332
8.6.4 Advantages and Disadvantages of Internal Combustion Engines	333
8.6.5 Advantages and Disadvantages of Centrifugal Compressors	334
8.6.6 Advantages and Disadvantages of Reciprocating Compressors	335
References	335
<hr/>	
<b>Chapter 9 Dynamic Behavior of Pumping Systems</b>	<b>339</b>
9.1 Introduction	339
9.2 Unsteady Governing Equations and Solution Techniques	339
9.2.1 Governing Equation for Constant Area Pipes	339
9.2.2 Solution Techniques	341
9.3 Boundary Conditions	342
9.3.1 Flow Transients Across Other Elements	343
9.3.2 Flow Transients of an Accumulator	344
9.4 Dynamics Behaviour of Centrifugal Pumps	346
9.4.1 Homologous Relations	347
9.4.2 Full Pump Characteristics	347
9.4.3 Dynamic Equation	348
9.4.4 Pump and Motor Inertias	352
9.5 Other Useful Representations of Pump Four Quadrants	354
9.5.1 Application Examples of the Use of Pump Four Quadrant Charts	354
9.6 Water Hammer, Cavitation, and Column Separation	357
9.6.1 Water Hammer	357
9.6.2 Cavitation and Column Separation	358
9.6.3 Steam Condensation-Induced Water Hammer	359
9.7 Examples and Case Studies	361
9.7.1 Styrene Transfer System	361
9.7.2 Ethylene Pump	365
References	369
Other Bibliography	370
<hr/>	
<b>Chapter 10 Dynamics of Centrifugal Compression Systems</b>	<b>371</b>
10.1 Introduction	371
10.2 Fundamentals of Dynamic Instabilities of Compression Systems	372
10.2.1 Simple Compression Systems	372
10.2.2 Complex Compression Systems	375
10.2.3 Control Dynamics	379
10.2.4 Solution Techniques	382
10.3 Emergency Shut Down	386
10.3.1 Effects of Compressor Performance Characteristics	389
10.3.2 Effects of Rotor Inertia	393
10.3.3 Example of Dynamic Instabilities in an Industrial Compression System	394
10.3.4 Integrally-Geared Compression Systems	402
10.3.5 Concept of Inertia Number	405
10.3.6 Recycle System around Compressors Arranged in Series	409
10.4 Check Valve Dynamics	411
10.4.1 Dynamics of Swing Type Check Valves	413
10.4.2 Slamming Characteristics of Swing Check Valves	417

10.4.3 Effects of Counterbalance on Maximum Reverse Velocity	421
10.4.4 Dynamics of Piston Type Check Valves	422
10.4.5 Dynamics of Wafer Type Check Valves	424
10.4.6 Effects of Check Valves of Compression Recycle System	425
10.5 Relief Valve Dynamics	427
10.5.1 Dynamics of Pilot-Operated Relief Valves	429
10.5.2 Solution Technique	434
10.5.3 Example	436
10.5.4 Field Tests	441
10.6 Station and Gas Pipeline Blowdown	444
10.6.1 Volume Model	446
10.6.2 Pipe Model	449
10.6.3 Comparison Between Models	450
10.6.4 Non-Isothermal Blowdown	453
References	457

---

<b>Chapter 11 Pulsation and Vibration Analysis of Compression and Pumping Systems</b>	<b>463</b>
11.1 Introduction	463
11.2 Pulsation Transmission Through Piping Elements	463
11.2.1 Acoustic Transfer Matrix for a Pipe Element	464
11.2.2 Acoustic Transfer Matrix for a Throttle Element	472
11.2.3 Acoustic Transfer Matrix for a Volume Element	478
11.2.4 Acoustic Transfer Matrix for a Centrifugal Compressor	479
11.3 Pulsation Generation	480
11.3.1 Flow-Generated Pulsation from Throttling Elements	480
11.3.2 Flow-Generated Single-Tone Pulsation from Closed End Side Branch	482
11.3.3 Pulsation Generated by Reciprocating Compressors and Pumps	485
11.4 Solution Techniques	487
11.5 Acoustic Boundary Conditions and Resonance	488
11.6 Techniques for Pulsation Suppression	490
11.6.1 Reactive Silencers	490
11.6.2 Spoilers for Pulsation Suppression at Source	493
11.6.3 Suppression of Noise From Blowdown Stacks	496
11.7 Liquid versus Gas Applications	499
11.8 Standards and Guidelines	502
11.8.1 API 618 Standard	502
11.8.2 API 674 Standard	510
11.8.3 Shaking Forces Arising from Pressure Pulsation	512
11.8.4 GMRC Design Guideline for High Speed Reciprocating Compressor Packages for Natural Gas Transmission & Storage Applications	513
11.8.5 API 610 and ANSI/HI 9.6.8	516
11.9 Case Study Examples	518
11.9.1 Case Study #1: Single-Source Pulsation	520
11.9.2 Case Study #2: Multiple Source Pulsation	521
11.9.3 Case Study #3: Pulsation Generated by a Reciprocating Compressor	523
11.10 Instability Criteria of Pressure Relief Valves	525
References	530

<b>Chapter 12 Mechanical Analysis</b>	<b>533</b>
12.1 Introduction To Mechanical Analysis	533
12.2 Basic Aspects Of Vibration	533
12.2.1 General	533
12.2.2 Mechanical Natural Frequency and Resonance	535
12.3 Mechanical Analysis of Rotating Equipment	536
12.3.1 General	536
12.3.2 Lateral Rotordynamics	537
12.3.3 Stability	540
12.3.4 Torsional Rotordynamics	541
12.3.5 Specific Machinery Considerations for Rotordynamics	551
12.3.6 Balancing	561
12.4 Mechanical Analysis of Piping Systems	563
12.4.1 Excitation Mechanisms	563
12.4.2 Vibration and Stress	564
12.4.3 Unbalanced Forces	566
12.4.4 Small-Bore Connections	569
12.4.5 Forced Response Analysis	572
12.4.6 Adding Damping to Mechanically Resonant Systems	577
12.4.7 Thermal Analysis	583
12.4.8 Centrifugal Compressors	584
References	588
<hr/>	
<b>Chapter 13 Environmental Issues Related to Compressor and Pump Stations</b>	<b>591</b>
13.1 Introduction	591
13.2 Environmental Issues	591
13.2.1 Summary	591
13.2.2 Designing for Environmental Requirements	593
13.3 Noise Measurement	594
13.3.1 Noise Level Parameters	594
13.3.2 Noise Criteria Limits	595
13.3.3 Predictions of Noise Level from Compressor Stations	601
13.4 Noise Surveys	608
13.4.1 Noise Mapping Methodology	608
13.4.2 Example Application on a Compressor Station	610
13.5 NO <sub>x</sub> Emissions from Gas Turbines	612
13.5.1 AP-42 Emission Factors	613
13.5.2 CEM Measurements	613
13.5.3 Neural Network Based PEM Models	615
13.5.4 PEM Implementation	620
13.6 Innovations in Capturing Vent Gas from Dry Gas Seals	624
13.6.1 Dry Gas Seal Leakage Rates	625
13.6.2 Primary Challenges of Supersonic Ejectors	625
13.6.3 Description of the Two Stages of the Ejector	626
13.6.4 Performance of the Integrated Two-Stage Supersonic Ejector	629
13.6.5 Supersonic Ejector in Operation	631
References	635
<b>Index</b>	<b>639</b>

# PREFACE

The technology of pipeline pumping and compression continues to change, so we decided that it was worthwhile to again spend the time and effort to produce this third edition. In the end, the improvements turned out to be substantial, which makes us grateful to again share our knowledge and experience and that of the industry at large. The reader will find a wide range of topics that are both practical in nature and ones that delve more deeply into the science and engineering basis behind pumping and compression processes.

One of the drivers for this edition was its use as the textbook by one of the authors (Tom) for a graduate course in Mechanical Engineering at the University of Calgary called Pipeline Pump and Compressor Stations, a part of the Pipeline Engineering Center. In particular, a number of additions were made to enhance the content for this course.

There are no new chapters this time but significant additions include updated information on the pipeline industry, pipeline safety, contamination between batches, design of terminals, booster pumps, pump station design, monitoring of centrifugal compressor degradation, equations of state for gas mixtures, gas turbine auxiliary systems, cold vs. hot recycle surge protection, PSV instability, integrally geared compressors, pulsation and vibration control for reciprocating compressors, damping of mechanically resonant systems, transient analysis of liquid pipeline systems, a more comprehensive introduction to environmental issues and many more topics. We must admit to removing some sections related to gas and liquid hydraulics since these topics are already well covered in a similar publication from ASME, Pipeline Design and Construction – A Practical Approach, as well as other industry publications. This enabled the addition of other, more relevant advances in this area.

We have again reached out to colleagues and contacts in the industry and want to specifically recognize the following for their contributions and assistance:

John Sears – Flowserve  
Matthew Piripavel – Flowserve  
Wally Bratek – Wood.  
Russ Barss – Wood.  
Suzanne Wilton – Enbridge Inc.  
Drew Devitt – New Way Air Bearings  
Bill Forbes – Enbridge Inc.  
Vik Kohli – Enbridge Inc.  
Steve McNair – Windrock  
Dr. Ron Hugo – University of Calgary.

Another improvement that was made was to provide many of the figures in color for the digital edition. Unfortunately, the printed book will still be in B&W so as not to drastically increase its cost but as compensation, many of the figures have been improved in quality.

Without ASME, this edition would not have been possible, so we want to particularly acknowledge the continuing support and encouragement of Mary Grace Stefanchik and Tara Collins Smith of ASME Press.

Again, we deeply appreciate the opportunity to contribute to this important field of engineering and restate that “This is the book I wish I had when I was a young engineer wanting to learn about pipeline pumping and compression.”

*Kamal K. Botros*

*Thomas Van Hardeveld*

# FOREWORDS

## Foreword to the first and second editions from TransCanada Pipelines

Pumping and Compression facilities are critical components of pipeline systems and *Pipeline Pumping and Compression Systems—A Practical Approach* is a tremendous resource that marks another milestone of excellence and achievement for the pipeline industry.

ASME Press initiated the development and publication of the pipeline series in 2000 with *Pipeline Design & Construction—A Practical Approach* and a number of excellently detailed and comprehensive pipeline titles since then. This book is in response to the needs of the industry and the community to further augment this series.

The book is a wide-ranging professional reference, training tool, and text covering all aspects of pipeline pumping and compression system design, configuration optimization, installation, commissioning, and operation. It provides practical solutions for dynamic situations encountered in designing pipeline systems to support reliable operation.

The content of this book reflects the considerable knowledge and expertise of the authors. Their learnings through eight decades of collective industry experience is supplemented by research and development as well as industry-generated data.

We are very pleased to continue with our support for this series of the ASME books and related efforts made in capturing the knowledge important to our industry.

Andrew Jenkins  
*Vice President, TransCanada PipeLines Limited*



**TransCanada**

## Foreword to the first and second editions from GE Oil & Gas

GE Oil & Gas has supported the preparation, review, and publication of the ASME book *Pipeline Pumping and Compressions Systems—A Practical Approach*. This timely publication completes the pipeline system design, construction, operation, and maintenance series of books, which ASME initiated in 2000.

Pumps and compressors are key elements in any pipeline transmission project. Today, a total of almost 50 million horsepower is used to service natural gas pipeline compression needs; a similar amount of power is used in pumping hydrocarbon liquids through transmission pipelines. Pump and compression units power range roughly between 500 and 45,000 hp, and new designs are increasing this power. There is no doubt that these units' capability have substantially contributed to increase the size, length, and grade of pipeline networks worldwide.

In the early 1900s, the throughput-to-fuel gas ratio was almost 50:50, whereas for modern day gas compression, the ratio is 94:6. Much of this development has been driven by environmental, operational, and cost implications. These demands for stricter emission controls, lower fuel costs, and higher availability are impacting new equipment purchase and also the decisions to replace older units.

*Pipeline Pumping and Compressions Systems—A Practical Approach* represents a thorough evaluation and presentation of pipeline pumping and compression needs and development. It serves as a useful guide for the design of such facilities in liquid and gas pipeline transmission systems, as well as a guide to various installation options.

The authors have used their considerable knowledge and experience of the pipeline industry to provide a very useful and practical document not only to augment the knowledge of professionals but also to help to convey the knowledge to new entrants in the industry.

I am pleased that such a comprehensive training and reference tool, covering all aspects of pipeline pumping and compression systems, is available to the industry.

Patrick Campbell, P.Eng.  
*General Manager,*





## Foreword to the third edition from Dr. Ron J. Hugo

Pipeline Pumping and Compression Systems – A Practical Approach was first published in 2008 in advance of the ASME International Pipeline Conference in Calgary, Alberta, CANADA. The second edition of this book was published in 2013.

Since the first edition of this book was first published in 2008, the industry has seen the retirement of a generation of experienced pipeline engineers who honed their skills working on complex projects with companies that performed the full lifecycle of an engineering project in-house, beginning with feasibility studies, to design, followed by construction and operation. Through the retirement of this experienced generation comes an apparent void. In response, this most recent edition by Botros and Van Hardeveld offers a critical and effective transfer of knowledge. This book provides the new generation of pipeline engineers with a solid foundation upon which they can build their careers.

The evolution of this third edition came about through its use in a graduate course taught by the second author, Thomas Van Hardeveld, and offered through the Pipeline Engineering Centre at the University of Calgary. With this in mind, the book will prove to be equally useful for both the engineering graduate student and the working professional. The collective years of experience of the two co-authors and the founding author in both gas and liquid transmission systems is unmatched, providing the reader with valuable knowledge and insight that has been gained through years of professional practice.

On behalf of the pipeline engineering community, I am grateful to the authors for investing so much of their time to share and give back to their profession. Their work provides an inspiration for all professional engineers.

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