

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

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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.



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# 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.

Ron J. Hugo, Ph.D., P.Eng.  
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