Preface

Differential-pressure flowmeters are low-cost and robust and can achieve high accuracy. The majority of industrial flowmeters are based on the differential-pressure principle. The increasing use of diagnostics will help ensure that the use of differential-pressure flowmeters continues to grow.

For those who want to use an orifice plate or a Venturi tube, the ISO (International Organization for Standardization) standard (ISO 5167) and its associated Technical Reports give the instructions required. However, they rarely tell the users why they should follow certain instructions. The aim of this book is to help users of the ISO standards for orifice plates and Venturi tubes to understand the reasons why the standards are as they are, to apply them effectively and to understand the consequences of deviations from the standards. So this book gives the background to differential-pressure flow measurement and then in Chaps. 2–4 goes through the requirements explaining the reason for them.

The money involved in differential-pressure flow measurement is enormous. In the UK, most natural gas is measured at least once using an orifice plate: each year perhaps £25 billion of natural gas is so metered with an uncertainty of about £250 million. So the actual equations are of immense importance: these are covered in Chaps. 5 and 6 (and Chap. 7 covers the discharge coefficient for Venturi tubes at high Reynolds number).

High accuracy depends on correct installation: Chapter 8 covers installation requirements. Chapter 9 covers the performance of flow nozzles, particularly in order to help explain the performance of Venturi tubes. Dry-gas flows with occasional addition of liquid may be handled using orifice plates with drain holes: see Chap. 10. Wet-gas flow through Venturi tubes and orifice plates is covered in Chap. 11. Although proprietary designs of wet-gas and multiphase flowmeters are not covered in this book, most of them include a Venturi tube: the number of these meters has increased rapidly; this trend is expected to continue, and a fundamental understanding of Venturi tubes is essential for their continued development.

Sir Cyril Hinshelwood said that ‘in the 19th century fluid dynamicists were divided into hydraulic engineers who observed what could not be explained and mathematicians who explained things that could not be observed' (Lighthill, *Nature:* 178 No 4529: 343 18th Aug 1956). This book aims to provide physically well-founded equations that describe the actual experience.

It is expected that many of the users of this book will be from the oil and gas industries: accordingly, although equations require consistent units (most conveniently SI), nominal pipe sizes (and nominal nozzle diameters in Chap. 9) are in inches, static pressures are often given in bar and differential pressure in mbar.

This book will be particularly useful for members of standards committees: one of the difficulties in revising standards is to know where the data can be found on which a clause in the standard is based or whether the clause is based solely on engineering judgment. If there are data, a reviser must follow the original data (unless there are better data); if there are no data, modern engineering judgment may, perhaps, replace the older judgment. The author of this book has sought to ensure that any revisions to the ISO standards are adequately referenced; however, earlier versions of the standards had an absence of references: this book will be invaluable for members of standards committees in the future.

Following ISO 5167, this book only covers flow in circular pipes. Except where wet-gas flow is discussed, the pipes must run full.

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