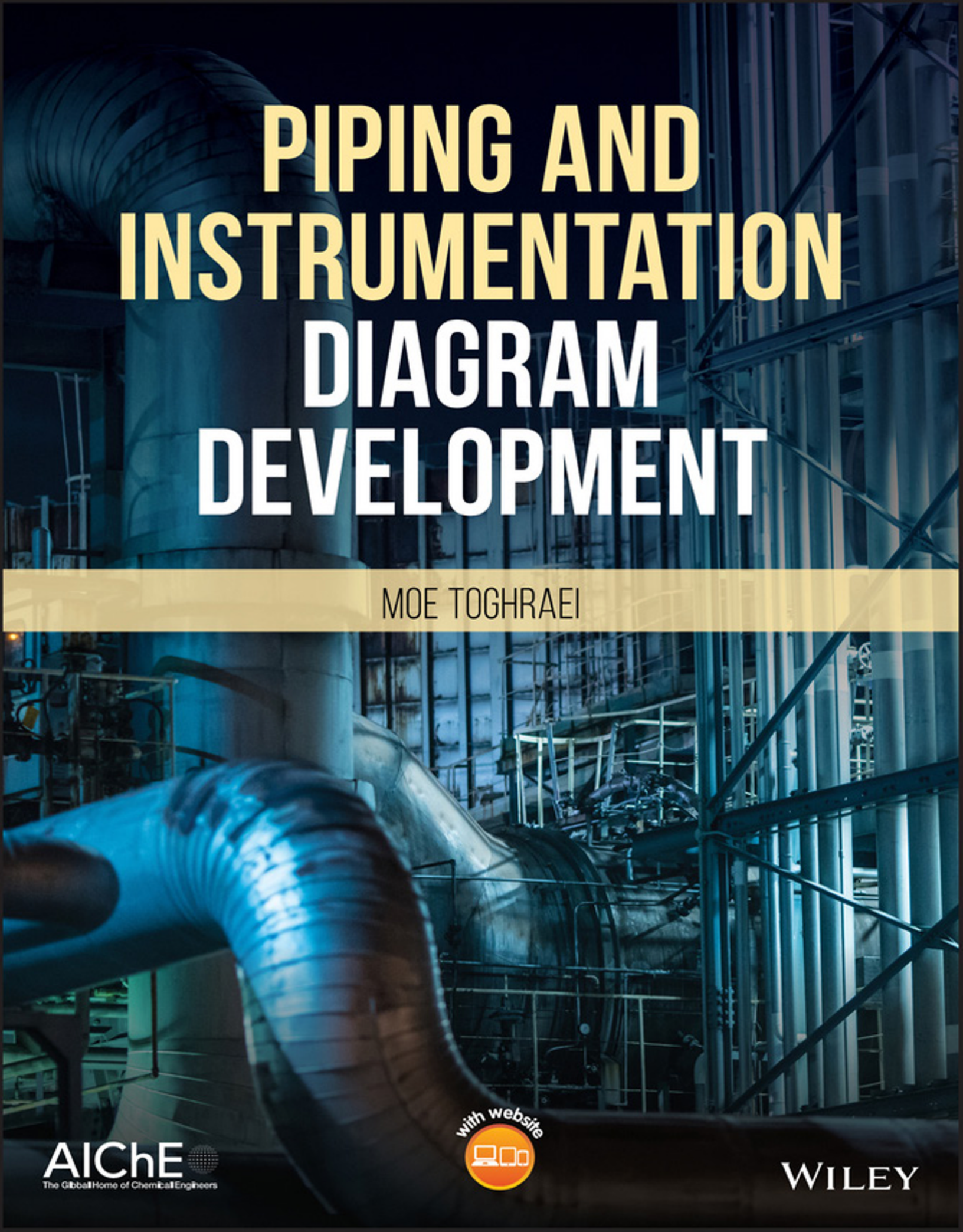
PIPING AND INSTRUMENTATION DIAGRAM DEVELOPMENT

MOE TOGHRAEI



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This edition first published 2019

A Joint Publication of the American Institute of Chemical Engineers and John Wiley & Sons, Inc.

Registered Office
John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA

Editorial Office
111 River Street, Hoboken, NJ 07030, USA

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Library of Congress Cataloging-in-Publication Data

Names: Toghraei, Moe, 1968– author.
Title: Piping and instrumentation diagram development / Moe Toghraei.
Description: First edition. | Hoboken, NJ, USA : John Wiley & Sons, Inc., 2018. | Includes bibliographical references and index. |
Identifiers: LCCN 2018034188 (print) | LCCN 2018037545 (ebook) | ISBN 9781119329343 (Adobe PDF) | ISBN 9781119329831 (ePub) | ISBN 9781119329336 (hardcover)
Subjects: LCSH: Chemical plants–Piping–Drawings. | Chemical apparatus–Drawings. | Blueprints.
Classification: LCC TP159.P5 (ebook) | LCC TP159.P5 T64 2018 (print) | DDC 621.8/6720222–dc23
LC record available at https://lccn.loc.gov/2018034188

Cover Design: Wiley
Cover Image: © tdub303/iStock.com

Set in 10/12pt Warnock by SPi Global, Pondicherry, India

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

This book is dedicated to the soul of my father:

Behrouz

Contents

Preface

The need for a book on piping and instrument diagram (P&ID) development is always felt in the process industries. However, for a long time there no book covered this topic.

There are several reasons for this.

One reason is the practical nature of this skill. A large number of books written for working professionals are authored by university professors. The skill of P&ID development however is not pure theoretical knowledge. It is a combination of technical skills and other considerations like ease of operation, ease of maintenance, client preferences, and jurisdictional codes.

On the other hand, the required technical skill is not exclusively in the territory of chemical engineers or instruments/control engineers or any other single engineering discipline. The set of skills for P&ID development comes from different engineering disciplines.

Because of the above issues, the P&ID development skill is always considered as an "on the job learning" skill.

The roadblocks of a book on P&ID development are not only the vastness of the skill or the practical nature of it, but also some preventing beliefs.

Some people claim that P&ID drawing is similar to a painting, which involves a bunch of creativity. Therefore "P&ID development" cannot be taught. However, the answer is in their question: even though painting needs a bunch of creativity it doesn't prevent teachers/instructors from writing books to explain the fundamentals of painting and also showing some of the creativities by other painters to spur the learner's creativity.

Some other people claim that P&ID development can be done only by following the company guidelines and such a topic cannot be taught as a general course. However, all the instructions in the company's guidelines have underlying logic. This book tries to explain these logical backgrounds.

The goal of this book is to provide information about the development of P&IDs for designers and personnel of process plants.

When it comes to P&ID, there are three main group of knowledge may come to mind. They are:

1) The group of information on the technical "development" of P&IDs
2) The group of information that shows different elements on P&ID sheets
3) The group of information about how to draw already-developed P&IDs (drafting P&IDs).

A P&ID should first be developed (step 1), then drafted (step 3) based on the rules of P&ID appearance (step2).

This concept is shown in the diagram.

This book doesn't address how to "draw" a P&ID (group 3). There is plenty of software and plenty of training courses by the software companies that cover that topic.

This book mainly focuses on the development of P&IDs and how to show different elements on P&IDs.

The information in this book will not only help in the development of P&IDs, but will also help in understanding the activities of process plants that are related to P&IDs.

Chemical engineers will use this book to learn how to design process plants based on selected and designed/specified equipment or unit operations or process units. They will learn how to "tie" together different units to make sure the plant runs safely and produces the predetermined products with the highest level of operability.

Chemical engineers and other engineers in process plants will use this book so that they can read and interpret P&IDs deeply in order to maintain any piece of equipment in the plant and/or doing repair.

There are several disciplines involved, including chemical engineering, mechanical, piping instrumentation and control, electrical engineering, and civil engineering disciplines.

All disciplines involving a process plant should be familiar with P&IDs.

Since the P&ID is a multidisciplinary drawing, the concepts must be presented in layman's terms in order to be accessible to a wide range of engineers. As it has been seen that individuals with different level of study, from engineers to technologists and technicians, have the duty of P&ID development, this book is written for whoever has enough knowledge of process plants and wants to learn P&ID development skills. Therefore the concepts are not necessarily explained in university level language.

The skeleton of this book has five parts as below.

Part 1: Fundamentals of P&ID Development

This part covers the fundamentals of P&IDs and P&ID development. Chapters 1 to 5 comprise Part 1 of this book.

At the beginning I will explain the nature and importance of P&IDs (Chapter 1). Then I will explain the milestones in developing P&IDs (Chapter 2). In Chapter 3 the "court of game", or different sections of a P&ID sheet will be explained. In Chapter 4, the basic rules of drafting P&IDs will be discussed. Chapter 5 talks about the thought process for developing P&IDs and what goals a designer needs to look for to develop a good P&ID.

When talking about "piping and instrumentation diagrams" it seems the topic can be explained by explaining two elements of piping (and equipment) and instrumentation. However for different reasons I have decided to divide the topic into the three elements of pipes and equipment, instrumentation/control systems, and utility generation and networks.

Part 2 is devoted to pipes and equipment, Part 3 will cover instrumentation and control systems, and Part 4 covers topics related to utilities.

For each of these elements the skills for P&ID development is explained together with plenty of general practices for each component.

Part 2: Pipes and Equipment

The majority of process items (pipes and equipment) in different P&IDs are pipes and pipe appurtenances, valves (manual and automatic), containers (tanks and vessels), fluid movers (including pump, compressor, fan, and blower), and heat exchangers.

Part 2 has seven chapters. In Chapter 6, pipe and pipe fittings are discussed. Chapter 7 belongs to different types of valves.

Chapter 8 provides information about the development of P&IDs considering inspection and maintenance. As such provision needs to be made for specific types of pipe and valve arrangement and this topic is placed after Chapter 6.

Chapter 9 discuss different types of containers including tanks and vessels and the way we develop their P&IDs.

Chapter 10 covers fluid movers. Fluid movers include liquid movers or pumps and gas/vapor movers or compressors, blowers, and fans.

Chapter 11 talks about heat transfer units. They are mainly divided into heat exchangers and furnaces (fired heaters).

Pressure safety devices (PSDs) are discussed in Chapter 12. Although one main portion of PSDs are pressure safety valves (PSVs), and are a special type of valves, it was decided to devote a separate chapter to them. The reason is that another portion of PSD is rupture disks, which are not a type of valve, and also the concept of PSDs is adequately important to consider a separate chapter for them.

Part 3: Instrumentation and Control

Part 3 comprises the four Chapters of 13, 14, 15, and 16.

Chapter 13 developed to give a basic practical idea about instrumentation and control to the reader. As is mentioned there, the control system, or in a more complete phrase integrated control and safety, in each plant has three main elements.

In Chapter 14 the concept of control loop and the method of developing control loops on P&ID are discussed.

The first element of control is covered in Chapter 14 as "plant control". The other two elements, interlock and alarm systems are covered in Chapters 15 and 16.

Part 4: Utilities

In Chapter 17, the reader will learn about utility systems in a process plant and how to develop their P&IDs. When talking about utilities, there are two separate concepts that should be discussed: utility generation and then the distribution of utilities and the collection of "used" utilities. Both of them are discussed in this chapter.

Part 5: Additional Information and Wrap-up

Part 5 covers additional information to that covered in the previous chapters. Part 5 has two chapters, Chapters 17 and 18.

Chapter 17 covers some additional small systems (tracing and insulation, utility stations, safety showers and eye washers, sampling systems, and corrosion coupons) and also an important topic that is very important in P&ID development.

The important topic, covered as part of chapter 17, is "design pressure and temperature considerations". This topic covers precautions should be taken when tying together different process elements in P&IDs.

In chapter 18 some units that could be categorized in the previous chapters are presented. The important concept of design temperature and design pressure is also studied here.

Chapter 19 could be considered as summary of the previous chapters. In this chapter a general methodology is provided for P&ID development of a new item (not familiar for the designer) and then P&ID development of some common systems (like chemical injection system,

silo and solid transfer, etc.) is brought. At the end P&ID reviewing and checking is discussed.

Introduction: What is P&ID Development Skill?

The first thing is to decide is the meaning of P&ID development. The answer can be prepared regarding two aspects: the depth and the breadth.

All the items on a P&ID sheet went through two steps and several engineering disciplines. The depth of P&ID development could be defined as all activities to develop a P&ID but beyond the design.

The breadth of P&ID development could be defined as all activities by different engineering disciplines.

The depth of P&ID development is explained in more detail below.

Each discipline does the design and then P&ID development.

The design, in this context, means sizing or specifying a piece of an element such as a pipe, equipment, instrument, etc.

There are different disciplines involved in the design of a process plant, including process engineering, piping and piping engineering, instrumentation and control engineering, mechanical engineering, and civil engineering.

The duties of the chemical engineer in a CPI project can be broadly split into two categories: equipment sizing/specification and P&ID development. Therefore the chemical engineer needs to have skills in both classes.

The former skill needs primarily knowledge of hydraulic calculations, pump/compressor sizing, vessel/tank sizing, PSV sizing, and heat exchanger sizing. At a higher level of sizing skill the chemical engineer should have the knowledge of designing different unit operation and unit processes. For example an engineer in the air purification industry may need to know about the design of different solid–gas separation units. Another engineer in the oil refining industry may need to know how to size a distillation tower. All of these sizing skills could have been learned during the acquisition of an engineering degree.

However, the latter—which is not formally taught and considered as "on the job" learning—includes the skills required to determine appropriate piping, piping appurtenances, proper tanks, vessels, pumps, and also instrumentation/control to determine the goal of the plant.

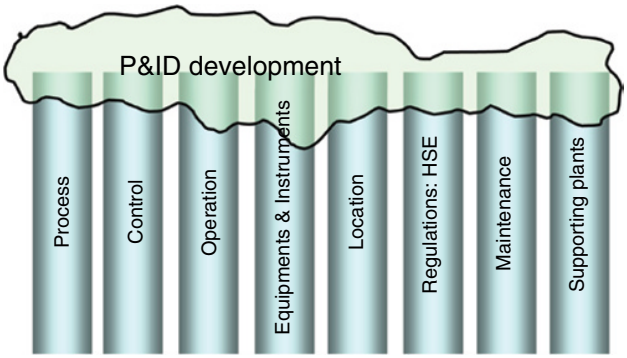
Equipment sizing is beyond the scope of this book. However, sometimes it is not easy to put a separation line between equipment sizing and P&ID development. The result of equipment sizing AND P&ID development effort makes P&IDs.

Some concepts in this book may be considered as sizing skill concepts by some individuals but they are still included in the book. The reason is that a P&ID document could be used to "check" the sizing during the P&ID development stage. As a P&ID gives a big picture of a plant, sometimes the mistakes in equipment sizing could be revealed when the equipment appears on the P&ID. Therefore, some of the concepts in this book can be used to "roughly" check the accuracy of sizing of pipes and equipment.

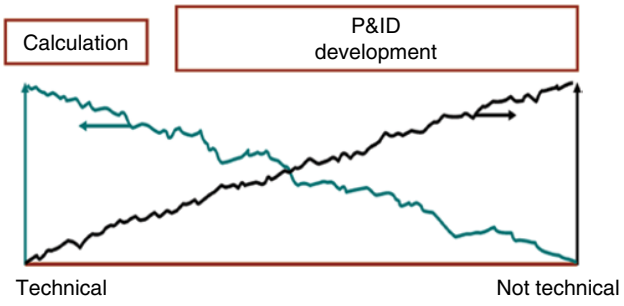
The breadth of P&ID development is explained in more detail below.

The question is: which sector of P&ID skills are outlined here? Chemical engineering sector? Instrumentation and control sector? Mechanical engineering sector?

As was mentioned before, P&ID development skills are stretched over multiple disciplines. A P&ID sheet is the result of exhaustive work by different disciplines. Each item on a P&ID may be rooted in a deep concept of chemical engineering, instrumentation and control engineering, mechanical engineering, etc.



At the beginning of P&ID development the items are added on P&IDs based on some calculations and sizing. However, when we progress further, the added items on P&IDs are not backed by quantitative documents but by qualitative, judgment-type decisions.



The content of this book covers not only the chemical engineering sector of P&ID development but also the required knowledge of other disciples to develop P&IDs is covered.

This book, however, doesn't eliminate the need for professionals in different areas because it only provides some rule of thumbs in those areas to help and accelerate the developing of P&IDs.

No attempt was made to explain the deep concepts, as they are discussed in other books with better depth and breadth. This is the reason that there are few references in each chapter because I try to convey only the skill of P&ID development.

Therefore, this book can be considered as book of rules of thumb for P&ID development. The readers learn the "root" of knowledge needed to refer to the respective resources.

Acknowledgement

In preparing this book I indebted to many professionals who have helped me. Amongst them, I acknowledge assistance of Dr. Ashgar Mesbah for his helpful notes on Chapter 13, Greg Pajak for his consultation to provide a better content in chapter 16. I am also very grateful my old fried, Shahriar Gilanmorad for accepting to develop and draw many schematics of this book.

I also must acknowledge all the helpful guidance and help I received from Rasoul Sayedin during my career and regarding P&ID development.

Finally, to my wife, Mishga Abedin, who suffered but supported me through the writing of this book.

At the end, I will appreciate it very much if all professionals who use this book let me know of any errors which is made or any change, they believe needed to improve the book.

Moe Toghraei
Calgary, Alberta
2018

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/Toghraei_PID

The website includes:

- Figures for which user should mention their comments or an interpretation.

Part I

Fundamentals of P&ID Development

In part 1 we are going to cover the common rules of P&ID development. This part has five chapters:

Chapter 1: What is P&ID?
Chapter 2: Management of P&ID development
Chapter 3: Anatomy of a P&ID sheet
Chapter 4: General rules in drawing P&IDs
Chapter 5: Principles of P&ID development

In Chapter 1 we will cover the identification of P&ID and its role in process industries.

Chapter 2 covers the progress steps of P&ID during a design project.

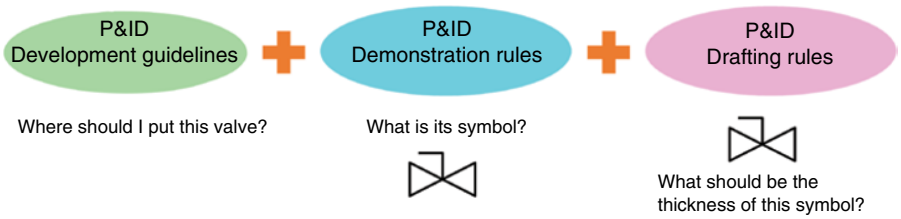
Chapter 3 talk about different components of a P&ID sheet and their meaning.

Chapters 4 and 5 cover some rules and guidelines about P&IDs. In the world of P&IDs there would be at least three sets of rules, guidelines or standards.

An example is a valve. The engineer should decide if they need to put the valve in that specific location or not, and if needed, which type of valve with which type of actuator should be used.

The engineer uses "P&ID development rules."

In the second step, when it is decided to put a manual gate valve, the question is how to show it. The engineer and the drafter together agree on a specific symbol based on "P&ID demonstration rules."



As it was mentioned before, we are not going to talk about drafting rules. Chapter 4 covers demonstration rules and Chapter 5 explains the general guidelines about P&ID development.

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