Hydraulic Systems Volume 3

# Hydraulic Fluids and Contamination Control

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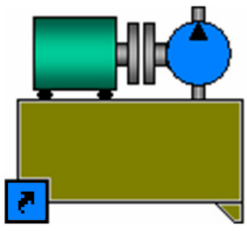

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Disclaimer

It is always advisable to review the relevant standards and the recommendations from the system manufacturer. However, the content of this book provides guidelines based on the author's experience.

Any portion of information presented in this book might not be suitable for some applications due to various reasons. Since errors can occur in circuits, tables, and text, the author/publisher assumes no liability for the safe and/or satisfactory operation of any system designed based on the information in this book.

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# Hydraulic Systems Volume 3
# Hydraulic Fluids and Contamination Control

# PREFACE

Contamination control is a crucial for hydraulic systems to survive and to sustain their reliability and performance. Hydraulic fluids are inevitably contaminated by various sources. Hydraulic fluid contamination is not limited to just the particulate contaminants as many people may think. Hydraulic fluid contamination can be broadly defined as any internal or external reason that can change the properties or performance.

Therefore, this textbook focuses on hydraulic fluids and contamination control. The text book discusses thoroughly the different types of hydraulic fluids, their properties and standard methods of testing. The textbook also covers all types of contamination, their sources, effects, and best practices to avoid and control them.

With 30+ years of experience in teaching fluid power for industry professionals, the author had effectively applied his solid understanding to the subject and his post-doctoral level of academic education in developing this book.

The author wants to continue his goal of supporting fluid power and motion control professional education by developing the following series of volumes:

- Hydraulic Systems Volume 1: Introduction to Hydraulics for Industry Professionals.
- Hydraulic Systems Volume 2: Electro-Hydraulic Components and Systems.
- Hydraulic Systems Volume 3: Hydraulic Fluids and Contamination Control.
- Hydraulic Systems Volume 4: Hydraulic Fluids Conditioning.
- Hydraulic Systems Volume 5: Best Practices for Safety and Maintenance.
- Hydraulic Systems Volume 6: Troubleshooting and Failure Analysis.
- Hydraulic Systems Volume 7: Hydraulic Systems Modeling and Simulation for Application Engineers.
- Hydraulic Systems Volume 8: Design Strategies of Hydraulic Systems.
- Hydraulic Systems Volume 9: Design Strategies of Electro-Hydraulic Systems.
- Hydraulic Systems Volume 10: Hydraulic Components Modeling and Simulation.

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All praise is to Allah who granted me the knowledge, resources and health to finish this work.

To the soul of my parents who taught me the values of ISLAM

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# ABOUT THE BOOK

## Book Description:

The book is targeting students and professionals who are looking to advance their fluid power careers. The book is colored and has the size of standard A4. The book is associated with a separate colored workbook. The workbook contains printed power point slides, chapter reviews and assignments. This book is the third in a series that the author plans to publish to offer complete and comprehensive teaching references for the fluid power industry. This book is an attempt to fill the gap between the very academic style of fluid power books and the very commercial style of books that are produced by fluid power manufacturers basically to promote their products.

The book presents the different types of hydraulic fluids, their physical properties, and their standard test methods. The book also overviews the various types of contamination including, energetic, gaseous, fluidic, and particulate contamination. This book introduces, comprehensively, methods for hydraulic fluid analysis including the various types of standards for evaluating cleanliness level of hydraulic fluids. This book discusses methods for controlling contamination in hydraulic transmission lines including projectile cleaning and flushing.

The book contains a total of ten chapters distributed over 300 pages with very demonstrative figure and tables. The contents of the book are brand non-biased and intends to introduce the latest technologies related to the subject of the book.

## Book Objectives:

### Chapter 1: Introduction

This chapter introduces the scope of hydraulic fluids conditioning and contamination control. The chapter also overviews various organizations who are involved in developing standards and set standard test methods for fluid power components and systems.

### Chapter 2: Hydraulic Fluids

This chapter provides an overview of the commonly used hydraulic fluids including petroleum-based, water-based, chemical-based, fire-resistant, and environmental-friendly types of hydraulic fluids. The chapter discusses thoroughly 21 various properties and the relevant standard test methods of hydraulic fluids. Fluid properties are categorized as physical, thermal, and chemical properties. The chapter introduces the best practices for hydraulic fluid selection, replacement, and storage.

## Chapter 3: Energetic Contamination

This chapter presents the sources hydraulic fluids energetic contamination. For each source, the chapter explains how the system performance will be affected and possible recommendations to minimize such consequences.

## Chapter 4: Gaseous Contamination

This chapter presents the sources of hydraulic fluids gaseous contamination. For each source, the chapter explains how the system performance will be affected and recommendations to minimize such consequences.

## Chapter 5: Fluidic Contamination

This chapters covers the sources of hydraulic fluids fluidic contamination. For each source, the chapter explains how the system performance will be affected and possible recommendations to minimize such consequences.

## Chapter 6: Chemical Contamination

This chapter presents the sources of hydraulic fluids chemical contamination. For each source, the chapter explains how the system performance will be affected and possible recommendations to minimize such consequences.

## Chapter 7: Particulate Contamination

This chapters presents the sources of hydraulic fluids particulate contamination. For each source, the chapter explains how the system performance will be affected and possible recommendations to minimize such consequences.

## Chapter 8: Hydraulic Fluids Analysis

This chapter discusses standard methods for hydraulic fluid analysis including methods for particle and material analysis. The chapter covers the various standard cleanliness classes used to evaluate the contamination level in hydraulic fluids. The chapter also provides examples for interpretation of hydraulic fluid analysis reports.

## Chapter 9: Hydraulic Filters Performance Ratings

This chapters discusses the standard methods for evaluating the performance of a hydraulic filter. The purpose is to make the reader aware of the factors based on which type of filter may be more suitable for a specific application.

## Chapter 10-Contamination Control in Hydraulic Transmission Lines

This chapter discusses best practices for controlling contamination in hydraulic transmission lines including projectile cleaning and hydraulic system flushing.

## Book Statistics:

The table shown below contains interesting statistical date about the textbook:

| Chapter # | Pages | Figures | Animated Circuits | Equations | Tables | Lines | Words | Characters |
|---|---|---|---|---|---|---|---|---|
| First Part | 14 | 0 | | 0 | 0 | 0 | 0 | 0 |
| Chapter 1 | 8 | 3 | - | 0 | 0 | 65 | 1383 | 7884 |
| Chapter2 | 85 | 65 | - | 13 | 26 | 652 | 13736 | 78298 |
| Chapter 3 | 9 | 8 | - | 0 | 0 | 59 | 1250 | 7126 |
| Chapter 4 | 8 | 5 | - | 0 | 3 | 58 | 1237 | 7055 |
| Chapter 5 | 30 | 22 | - | 0 | 3 | 170 | 3579 | 20402 |
| Chapter 6 | 18 | 22 | - | 0 | 1 | 97 | 2050 | 11691 |
| Chapter 7 | 41 | 43 | - | 0 | 5 | 269 | 5667 | 32303 |
| Chapter 8 | 59 | 57 | - | 0 | 18 | 320 | 6737 | 38404 |
| Chapter 9 | 25 | 25 | - | 6 | 4 | 152 | 3210 | 18303 |
| Chapter 10 | 19 | 20 | - | 1 | 0 | 182 | 3836 | 21866 |
| Appendices | 20 | 0 | - | 0 | 0 | 0 | 0 | 0 |
| Index | 6 | 0 | - | 0 | 0 | 0 | 0 | 0 |
| **Total** | **342** | **270** | **-** | **20** | **60** | **2,024** | **42,685** | **243,332** |

# ABOUT THE AUTHOR

Medhat Khalil, Ph.D., Director of Professional Education & Research Development at the Applied Technology Center, Milwaukee School of Engineering, Milwaukee, WI, USA. Medhat got his bachelor's degree in mechanical engineering from Military Technical College (MTC), Cairo, Egypt. He got his master's degree in Mechanical Engineering from Cairo University, Cairo, Egypt. Medhat has been granted his Ph.D. in Mechanical Engineering and Post-Doctoral Industrial Research Fellowship from Concordia University in Montreal, Quebec, Canada. Medhat, published several fluid power textbooks. He participated in many technical conferences, published several reviewed technical papers, and is in the process of registering a number of patents. Medhat has been certified by the International Fluid Power Society (IFPS) as: Certified Fluid Power Hydraulic Specialist (CFPHS) and Certified Fluid Power Accredited Instructor (CFPAI). Medhat is a member of many grand institutions such as Center for Compact and Efficient Fluid Power Engineering Research Center (CCEFP), listed Fluid Power Consultant by the National Fluid Power Association (NFPA) and listed professional instructor by the American Society of Mechanical Engineers (ASME) and National American Die Casting Association (NADCA). Medhat has been assigned as the chair of the education committee for the International Fluid Power Exposition (IFPE 2017 and 2020). Medhat developed and taught various courses for industry professionals. He has a balanced academic and industrial experience. Medhat has a deep working experience in the field of Mechanical Engineering; more specifically in fluid power and motion control. Medhat had worked for several world-wide recognized industrial organizations such as Rexroth in Germany and CAE in Canada. Medhat has designed several hydraulic systems and developed analytical and educational software. Medhat also has vast experience in modeling and simulation of dynamic systems using Matlab-Simulink. Medhat was the designer and founder of the Universal Fluid Power Trainers. Medhat was the recipient of the "Otto Maha Pioneers in Fluid Power" award in 2012.