Hydraulic Systems Volume 6

Troubleshooting and Failure Analysis

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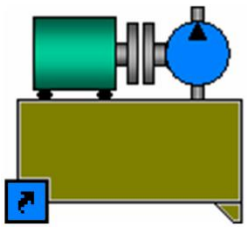

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Troubleshooting and Failure Analysis

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Disclaimer

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

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PREFACE

Troubleshooting and failure analysis are very important experience to resolve hydraulic systems problems and to find the root causes of such problems. Gaining such experience help to avoid future unexpected shutdowns, hence improve system reliability. This book introduces the approach of logic and analytical troubleshooting fault detection methodologies.

This book is targeting industry professionals who are in charge for operating, maintaining, and troubleshooting hydraulic systems. This book is also a great resource for mechanical engineers and service manuals technical writers.

The book presents more than 40 troubleshooting charts to cover system-level and components-level troubleshooting including hydraulic fluids, pumps, motors, valves, cylinders, accumulators, reservoirs, transmission lines, heat exchanges, filters, and sealing elements. The book also contains proposed inspection sheets for the aforementioned components and investigations for the typical types of failures for each component.

The author is working hard to finish his goal of supporting fluid power professional education by developing the following series of volumes and relevant software:

- 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. Under Development
- Hydraulic Systems Volume 5: Safety and Maintenance.
- Hydraulic Systems Volume 6: Troubleshooting and Failure Analysis.
- Hydraulic Systems Volume 7: Modeling and Simulation for Application Engineers.
- Hydraulic Systems Volume 8: Design Strategies of Hydraulic Systems. (Under Development).
- Hydraulic Systems Volume 9: Design Strategies of Electro-Hydraulic Systems. (Under Development).
- Hydraulic Systems Volume 10: Hydraulic Components Modeling and Simulation. (Under Development).

Dr. Medhat Kamel Bahr Khalil

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This book was written during the hardship of Covid-19 Virus.

All praises are 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 believe in God

To my wife who offered me all the best she can to make this work completed

To my family: wife, sons, daughters in law, and grandson “Adam”

To my best teachers and supervisors

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The author also thanks the following companies (listed alphabetically) for granting the permission to use portions of their copyrighted literatures in this book.

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- www.alamo-industrial.com
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ABOUT THE BOOK

Book Description:

This book is targeting industry professionals who are in charge of operating, maintaining, and troubleshooting hydraulic systems. This book is also a great resource for mechanical engineers and service manuals technical writers. The book presents more than 40 troubleshooting charts to cover system-level and components-level troubleshooting including hydraulic fluids, pumps, motors, valves, cylinders, accumulators, reservoirs, transmission lines, heat exchanges, filters, and sealing elements. The book also contains proposed inspection sheets for the aforementioned components and investigations for the typical types of failures for each component. This 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 sixth in a series that the author plans to publish to offer complete and comprehensive teaching references for the fluid power industry. The book contains a total of fourteen chapters distributed over 250 pages with very demonstrative figures 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: Hydraulic Systems Troubleshooting Logical Methodology

This chapter discusses the common methodologies applied for hydraulic system fault detection. This chapter introduces, in a step-by-step, the logic methodology for hydraulic system troubleshooting.

Chapter 2: Basic Troubleshooting Equipment

Servicing staff for hydraulic-driven machines should be aware of the troubleshooting equipment that are used in detecting faults of hydraulic systems. This chapter presents examples of troubleshooting equipment for hydraulic systems.

Chapter 3: Troubleshooting and Failure Analysis of Sealing Elements

This chapter presents guidelines for inspecting and troubleshooting hydraulic sealing elements. The chapter also presents 26 different failure modes, their causes and suggested solutions.

Chapter 4: Troubleshooting and Failure Analysis of Pumps

This chapter discusses hydraulic *pumps* inspection, troubleshooting, and failure analysis. In this chapter, troubleshooting charts for twelve different faults of hydraulic pumps are presented. The chapter also presents examples of defective pumps due to contamination, overheating, cavitation, and fatigue stress for gear, vane, and piston pumps.

Chapter 5: Troubleshooting and Failure Analysis of Motors

This chapter discusses hydraulic *motors* inspection, troubleshooting, and failure analysis. In this chapter, a troubleshooting chart for motor faults is presented. The chapter also presents examples of defective motors due to various reasons such as contamination, clogged case drain, shaft failure, etc.

Chapter 6: Troubleshooting and Failure Analysis of Cylinders

This chapter discusses hydraulic *cylinders* inspection, troubleshooting, and failure analysis. In this chapter, a troubleshooting chart for cylinder faults is presented. The chapter also presents examples of defective cylinder due to various reasons such as contamination, improper mounting, improper load attachment, side loading, overpressure, overheating, fluid incompatibility, saltwater, external leakage, etc.

Chapter 7: Troubleshooting and Failure Analysis of Valves

This chapter discusses hydraulic *valves* inspection, troubleshooting, and failure analysis. In this chapter, a troubleshooting chart for valve faults is presented. The chapter also presents examples of defective hydromechanical and electrohydraulic valves due to various reasons such as particulate and chemical contamination, solenoid burning due to inrush current, etc.

Chapter 8: Troubleshooting and Failure Analysis of Accumulators

This chapter discusses hydraulic *accumulators* inspection, troubleshooting, and failure analysis. In this chapter, a troubleshooting chart for accumulator faults is presented. The chapter also presents examples of defective accumulators caused by various reasons such as vessel explosion due to material defects and pressure shocks etc.

Chapter 9: Troubleshooting and Failure Analysis of Reservoirs

This chapter discusses hydraulic *reservoirs* inspection, troubleshooting, and failure analysis. In this chapter, a troubleshooting chart for reservoirs faults are presented. The chapter also presents examples of defective reservoirs.

Chapter 10: Troubleshooting and Failure Analysis of Transmission Lines

This chapter discusses hydraulic *transmission lines* inspection, troubleshooting, and failure analysis. In this chapter, a troubleshooting chart for transmission line faults is presented. The chapter also presents examples of defective transmission lines.

Chapter 11: Troubleshooting and Failure Analysis of Heat Exchangers

This chapter discusses hydraulic *heat exchangers* inspection, troubleshooting, and failure analysis. In this chapter, a troubleshooting chart for heat exchanger faults is presented. The chapter also presents examples of defective heat exchangers.

Chapter 12: Troubleshooting and Failure Analysis of Filters

This chapter discusses hydraulic f*ilters* inspection, troubleshooting, and failure analysis. In this chapter, a troubleshooting chart for filter faults is presented. This chapter also presents examples of defective filter.

Chapter 13: Hydraulic Systems Troubleshooting

This chapter introduces troubleshooting charts for failures of generic hydraulic systems. Each troubleshooting chart includes relevant notes and examples for better understanding.

Chapter 14: Examples of Hydraulic Systems Troubleshooting

In this chapter several case studies are presented as examples of applying the logic trouble shooting methodology for hydraulic systems fault detection. In addition, troubleshooting case studies following analytical fault detection methodology are presented. Examples were chosen from both industrial and mobile applications.

Book Statistics:

Chapter #	Pages	Figures	Tables	Words	Editing Time (min)
Chapter 1	7	2	3	1557	8798
Chapter2	13	15	0	1428	8786
Chapter 3	35	49	3	4270	5429
Chapter 4	40	53	14	4828	6606
Chapter 5	8	5	2	1021	5452
Chapter 6	13	16	2	1569	5737
Chapter 7	18	17	5	3132	5759
Chapter 8	6	5	2	1065	5442
Chapter 9	5	4	2	472	5251
Chapter 10	11	16	2	1462	5569
Chapter 11	7	7	2	883	5367
Chapter 12	5	4	2	549	5264
Chapter 13	41	30	18	8091	5582
Chapter 14	46	32	2	11681	6473
Total	**255**	**255**	**59**	**42008**	**85515/60 = 1,425 Hour = 60 Days**

ABOUT THE AUTHOR (IFPS Hall of Fam Reciepient)

Medhat Khalil, Ph.D. is Director of Professional Education & Research Development at the Applied Technology Center, Milwaukee School of Engineering, Milwaukee, WI, USA. Medhat has consistently been working on his academic development through the years, starting from bachelor's and master's Degrees in Mechanical Engineering in Cairo Egypt and proceeding with his Ph.D. in Mechanical Engineering and Post-Doctoral Industrial Research Fellowship at Concordia University in Montreal, Quebec, Canada. He has been certified and is a member of many institutions such as: Certified Fluid Power Hydraulic Specialist (CFPHS) by the International Fluid Power Society (IFPS); Certified Fluid Power Accredited Instructor (CFPAI) by the International Fluid Power Society (IFPS); Member of 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). Medhat has balanced academic and industrial experience. Medhat has vast working experience in Fluid Power teaching courses for industry professionals. Being quite aware of the technological developments in the field of fluid power,

Medhat had worked for several world-wide recognized industrial organizations such as Rexroth in Egypt and CAE in Canada. Medhat had designed several hydraulic systems and developed several analytical and educational software. Medhat also has considerable experience in modeling and simulation of dynamic systems using Matlab-Simulink. Medhat has been selected among the inductees for Pioneers in fluid Power by NFPA (2012) and Hall of Fam in fluid Power by IFPS (2021).