



# **The Shock Absorber Handbook** *Second Edition*

## **List of Chapters:**

### **Preface**

### **Acknowledgements**

### **1 Introduction**

- 1.1 History
- 1.2 Types of Friction
- 1.3 Damper Configurations
- 1.4 Ride-Levelling Dampers
- 1.5 Position-Dependent Dampers
- 1.6 General Form of the Telescopic Damper
- 1.7 Mountings
- 1.8 Operating Speeds and Strokes
- 1.9 Manufacture
- 1.10 Literature Review

### **2 Vibration Theory**

- 2.1 Introduction
- 2.2 Free Vibration Undamped (1-dof)
- 2.3 Free Vibration Damped (1-dof)
- 2.4 Forced Vibration Undamped (1-dof)
- 2.5 Forced Vibration Damped (1-dof)
- 2.6 Coulomb Damping
- 2.7 Quadratic Damping
- 2.8 Series Stiffness
- 2.9 Free Vibration Undamped (2-dof)
- 2.10 Free Vibration Damped (2-dof)
- 2.11 The Resonant Absorber
- 2.12 Damper Models in Ride and Handling
- 2.13 End Frequencies
- 2.14 Heave and Pitch Undamped 1-dof
- 2.15 Heave and Pitch Damped 1-dof
- 2.16 Roll Vibration Undamped
- 2.17 Roll Vibration Damped
- 2.18 Heave-and-Pitch Undamped 2-dof
- 2.19 Heave-and-Pitch Damped 2-dof Simplified
- 2.20 Heave-and-Pitch Damped 2-dof Full Analysis

### **3 Ride and Handling**

- 3.1 Introduction
- 3.2 Modelling the Road
- 3.3 Ride
- 3.4 Time-Domain Ride Analysis
- 3.5 Frequency-Domain Ride Analysis

- 3.6 Passenger on Seat
- 3.7 Wheel Hop
- 3.8 Handling
- 3.9 Axle Vibrations
- 3.10 Steering Vibrations
- 3.11 The Ride-Handling Compromise
- 3.12 Damper Optimisation
- 3.13 Damper Asymmetry

### **4 Installation**

- 4.1 Introduction
- 4.2 Motion Ratio
- 4.3 Displacement Method
- 4.4 Velocity Diagrams
- 4.5 Computer Evaluation
- 4.6 Mechanical Displacement
- 4.7 Effect of Motion Ratio
- 4.8 Evaluation of Motion Ratio
- 4.9 The Rocker
- 4.10 The Rigid Arm
- 4.11 Double Wishbones
- 4.12 Struts
- 4.13 Pushrods and Pullrods
- 4.14 Motorcycle Front Suspensions
- 4.15 Motorcycle Rear Suspensions
- 4.16 Solid Axles
- 4.17 Dry Scissor Dampers

### **5 Fluid Mechanics**

- 5.1 Introduction
- 5.2 Properties of Fluids
- 5.3 Chemical Properties
- 5.4 Density
- 5.5 Thermal Expansion
- 5.6 Compressibility
- 5.7 Viscosity
- 5.8 Thermal Capacity
- 5.9 Thermal Conductivity
- 5.10 Vapour Pressure
- 5.11 Gas Density
- 5.12 Gas Viscosity
- 5.13 Gas Compressibility
- 5.14 Gas Absorbability
- 5.15 Emulsification
- 5.16 Continuity
- 5.17 Bernoulli's Equation

# The **Shock Absorber Handbook** *Second Edition*

- 5.18 Fluid Momentum
- 5.19 Pipe Flow
- 5.20 Velocity Profiles
- 5.21 Other Losses
- 5.22 The Orifice
- 5.23 Combined Orifices
- 5.24 Vortices
- 5.25 Bingham Flow
- 5.26 Liquid-Solid Suspensions
- 5.27 ER and MR Fluids
- 6 Valve Design**
  - 6.1 Introduction
  - 6.2 Valve Types
  - 6.3 Disc Valves
  - 6.4 Rod Valves
  - 6.5 Spool Valves
  - 6.6 Shim Valves
  - 6.7 Valve Characteristics
  - 6.8 Basic Valve Models
  - 6.9 Complete Valve Models
  - 6.10 Solution of Valve Flow
  - 6.11 Temperature Compensation
  - 6.12 Position-Sensitive Valves
  - 6.13 Acceleration-Sensitive Valves
  - 6.14 Pressure-Rate Valves
  - 6.15 Frequency-Sensitive Valves
  - 6.16 Stroke-Sensitive Valves
  - 6.17 Piezoelectric Valves
  - 6.18 Double-Acting Shim Valves
  - 6.19 Rotary Adjustables
  - 6.20 Bellows Valves
  - 6.21 Simple Tube Valves
  - 6.22 Head Valves
  - 6.23 Multi-Stage Valves
- 7 Damper Characteristics**
  - 7.1 Introduction
  - 7.2 Basic Damper Parameters
  - 7.3 Mechanical Friction
  - 7.4 Static Forces
  - 7.5 Piston Free Body Diagram
  - 7.6 Valve Flow Rates
  - 7.7 Pressures and Forces
  - 7.8 Linear Valve Analysis
  - 7.9 Cavitation
  - 7.10 Temperature
  - 7.11 Compressibility
  - 7.12 Cyclical Characteristics,  $F(X)$
  - 7.13 Extreme Cyclic Operation
  - 7.14 Stresses and Strains
  - 7.15 Damper Jacking
  - 7.16 Noise
- 8 Adjustables**
  - 8.1 Introduction
  - 8.2 The Adjustable Valve
  - 8.3 Parallel Hole
  - 8.4 Series Hole
  - 8.5 Maximum Area
  - 8.6 Opening Pressure
  - 8.7 Area Coefficient (Stiffness)
  - 8.8 Automatic Systems
  - 8.9 Fast Adaptive Systems
  - 8.10 Motion Ratio
- 9 ER and MR Dampers**
  - 9.1 Introduction
  - 9.2 ER-MR History
  - 9.3 ER Materials
  - 9.4 ER Dampers
  - 9.5 ER Controlled Valve
  - 9.6 MR Materials
  - 9.7 MR Dampers
- 10 Specifying a Damper**
  - 10.1 Introduction
  - 10.2 End Fittings
  - 10.3 Length Range
  - 10.4  $F(V)$  Curve
  - 10.5 Configuration
  - 10.6 Diameter
  - 10.7 Oil Properties
  - 10.8 Life
  - 10.9 Cost
- 11 Testing**
  - 11.1 Introduction
  - 11.2 Transient Testing
  - 11.3 Electromechanical Testers
  - 11.4 Hydraulic Testers
  - 11.5 Instrumentation
  - 11.6 Data Processing
  - 11.7 Sinusoidal Test Theory
  - 11.8 Test Procedure
  - 11.9 Triangular Test
  - 11.10 Other Laboratory Tests
  - 11.11 On-Road Testing
- Appendix A: Nomenclature
- Appendix B: Properties of Air
- Appendix C: Properties of Water
- Appendix D: Test Sheets
- Appendix E: Solution of Algebraic Equations
- Appendix F: Units
- Appendix G: Bingham Flow
- References**
- Index**