Preface

Heavy Equipment Power Trains and Systems was developed to educate students who are planning a career in the off-highway industry, especially construction and agricultural equipment. However, this textbook will empower students working in other heavy equipment power train fields, like forestry or mining, and it is appropriate for students who are pursuing a certificate, associate's degree, bachelor's degree, or master's degree.

The author and publisher proudly support the mission of the AED Foundation, which encourages continuous learning, provides educational opportunities for today's employees, and elevates the quality of tomorrow's equipment industry technicians. The contents of this textbook have been carefully correlated to the Power Trains section and key areas of the Safety and Hydraulics/Hydrostatics sections of AED's Standards for Construction Equipment Technology.

This textbook includes traditional power train content such as safety, tools and equipment, overhead lifting, belts, chains, gearing, manual transmissions, planetary transmissions, countershaft transmissions, powershift and automatic transmissions, torque converters, hydrostatic drives, brake systems, axles, differentials, final drives, suspensions, tires, undercarriages, track steering, wheeled steering systems, and electric drives. In addition, the book is especially unique in providing an in-depth explanation of late-model continuously variable transmissions.

The textbook provides fundamental instruction on hydrostatic transmissions with the goal of having students fully comprehend the systems rather than needing to rely on troubleshooting charts. Students will also gain instruction in hydraulic diagnostic principles such as how to tap into the system, what tools are available, how to properly use those tools, and how to perform the tests safely.

Heavy Equipment Power Trains and Systems provides students with the necessary foundational building blocks, equipping them for a bright future in off-highway power train technology. The book includes over 1,000 images comprised of multicolor line art, cross-sectional drawings, photographs, and 3D images. The book includes review questions, case studies and discussion questions, and helpful techniques for diagnosing power trains.

About the Author

Timothy W. Dell, Ph.D. is a Professor of Automotive Technology at Pittsburg State University and serves as the department's Diesel and Heavy Equipment Coordinator. Dr. Dell received his doctorate in curriculum and instruction from Kansas State University, a master of science in technology education from Pittsburg State University, and a bachelor of science in automotive technology with an emphasis in diesel and heavy equipment from Pittsburg State University.

Dr. Dell began his career working for Case IH in their Technical Service Group, specializing in combine diagnostics. He has served on John Deere's Agricultural National Service Training Advisory Board and has been the advisor of Pittsburg State University's Caterpillar ThinkBIGGER four-year degree since its inception. He currently teaches Automotive Electricity and Electronic Systems, Automotive Automatic Transmissions, Fluid Power, Advanced Hydraulic Systems, and Construction Equipment Systems. Dr. Dell served as the automotive department chair for four years, but he returned to the classroom full-time to pursue his passion for curriculum development and teaching. Dr. Dell also trains industry personnel and faculty with hands-on, face-to-face instruction.

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The author and publisher wish to thank the following industry and teaching professionals for their valuable input into the development of *Heavy Equipment Power Trains and Systems*.

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Chris Thompson
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Beebe, Arkansas

Joe Valora
Elizabethtown Community and Technical College
Elizabethtown, Kentucky

Gary Wenter (retired)
Reedley College
Reedley, California

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Acknowledgments

The author and publisher would like to thank the following companies, organizations, and individuals for their contribution of resource material, images, or other support in the development of *Heavy Equipment Power Trains and Systems.*

AGCO—Matthew Keller, Sherwood Wheeler, Dallas Grothusen, Henry Heiman, and Stacy Hofferbert

Auburn Gear—Gary Grogg

B & B Hydraulics—Bill Speakman, Ray Miller, Josh Johannsen, and Kyler Ridgeway

Bosch Rexroth—Güenter Luckhardt, Doug Wilson (retired), David Eckerd (retired), Rüdiger Weiss, Dario Alfredo Caputo, Eduard Engel, and David Gingery

Bertha Dell

Boyd Cat—Ray Genet (retired), Nick Hill, and Jacob Reynolds

Butler Machinery—Wyatt Wilm

Calvin Dell

Caterpillar—Andrew Henry, Simon Bishop (retired), Zack Palmquist, Todd Cole, Bobby Kellum, Pete Holman (retired), Steve Hitch (retired), Kelley Maxwell, Nick Johnson, Travis McClung, and Brent Dyche

CNH—Kelly Burgess, Ted Polzer, Russell Skewes, Derek Lee, Scott McElroy, Daniel Mitchell, Vang Moua, Cody Garrett, Kim Moulds (retired), Roger Lewno, Ed Wojcik, Lane Robert, David North (retired), and Russel Schuchaskie (retired)

Fabick Caterpillar—Mackenzie McDaniel

Flaherty Farms—Calvin and Brian Flaherty

Foley Caterpillar—Chris Scharrer, Shannon Dudley, Jarrod Haas, Cory Forshee, Tommy Phelps, Aaron Monhollon, Anthony Dahl, Jon Robinson, Gregg Haas (retired), Jeff Smarsh, Jack Frederick, and Jeremy Thoennes

Great Plains Manufacturing—Andrew Veer

Hayes Manufacturing, Inc.—Zeb Sieting

Hitachi—Glenn Blackburn

Illinois Central College—David Cook (retired) and Colin Campbell

Industrial Sealing & Lubrication, Inc.—David Consiglio

J & M Clutch and Converter—Terry McWhirter

Jim Radell Construction—Dennis Shouse

John Deere—Neil Miller, Glen Oetken, John Bowman, William Eck, Ben Hertle, Ross Graham, Matt Davied, Chris Bennet, and Mark Colvin

Joseph Industries—Samuel Osinsky

Joy Global—Ken Gould (retired)

Kiewit Construction—Jason Halliburton, Marlin Klotz, Scott Morris, and Bill Biesterfeld

Kirby-Smith Machinery—Brian DeVore

Kunshek Chat & Coal Company—Scott Kunshek and Bob Krumby (retired)

Lang Diesel Incorporated—John Stewart and Ethan Meier

Lake Area Technical College—Corey Mushitz and Wyatt Voelsch

Liebherr—Thomas Williams

Lincoln Land Community College—Jeff Gardner and Dillon Cuthbert

Michael Farms—Bryan Bell and Jim Michael

Minnesota State Community and Technical College—Dick Weber

Murphy Tractor—Clark Rutledge

Oehme Farms—Dustin Oehme

Payne's Machine Shop Inc.—Jim Payne and Andy Rogers

Palmer Johnson Power Systems—Mike Kopetsky

Pittsburg State University—Chauncey Pennington, Bob Schroer, Philip McNew, David Oldham, Mike Elder, Scott Norman, Christel Benson

Red International Communications—Kerrie Kashani

Ron Morey Excavation—Ron Morey

Southeast Community College—Owen Haulmark

Wabtec—Brent Wood

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New to This Edition

Notable changes in this edition of *Heavy Equipment Power Trains and Systems* include overarching revisions, such as updated photos and illustrations, additional case studies, discussion questions added to the case studies, and multiple types of new end-of-chapter assessment.

The subsequent chapters feature new or updated content on the following industry topics, including:

- **Chapter 1:** electrical hazards in the heavy equipment industry; traversing inclined slopes with a machine; using chains, straps, and chain binders to secure equipment and components onto trailers for transport; and exothermic cutting.
- **Chapter 2:** ratchets; electronic torque wrenches; torque angle gauges; hydraulic torque wrenches and pullers; torque multipliers; taps, dies, and thread chasers; wireless electronic pressure transducers; photocell tachometers; infrared temperature guns; thermal imaging cameras; transfer gauges; and torque-to-yield bolts.
- **Chapter 5:** chain and cable hoists (come-a-longs) and snatch blocks, Warrington wire rope, and machine securing chains (transport chains).
- **Chapter 6:** flat idler pulleys, new style of serpentine belt gauge, and chain breaker.
- **Chapter 7:** double-helical gears, compound spur gear sets, ceramic bearings, and revised John Deere DirectDrive dual clutch and Case IH Maxxum Active Drive 8 transmissions.
- **Chapter 8:** PTO overrunning clutches, cam-type overrunning clutches, ramp-style dog overrunning clutches, and ratchet-type overrunning clutches.
- **Chapter 10:** Case IH Magnum 21-speed countershaft powershift transmissions, Case New Holland articulated tractor 16-speed powershift transmissions, John Deere 7R and 8R e23 countershaft transmissions, and Caterpillar TA19 and TA22 powershift transmissions.
- **Chapter 11:** Caterpillar D10 transmission oil flow.
- **Chapter 12:** the k factor in relation to stall testing a torque converter, oil sampling as part of fluid contamination control, and reconditioning a contaminated hydraulic system.
- **Chapter 13:** hydrostatic transmissions incorporated into non-propulsion applications and in continuously variable transmissions (CVTs); AGCO, John Deere W155/W170 and W235, New Holland 220 Speedrower, and MacDon M-Series swathers; Caterpillar PM822 cold planers; sizing a hydrostatic transmission charge pump; Danfoss H1 Type 53 closed-loop pumps; neutral charge and flushing relief valves; and hydrostatic transmission enable solenoid valves.
- **Chapter 15:** Komatsu wheel loader; Claas Lexion C8x combine hydrostatic drives; and John Deere 8R, 744, and 824 X electronically variable transmissions (EVTs).
- **Chapter 18:** axle disconnects.
- **Chapter 21:** rubber and spring cab mount suspensions and new and revised suspension photos and schematics of various manufacturer machines.
- **Chapter 22:** front-mounted ballasting weights.

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- **Chapter 23:** Komatsu Parallel Link Undercarriage Systems (PLUS) and John Deere undercarriage designs. Updated rubber track drives.
- **Chapter 25:** four types of dual-path hydrostatic transmissions on swathers, non-load-sensing steering priority valves for open-center SCUs, and implement steering and implement guidance. Updated electronic steering features and motor graders combination steering systems.
- **Chapter 26:** high-voltage charging systems, high-voltage batteries, on-board AC chargers, off-board DC fast chargers, types of EVSEs, electric power generation, types and basic chemistry of HV batteries, HV battery health monitors, and Deere 850 X-Tier electric-drive dozers.

Credentialing Partners and Support

Goodheart-Willcox appreciates the value of industry credentials, certifications, and accreditation. We are pleased to partner with leading organizations to support students and programs in achieving credentials. Integrating industry-recognized credentialing into a career and technical education (CTE) program provides many benefits for the student and for the institution. By achieving third-party certificates, students gain confidence, have proof of a measurable level of knowledge and skills, and earn a valuable achievement to include in their résumés. For educators and administrators, industry-recognized credentials and accreditation validate learning, enhance the credibility of programs, and provide valuable data to measure student performance and help guide continuous program improvement.

The AED and ASE Education Foundation Connections

Goodheart-Willcox is pleased to partner with the Associated Equipment Distributors (AED) and ASE Education Foundation by correlating *Heavy Equipment Power Trains and Systems* to both the AED Standards for Construction Equipment and the ASE Education Foundation Medium/Heavy Duty Truck task list. These standards were created in concert with industry and subject matter experts to match real-world job skills and marketplace demands.

To see how *Heavy Equipment Power Trains and Systems* correlates to credentialing and certification standards, visit the Correlations tab at www.g-w.com/heavy-equipment-power-trains-systems-2028.

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Features of the Textbook

The instructional design of this textbook includes student-focused learning tools to help you succeed. This visual guide highlights these features.

Chapter Opening Materials

Each chapter opener contains a list of learning outcomes, a list of technical terms, and an introduction.

Learning Outcomes clearly identify the knowledge and skills to be gained when the chapter is completed. These outcomes are labeled and correlated to related assessment elements to facilitate reporting and remediation.

Technical Terms list the key words to be learned in the chapter.

The **Introduction** provides an overview and preview of the chapter content.

Additional Features

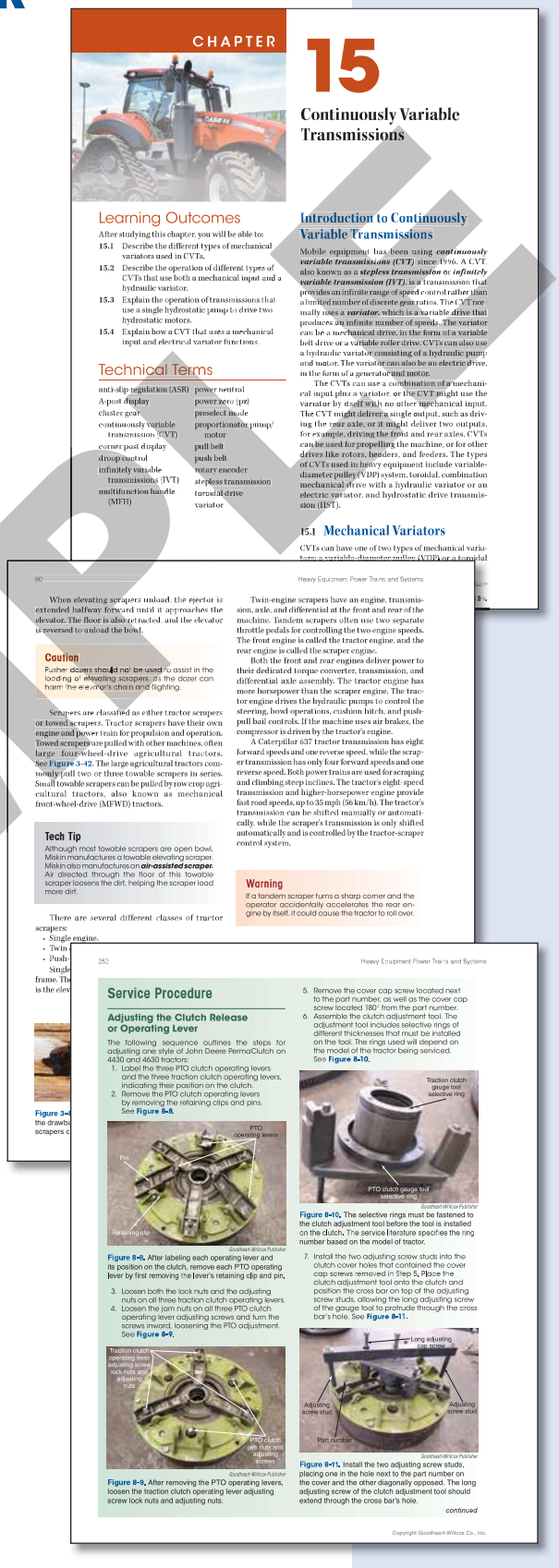
Additional features are used throughout the body of each chapter to further learning and knowledge.

Warnings alert you to potentially dangerous materials and practices.

Cautions alert you to practices that could potentially damage equipment or instruments.

Tech Tips help you develop critical thinking, diagnostic, and troubleshooting skills needed in the workplace today.

Service Procedures are provided throughout the textbook to provide clear instructions for hands-on service activities.



CHAPTER 15

Continuously Variable Transmissions

Learning Outcomes

Technical Terms

Introduction to Continuously Variable Transmissions

15.1 Mechanical Variators

Caution

Warning

Tech Tip

Service Procedure

Adjusting the Clutch Release or Operating Lever

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Illustrations

Illustrations have been designed to clearly and simply communicate the specific topic. Illustrations have been completely replaced and updated for this edition. Photographic images have been updated to show the latest equipment.

Expanding Your Learning

Case Studies present real-world diagnosis and service scenarios similar to those you can expect to encounter in the workplace. The questions associated with the Case Studies offer a deeper level of learning and engagement.

End-of-Chapter Content

End-of-chapter material provides an opportunity for review and application of concepts.

A concise **Summary** provides an additional review tool and reinforces key learning outcomes. This helps you focus on important concepts presented in the text.

Know and Understand questions enable you to demonstrate knowledge, identification, and comprehension of chapter material.

Apply and Analyze questions extend learning and develop your abilities to use learned material in new situations and to break down material into its component parts.

Critical Thinking questions develop higher-order thinking and problem-solving abilities.

AED- and ASE-Type Questions help you become familiar with and prepare for certification exams.

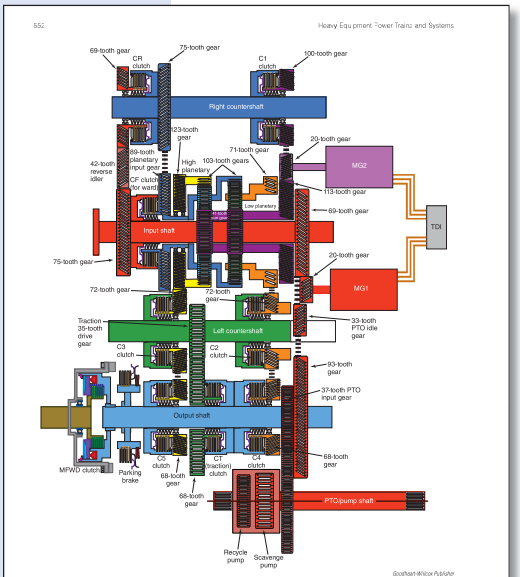
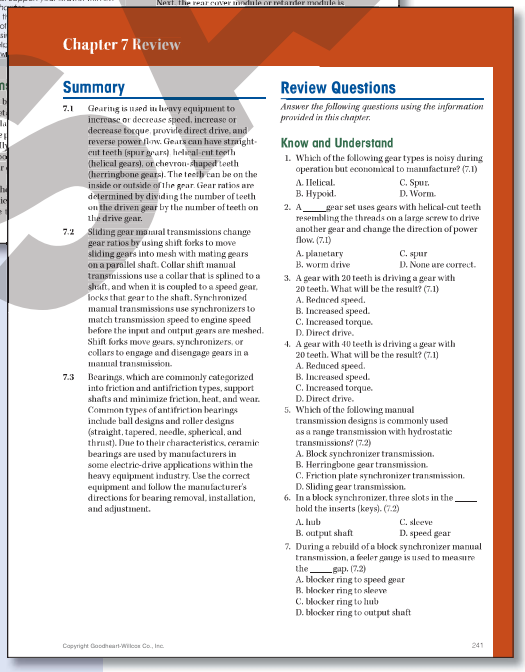
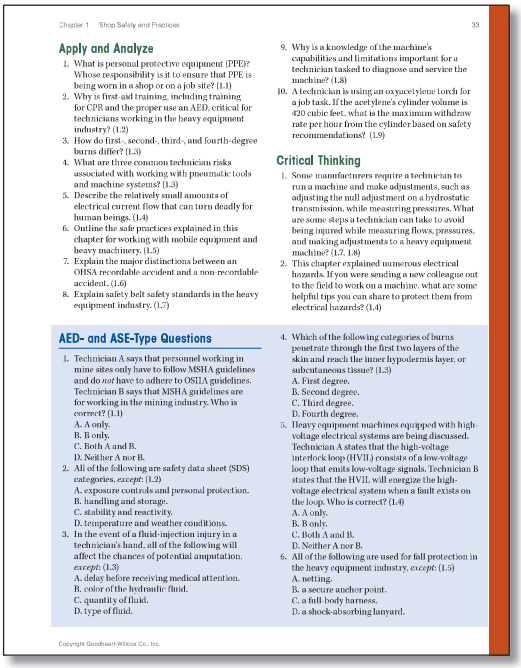


Figure 15-57. A simplified schematic of a John Deere 8R EVT. It contains a right and left countershaft, an input shaft, an output shaft, a PTO/pump shaft, and two motor generators.







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