



**JANUARY 2021  
TENTH EDITION**

# **STANDARDS FOR EQUIPMENT TECHNOLOGY**

**Skills standards  
for post-secondary  
schools preparing for  
careers as equipment technicians**



# Standards for Construction Equipment Technology

The AED Foundation, through its committed industry volunteers, is improving the quality of the equipment industry's workforce by publishing and maintaining the "Standards for Construction Equipment Technology." The goal is to help post-secondary institutions prepare students with the knowledge and skills they need to embark on successful careers as equipment service technicians. The contents are regularly reviewed and updated by The AED Foundation's Technical Training Committee in response to changes in technology and learning requirements.

Now in its **tenth edition**, this document is the result of voluntary efforts by technical experts in the construction equipment industry. The project is sponsored by The AED Foundation and includes the participation of leading construction equipment distributors, equipment manufacturers and post-secondary schools. The standards cover six areas that the industry considers most important for the education of entry-level technicians:

- Safety/Administrative
- Electrical/Electronics
- Hydraulics/Hydrostatics
- Power Trains
- Diesel Engines
- Air Conditioning/Heating

Established in 1991, The AED Foundation is the workforce development and educational affiliate of Associated Equipment Distributors (AED), an international association of the construction equipment industry representing over 700 independent distributor, manufacturer and related firms. AED was established in 1919. The National Center on Education and the Economy (NCEE), Washington, DC provided guidance for the development of the original standards.

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## Standards changes made in the:

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**2011 edition are in bold blue font**  
**2014 edition are in bold green font**  
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## About the AED Foundation Technical Standards Project

Educational institutions and the equipment industry must work together to develop a world-class technician workforce. Significant progress is being made in developing these relationships with the goal of identifying interested students and providing them with the technical education they will need when entering the workforce. In 2001, The AED Foundation introduced the AED Foundation Accreditation Program for post-secondary schools. Accreditation requirements are based on the technical standards contained in this book; schools must meet or exceed these specifications.

The AED Foundation believes that the construction equipment industry must do all it can to help post-secondary schools recruit and educate students for careers in equipment technology. Schools must also do their part by raising the standards of learning and seeking curriculum input from industry. Today's equipment service technicians are men and women with a high level of professional skills and knowledge. Such education is required to service

and repair construction equipment that is increasingly complex and sophisticated. Our industry faces a shortage of these highly skilled people. Occasional industry and economic downturns cannot hide the long-term need for well-educated technicians. This document is a key step toward addressing the problem. The standards are a valuable tool to ensure that students from technical schools have the skill sets that meet the industry-expressed needs of AED members.

At the end of this book is a list of present and past standards project participants. Our thanks to all these industry experts for their time and efforts, and their commitment to industry workforce excellence. Without equipment industry participation, this book would not exist. It is our hope that industry constituents will use these standards to help them meet their workforce needs in the future. Comments and ideas are always welcome.

Sincerely,

Paul Anderson  
Chairman, Technical Training Committee  
The AED Foundation  
Minneapolis, MN

# Purposes

1. To assist post-secondary schools, specifically colleges offering technical programs, in reviewing and updating courses in equipment technology based on what the construction equipment industry needs and expects from students entering the workforce.
2. To provide technical standards, endorsed by the construction equipment industry, that help educational institutions remove the guesswork in deciding what should be taught to students in equipment technology.
3. To create new relationships between schools and construction equipment industry businesses by developing the standards with broad industry representation and encouraging the use of the standards by all segments of the industry. This, in turn, leads to program improvements that advance the interests of all industry stakeholders.
4. To raise educational standards so that students will be better prepared for the more demanding entry-level jobs now available to equipment technicians.
5. To address the short and long-term shortage of technicians that affects the construction equipment and related industries.
6. To help the equipment industry to develop a world-class workforce.

# Background

**AED technical standards answer these important questions:**

- 1. What knowledge and skills do student equipment technicians need when they graduate?**
- 2. How do we know how well students can apply what they learn and perform well?**

Students need to have taken courses and received passing grades, but equally important is that they can demonstrate knowledge and mastery of the subjects.

The reader, whether from a school, dealer, manufacturer, or a related business, should keep in mind that these standards are rigorous and set the bar high. Several schools will meet or exceed the standards. For others, there may be difficulties as schools strive to upgrade their overall program and curriculum in accordance with the standards. However, our industry supports the standards as critical steps toward improvement; critical steps needed for the industry to move forward.

Presented here is a realistic picture painted by the equipment industry of what students need to succeed in the real world of construction equipment technology. The AED Foundation encourages educators to not only raise standards, but to work toward these standards with secondary schools as well. AED member businesses are also encouraged to use this document as a reference tool when they are discussing workforce development with local secondary and post-secondary schools.

Assistance to schools from construction equipment businesses can be offered in many ways; to name a few:

- Visit local secondary and post-secondary schools to promote career opportunities in our industry.
- Conduct local "informational events" for students, parents, school counselors, and other career influences.
- Be mentors for students in equipment technology; invite post-secondary teachers to industry companies for training.
- Provide internships, scholarships and or work/study programs for local students.
- Employ service technicians as part-time teachers of topics presented in this handbook.
- Provide part-time work or instructional programs in technology for school faculty members.
- Provide loans or donations of construction equipment, engines, parts, or testing devices to school classrooms and shops.
- Serve on school advisory committees or curriculum planning bodies.

## Benefits

### For Technical Schools & Colleges:

- Better understanding of the knowledge and skills students need to enter the field of equipment technology, based on high standards that are agreed upon by leading businesses in the construction equipment industry.
- Guidance for developing appropriate curriculum improvements, special programs, and teaching materials and equipment.
- Facilitation of school connections with local equipment distributor, manufacturer and related businesses familiar with the same set of published standards. This common reference point allows schools and businesses to have a good starting point from which to discuss needs and improvements.
- Detailed information for providing students with better career advice. Students can be shown: "Here is what the construction equipment industry expects you to know."
- Assistance in the marketing of school programs to students who are interested in equipment technology, and to parents who may be unaware of technical education options and this industry's attractive career opportunities.

# Benefits

## For Students and Parents:

- Understanding of what the construction equipment industry expects students to know and demonstrate to be well-qualified entry-level equipment technicians.
- Recognition of the need for high standards and high levels of knowledge and skills for a successful career in equipment technology.
- Awareness that the published AED Foundation standards are accepted by the industry as a whole and represent a progression of knowledge that will be recognized and respected by industry businesses.
- Awareness of various career path opportunities in the construction equipment industry including not only technician positions, but various levels of management positions as well. Opportunities include parts, service, rental, sales, product support, and senior management.
- Recognition that graduating from a school that meets AED Foundation standards leads to technical competency, a career path that enables equipment technicians to earn a good salary and benefits, and respect from employers and peers.
- Recognition of the value that dealer employers place on quality technical education and continued training, as well as the importance of hiring skilled equipment technicians and keeping them up to date with the latest technology innovations and techniques.

**Note: Invite students and parents to visit [www.aedfoundation.org/careers](http://www.aedfoundation.org/careers), a website with specific information about how to explore the dealer equipment technician career and its great opportunities.**

# Benefits

## For Equipment Industry Businesses:

- A larger pool of skilled equipment technicians from which to draw.
- Entry-level employees who have and can demonstrate high skill levels in the disciplines required of today's equipment technicians.
- The ability of new hires who graduate from schools meeting these standards to move up the learning curve faster, learn new technology faster, and be able to handle increasingly complex technical assignments; thereby contributing to service department profitability sooner.
- Greater return on educational investment and less need for additional entry-level and/or remedial education.
- Improved customer service resulting from highly qualified entry level people who offer a high level of performance.
- Up-front understanding of exactly what skills the new employee has, allowing easier identification of those additional or special skills needed for the equipment lines serviced by the company.
- Development of a more flexible workforce based on new people coming into the business who have mastered skills in safety/administrative, electronics/electrical, hydraulics/hydrostatics, power trains, diesel engines, and air conditioning/heating.

## Introduction to AED Foundation Standards:

- 1. Safety/Administrative**
- 2. Electronics/Electrical**
- 3. Hydraulics/Hydrostatics**
- 4. Power Trains**
- 5. Diesel Engines**
- 6. Air Conditioning/Heating**

**Note:** AED Foundation standards are updated as necessary to reflect changes in technology and educational requirements. Content needs for this publication are determined by The AED Foundation's Technical Training Committee. Users of this publication are encouraged to submit comments and suggestions to The AED Foundation.

**Post-secondary diesel/equipment technology programs that meet the standards prescribed in this publication can apply for Accreditation by The AED Foundation.**

**Contact The AED Foundation for more information on AED Foundation Accreditation and the application process.**

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# AED Foundation Accreditation – Additional Requirements

1. **Accredited programs must have a minimum of two onsite full-time instructors delivering the program's technical courses.**
2. **AED Foundation Technical Assessments are required for all graduating students in AED Foundation Accredited programs, to be given during the final 8 weeks of the program, to ensure that The AED Foundation can:**
  - a. Continually monitor student learning and program performance.
  - b. Obtain benchmark information that better reflects the collective results of all programs.

Exception: OEM diesel-technician programs that require usage of the OEM's test.
3. **Program faculty are required to facilitate a process for all graduating students to take a brief AED Foundation student survey that takes only minutes per student.**
  - a. It is expected that the program not just provide students with the URL but set aside a time for this to be done and bring students to the location where they can complete the survey.
  - b. Students have the right to decline to take the survey; that option is provided at the beginning of the survey.
4. **Equipment loans for teaching purposes**
  - a. For teaching purposes, use of unowned equipment is allowed if there is a written agreement whereby the equipment provider, via loan, lease or other agreement, and the school's diesel-equipment technology department commit to ensuring that the equipment will be available at the dates/times that the course/lab instruction requires.
  - b. The schools are to have owned equipment available that cover foundational subjects in diesel-equipment technology. AED Foundation Evaluation Team Leaders will advise programs on this individually due to the variety of options available that would meet this requirement.

# The Standards Contain Three Key Levels of Descriptors:

## *Three Key Standards Description Levels*

1. Critical Functions
2. Key Activities
3. Performance Descriptions

For each set of standards, there first are:

1

**CRITICAL FUNCTIONS** - Identify the major umbrellas of knowledge for specific bodies of skills. The critical functions are in the left columns for each set of standards.

2

**KEY ACTIVITIES** - Under each umbrella are the key activities that the learner must master to perform each of the critical functions. These are shown in the center columns of each set of standards.

3

**PERFORMANCE DESCRIPTIONS** - Knowing critical functions and learning key activities aren't enough. Educators and employers need to know when key activities are performed well by the learner. Specifically: Can the student demonstrate the activity competently? These important competencies are in the right columns of each set.

Standards details are presented in a manner that complements the post-secondary school AED Foundation Accreditation application form.

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**IMPORTANT: As you review these technical standards, please note that the delivery of technical core courses must be split among two or more full-time onsite instructors.**

# The Standards

## 1a. Safety

1a.1	<b>Identification and use of basic hand tools</b>	p. 14	1a.7	Use of fluid pressure testing equipment	p. 18
1a.2	Use of <b>all</b> electric <b>hand</b> tools	p. 16	1a.8	Environment of service facility	p. 19
1a.3	Use of air tools	p. 16	1a.9	Machine identification and operation	p. 19
1a.4	Use of hydraulic tools	p. 17	1a.10	Mandated regulations	p. 20
1a.5	Use of lifting equipment	p. 17	1a.11	Shop <b>and in-field</b> practices	p. 22
1a.6	Use of various cleaning equipment	p. 17	1a.12	Hazard identification and prevention	p. 22

## 1b. Administrative

1b.1	Comprehend basic academic functions	p. 24
1b.2	<b>Utilize industry software and electronic communications systems and reference resources</b>	p. 24
1b.3	<b>Awareness of dealership goals, objectives and policies</b>	p. 25
1b.4	Define basic business practices	p. 25
1b.5	<b>Describe functions of the dealership service department; explain department goals and procedures</b>	p. 26

## 1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<p>1a.1 Identification and use of basic hand tools</p>	<p>Identification, proper and safe use, <b>care and maintenance</b> of basic hand tools used by a technician.</p> <p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p> <ul style="list-style-type: none"> <li>• Use of and maintain/sharpen drills and punches</li> <li>• Use of and maintain/sharpen drills and punches</li> <li>• Use of taps, dies, thread chasers, thread identification and thread gauges</li> <li>• Use of cleaners, solvents, hot tanks, parts cleaners, glass bead machines including reading SDS sheets and understanding regulations governing solvents</li> <li>• Use of hydraulic and mechanical presses, pullers, and pushers.</li> <li>• <b>The proper use and care of all types of torque wrenches including proficiency performing the torque angle method, step method torque procedure and knowing the effects of extensions on torque wrenches.</b></li> </ul>	<p>Identify and correctly name the basic hand tools.</p> <p><b>Emphasis on safety will be demonstrated with all tool usage.</b></p> <p>Demonstrate the proper use, <b>care and maintenance of each tool, and safe operating procedure for each.</b></p> <p>Demonstrates <b>proper use, care and maintenance, and calibration of precision</b> hand tools.</p> <p>Review assignments, evaluation of identification exercises. Written exams that will determine the competency on many items unable to check by hands-on exercises. Emphasis on safety should be demonstrated with all tool usage.</p> <p><b>Test students' use of tools/equipment to check comprehension. Demonstrate all torque and de-torque methods with hands-on exercises.</b></p>

## 1a. Safety

Critical Functions	Key Activities	Performance Descriptions
1a.1 (cont'd.) Identification and use of basic hand tools	<ul style="list-style-type: none"><li>• Straight edges, feeler gauges, transfer gauges.</li><li>• Micrometers, dial indicators, calipers and bore gauges.</li><li>• Speed/RPM indicators, magnetic/optical tachometers and pulse generators.</li><li>• Pressure/flow gauges and meters, manometers, vacuum gauges.</li><li>• Temperature gauges, pyrometers, thermocouples, <b>and infrared thermometers.</b></li><li>• Hydrometers/refractrometers.</li><li>• Special tools - diagnostic tool groups.</li></ul> <p><b>TECHNICAL RESEARCH</b> - proper use of Tech Service Manuals /personal computers/laptops.</p>	<p>The student should be able to <b>demonstrate that they can accurately read</b> all precision measuring tools and gauges.</p> <p><b>Convert</b> standard to and from metric measurements, both pressure and distance.</p> <p><b>Determine</b> engine speed and pulses per revolution.</p> <p><b>Perform</b> tasks related to measuring, understanding, and recording pressure, flows and temperature.</p> <p><b>Perform</b> tasks related to measuring specific gravity of fuel, coolant, and electrolyte.</p>

## 1a. Safety

Critical Functions	Key Activities	Performance Descriptions
1a.2 Use of <b>all</b> electric <b>hand</b> tools	<p>Proper and safe use of basic electric hand tools used by a technician.</p> <p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p>	<p>Identify <b>and correctly name</b> the electrical tool.</p> <p>Demonstrate the proper use of the designed application and safe operating procedure for each.</p> <p>Demonstrate the proper inspection, care and storage for electric hand tools.</p> <p>Understand and exhibit the safe and proper use of ground fault circuits.</p>
1a.3 Use of air tools	<p>Proper and safe use of the air tools used by a technician.</p> <p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p>	<p>Identify <b>and correctly name</b> the basic air tool.</p> <p>Demonstrate the proper use of the designed application and safe operating procedure for each.</p> <p>Demonstrate the proper inspection, care, maintenance, and storage for air tools.</p>

## 1a. Safety

Critical Functions	Key Activities	Performance Descriptions
1a.4 Use of hydraulic tools	<p>Proper and safe use of hydraulic tools used by technician, <b>such as</b>:</p> <ol style="list-style-type: none"> <li>Porta powers and pullers</li> <li>Hydraulic presses</li> <li>Hydraulic pullers</li> <li>Hydraulic jacks</li> <li>Hydraulic torque wrenches</li> <li><b>Use by technician with correct guards</b></li> </ol> <p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p>	<p>Identify and correctly name the basic hydraulic tools.</p> <p>Demonstrate the proper inspection, care, maintenance, and storage <b>as applicable</b>.</p> <p>Demonstrate the proper use of the designed application and safe operating procedure <b>as applicable</b>.</p>
1a.5 Use of lifting equipment	<p>Proper and safe use of lifting equipment used in the shop or field location by a technician:</p> <ol style="list-style-type: none"> <li>Jack stands</li> <li>Hoists (overhead and floor type)</li> <li>Hydraulic jacks</li> <li>Blocking and cribbing</li> <li>Come-A-Long (chain and cable type)</li> <li><b>Lifting chains – lifting eyes, links, spreader bars, etc.</b></li> <li>Slings</li> <li>Securing chains</li> </ol> <p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p>	<p>Identify and correctly name the various types of lifting equipment.</p> <p>Demonstrate the proper inspection, care, maintenance, and storage for each.</p> <p><b>Demonstrate the proper use of the designed application and safe operating procedure for each.</b></p> <p><b>Students show understanding of current regulations and standards for use, inspection and certification of lifting equipment.</b></p>
1a.6 Use of various cleaning equipment	<p>Proper and safe use of the various types of cleaning equipment used to wash parts and components of machines.</p> <p><b>Wear proper PPE when working with cleaning solvents.</b></p> <p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p>	<p>Identify and correctly name the basic cleaning equipment used in our industry.</p> <p>Demonstrates the proper use of the designed application and safe operating procedures for each.</p> <p>Demonstrates the proper inspection, care, maintenance, and storage for cleaning equipment.</p>

	cal Functions	Key Activities Performance
1a.6 Use of various cleaning equipment (cont.)		<p>Identify the various solvents and solutions used in the cleaning process.</p> <p>Identify the risks, hazards, and precautions for cleaning materials, both personal and environmental.</p> <p>Demonstrate an understanding of Safety Data Sheets (SDS) and requirements to meet OSHA standards.</p>
1a.7 Use of <b>fluid pressure</b> testing equipment	<p>Proper and safe use of various types of <b>fluid pressure</b> test equipment and accessories:</p> <p>Bench testers and testing equipment, <b>such as:</b></p> <ol style="list-style-type: none"> <li>Gauges</li> <li>Transducers, <b>wired and wireless</b></li> <li>Flow rating equipment</li> <li>Hydraulic cylinder tests</li> <li>Hydraulic pump and motor</li> </ol> <p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p>	<p>Identify and correctly name the various types of <b>fluid pressure</b> test equipment and the accessories required for proper testing.</p> <p><b>Describe</b> the proper use of the designed application and safe operation of each type of equipment.</p> <p>Demonstrates <b>a proper source for calibration of precision test equipment and accessories.</b></p> <p>Identify, correctly name and demonstrate the use of the personal protective equipment required for the various types of <b>fluid pressure</b> testing equipment.</p> <p><b>Describe multiple dangers of working with fluids under pressure.</b></p>

Critical Functions	Key Activities	Performance Descriptions
<p><b>1a.8</b> Environment of service facility</p> <div data-bbox="111 289 625 613" style="border: 2px solid black; padding: 10px; margin: 10px 0;"> <p><b><u>IMPORTANT NOTE:</u></b>  <b>It is the responsibility of the educational institution to provide a classroom and lab facility that provides an acceptable, safe learning environment for students.</b></p> </div>	<p>Proper and safe use of ventilation and building exhaust systems.</p> <p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p> <p><b>Exhibits knowledge of a clean, contaminant free, hazard free shop as related to safety and contamination control.</b></p>	<p>Identify the various types of exhaust systems used in repair facility.</p> <p>Demonstrates the proper use of the designed application and safe operation of each type of system.</p> <p>Demonstrates the proper inspection, care, maintenance and storage of the systems and the equipment required for operation.</p> <p>Explain why carbon monoxide and diesel smoke can be hazardous to your health and the precautions required for eliminating injury or death.</p> <p><b>Recognize symptoms of exposure to carbon monoxide, diesel smoke and other hazardous materials.</b></p>
<p><b>1a.9</b> Machine identification and operation</p>	<p>Proper and safe operation of the machinery the technicians will be involved with. Examples:</p> <ol style="list-style-type: none"> <li>a. Excavators</li> <li>b. Skid steers</li> <li>c. Backhoes</li> <li>d. Compaction equipment</li> <li>e. Paving equipment</li> <li>f. Crawlers and track type loaders</li> <li>g. Scrapers</li> <li>h. Cranes</li> <li>i. Scissor lifts</li> <li>j. Forklifts and material handlers</li> <li>k. Wheel loaders</li> <li>l. Haul trucks</li> <li>m. Motor graders</li> <li>n. Trenchers</li> <li>o. Horizontal directional drills</li> </ol> <p><b>*** Hybrid drives ***</b></p>	<p>Identify the various types of construction equipment and forklifts, using the standard industry names accepted by equipment manufacturers.</p> <p>Demonstrates and can explain the proper, safe, and fundamental operation of the various types of machinery.</p> <p><b>Translate</b> from a user's perspective the importance of and reasons for caution/warning lights, backup alarms, seat belts, safety instructions, decals and other customer-related safety information.</p> <p><b>Recognize hybrid systems and/or machines as they relate to safety concerns.</b></p>

## 1a. Safety

<p><b>1a.9 Machine identification and operation (cont.)</b></p>	<p><b>Exhibits knowledge of personal protection equipment and hazardous materials –reference section 1a.10.</b></p>	
<p><b>1a.10 Mandated regulations</b></p>	<p>Various <b>federal and state</b> OSHA and <b>MSHA</b> regulations.</p> <p>a. Personal protection <b>equipment (PPE)</b>:</p> <ul style="list-style-type: none"><li>• Safety glasses and shoes</li><li>• Fire protection</li><li>• Ear protection</li><li>• Respirators</li><li>• Head protection</li><li>• <b>Loose clothing hazard</b></li><li>• <b>Proper gloves/hand protection</b></li><li>• Protective clothing</li></ul> <p>b. Hazardous material:</p> <ul style="list-style-type: none"><li>• Right-to-know</li></ul> <p>c. Proper handling of hazardous material</p> <p>d. Lock-out, Tag-out as it pertains to construction machinery</p> <p>e. <b>Proper use of wheel chocks</b></p> <p>f. Blood-borne pathogens</p> <p>g. Confined space regulations</p> <p>h. Forklift operation and certification</p> <p>i. Fire protection and suppression:</p> <ul style="list-style-type: none"><li>• Methods of fire protection</li><li>• Proper handling of various types of fires; electrical grease, etc.</li><li>• Use of fire extinguishers</li></ul> <p>j. Safety Data Sheets (SDS)</p> <p>k. <b>Machine guarding</b></p> <p>l. <b>Proper inspection of all electrical tools. Ex. Drills and grinders</b></p>	<p>Identify and correctly name the various types of equipment required for these regulations.</p> <p><b>Demonstrate</b> and explain the principles and procedures for each of the regulations.</p> <p>Demonstrates the operation, inspection, proper care and maintenance of the various equipment required for conforming with <b>federal and state OSHA and MSHA regulations.</b></p> <p>Identify the different types of fire extinguishers and know the applications and correct use of each type.</p> <p><b>Demonstrates how to find, explain and use an SDS for a product.</b></p>

## 1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<b>1a.10 Mandated regulations (cont.)</b>	<ul style="list-style-type: none"> <li>m. Handling of flammable liquids and materials.</li> <li>n. Handling of machinery with fluid leaks.</li> <li>o. Back-up alarm requirements for construction machinery.</li> <li>p. Rollover protective equipment for construction machinery (ROPS).</li> <li>q. Electrical ground fault protection.</li> <li>r. <b>Underground utility hazard – standard markings for each type.</b></li> <li>s. <b>Falling objects protection for construction machinery. (FOPS)</b></li> <li>t. Fall protection for workers.</li> <li>u. <b>Sub-surface, trench, excavation safety.</b></li> <li>v. Workman's compensation and accident prevention:               <ul style="list-style-type: none"> <li>1. Cost of accidents</li> <li>2. Lost time injury</li> <li>3. <b>Proper accident and injury reporting</b></li> </ul> </li> </ul>	<p><b>Recall and identify underground utility hazard marking that would commonly be encountered on a job site.</b></p> <p>Explain why working safely is important and explain the procedures for reporting unsafe working conditions and practices.</p>

## 1a. Safety

Critical Functions	Key Activities	Performance Descriptions
1a.11 Shop and in-field practices	<p>General safe work habits in the shop; general safe work habits when doing in-field repairs or at customer's facility.</p> <p>Proper lifting and pulling techniques.</p> <p><b>Proper shop/facility cleanliness and housekeeping practices.</b></p> <p><b>Performing safety risk assessments.</b></p>	<p><b>Identify</b> safe work practices in each situation. Demonstrate safe work practices in the shop or in the field.</p> <p><b>Identify</b> proper lifting and pulling techniques to avoid personal injury. Demonstrate proper lifting and pulling techniques.</p> <p><b>Demonstrate proper shop/facility cleanliness/appearance to dealer standards.</b></p> <p><b>Identify potential hazards and develop a plan to deal with them.</b></p>
1a.12 Hazard identification and prevention	<p>Proper mounting and dismounting of machinery.</p> <p><b>Load securement for transportation of components.</b></p> <p>General knowledge of safety practices.</p> <p><b>Hazard Communication (HazCom) Standard</b></p> <p><b>Implement a Toolbox Talk, or Safety Share Topic in daily startup.</b></p> <p><b>Proper use of jack stands, blocking, and cribbing while working under a machine.</b></p>	<p>Demonstrate safe mounting and dismounting practices on construction machinery. Explain proper types of chains and binders used in securing <b>loads</b>.</p> <p>Demonstrate proper lock out tag out procedures.</p> <p><b>Demonstrate understanding of the HazCom standard and how to use Safety Data Sheets and Chemical Labels.</b> Write about or discuss from personal or team experience (shop, workplaces, etc.,) common safety hazards and what you would have done to eliminate them.</p>

## 1a. Safety

Critical Functions	Key Activities	Performance Descriptions
	<p>Proper wheel assembly handling procedures.</p> <p>Proper tethering techniques.</p>	<p>Demonstrate proper work procedures in handling wheel assemblies safely. Refer to industry standard procedures.</p> <p>Identify when tethering is necessary and proper use of the fall protection equipment.</p>

**Note:** If service vehicles are used in training, basic safety instruction should extend to include the vehicle as well as devices such as cranes, compressors, generators, pumps, winches, etc. Local equipment dealers may be helpful in providing training for field service trucks and other

## 1b. Administrative

Critical Functions	Key Activities	Performance Descriptions
<b>1b.1 Comprehend</b> basic academic functions	<b>Read, write and comprehend written language, and math, science, and social studies at the minimum assessment level.</b>	<p>Exhibit the ability to use parts and service reference/technical materials, and safety materials in print or computer format.</p> <p>Exhibit the ability to follow written instructions.</p> <p>Exhibit the ability to complete forms, timecards, work orders, accident reports, sales leads, technical bulletins, parts requisitions, and other related written forms of communication.</p> <p>Exhibit the ability to perform basic math functions, including measurement in both U.S. and metric, calculations, conversions, and currency.</p> <p>Develop <b>and exhibit</b> good listening skills.</p>
<b>1b.2 Utilize industry software and electronic communications systems and reference resources</b>	<p>Demonstrate the use of communication technology options.</p> <p><b>Adequate keyboard skills.</b></p>	<p>Exhibit the ability to use a computer, and related hardware, current software, Internet, and technology currently in use.</p> <p><b>Exhibit the ability to use a computer or other electronic device and related hardware, current software, internet, and technology currently in use, including virtual meetings, cameras, and cell phones.</b></p> <p><b>Using a computer or other electronic device, demonstrate the ability to retrieve specifications, part numbers, bulletins, schematics, produce reports, and similar types of information using manufacturers' software and internet based resources.</b></p>

## 1b. Administrative

Critical Functions	Key Activities	Performance Descriptions
<p><b>1b.3 Awareness of dealership goals, objectives and policies</b></p> <p><i>Note: Sections 1b.3 – 1b.5 have been reorganized only; previous content remains; minimal new content is in bold blue.</i></p>	<p><b>Review and understand typical examples of potential dealership and college program</b> mission statements, <b>core values</b>, policies/procedures manuals, handbooks, and safety guidelines.</p>	<p>Exhibit the ability to work toward achieving established goals while in a diversified environment.</p> <p>Recognize organizational chart.</p> <p><b>Demonstrate understanding of how product support activities contribute to the overall profitability of the company.</b></p> <p>Identify expense control requirements.</p> <p><b>Maintain awareness of</b> sexual harassment policy, safety rules, environmental regulations, disciplinary action policy, and equal opportunity policy.</p> <p>Explain the need for performance reviews and the impact of different performance levels.</p> <p>Maintain confidentiality as required.</p>
<p><b>1b.4</b> Define basic business practices</p>	<p>Explain the importance of quality customer service and the role it plays with company profitability, as well as the effect it has on the wage and benefit package.</p>	<p>Explain the need for quality performance and the impact on customer satisfaction and profitability.</p> <p>Demonstrate a positive attitude towards the company and other contacts.</p> <p>Define impact of not meeting the customers' needs in a timely manner.</p> <p>Recognize customer retention policies and procedures.</p>

## 1b. Administrative

<p><b>1b.4</b> <i>Define basic business practices (cont.)</i></p>	<p><b>Demonstrate effective personal communications, organizational and learning skills</b></p> <p><b>Identify who are your customers, both internal and external customers.</b></p>	<p>Exhibit the ability to communicate to coworkers and customers in a courteous, professional manner.</p> <p>Demonstrate time management and organizational skills.</p> <p>Develop an awareness of stressful situations, and the ability to handle and resolve problems with difficult internal and external customers.</p> <p>Exhibit the ability to listen and follow verbal and written instructions.</p> <p>Respect authority and accept the responsibilities of the position.</p> <p><b>Demonstrate proper appearance to dealer standards.</b></p>
<p><b>1b.5</b> <b>Describe functions of the dealership service department; explain department goals and procedures</b></p>	<p>Describe how the <b>service</b> department fits into the corporate structure.</p> <p>Demonstrate the ability to write a service report.</p>	<p>Identify and establish both short and long-term goals and the requirements to achieve them (business and personal).</p> <p>Describe parts inventory control, procurement and accountability.</p> <p>Demonstrate knowledge of factors that can determine shop labor rates.</p> <p>Demonstrate the ability to accurately complete work orders/repair orders and other related reports, <b>including parts and consumables.</b></p> <p>Demonstrate the ability to write a thorough and comprehensive service report, <b>including warranty repairs.</b></p> <p>Describe tool procurement procedures.</p> <p><b>Describe time tracking.</b></p> <p>Demonstrate the ability to use correct industry terminology.</p>

# The Standards

## 2. Electronics/Electrical Systems

2.1	Fundamental knowledge	p. 28
2.2	Ohm's law	p. 29
2.3	12/24 volt <u>cranking</u> circuits	p. 29
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2.5	Lighting, accessory, <b>and control</b> systems	p. 31
2.6	Electrical schematics/diagrams	p. 32
2.7	SAE computer Can-Bus standards	p. 32
2.8	Diagnostics	p. 33

## 2. Electronics/Electrical Systems

### 2.1 Fundamental knowledge

a. Atomic structure.

**Define** the basic structure of conductors, insulators, and semi-conductors.

**Describe** the reaction of like and unlike charges.

b. Electron theory of electricity.

Describe the differences of conventional and electron theory current flow.

1. Testing conductors, semi-conductors, and insulators.

Demonstrate the principles of operation and the correct usage of the various types of meters to measure volts, amps, and ohms.

**Demonstrate ability to convert between kilo, milli, and micro units.**

2. Magnetism.

**Demonstrate knowledge** of the laws governing permanent magnets, electromagnets, and magnetic fields.

**Demonstrate knowledge** of the effects of magnetic forces on current carrying conductors.

3. Construction and operation of storage batteries.

**Describe** the basic parts and operation of the basic types of storage batteries.

**Describe the knowledge and laws of electromagnetic induction as it applies to generating electrical current using a magnetic field.**

c. **Telematics – remote monitoring.**

**Define remote monitoring systems and the ability to remotely diagnose electrical/electronic issues. Define what they are and what are their capabilities.**

## 2. Electronics/Electrical Systems

### 2.2 Ohm's law

- a. Ohm's law theory.
- b. Applications to series, parallel, and series/parallel DC circuits.

**Demonstrate the mathematical relationship** of the various terms in ohms law as they pertain to series, parallel, and series-parallel circuits.

Demonstrate the ability to set-up and measure voltage, amperage, and resistance values in series, parallel, and series/parallel DC circuits. **Ensure these circuits are tied to specific applications on vehicles, not just as classroom bench activities.**

### 2.3 12/24 Volt Cranking Circuits

- a. Components.
- b. Operation.
- c. Troubleshooting.
- d. Test and Replace if Required.

**Describe** the basic components that make up the various types of 12/24 volt cranking systems.

Demonstrate the sequence of operation of the components contained within a cranking system. The emphasis is on how each component effects the system's overall operation.

Demonstrate the ability to isolate problems **emphasizing voltage drops and other diagnostic methods.**

Demonstrate the ability to **correctly** test, **evaluate** and replace the following components using manufacturers' service publications and specifications.

1. Conductors
2. Relays/ Solenoids
3. Starters

## 2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
2.4 12/24 Volt <u>Charging Circuits</u>	<ul style="list-style-type: none"><li>a. Components.</li><li>b. Operation.</li><li>c. Troubleshooting.</li><li>d. Test and Replace if Required.</li></ul>	<p><b>Describe</b> the basic components that make up the various types of 12/24 volt charging systems.</p> <p>Demonstrate the sequence of operation of the components contained within a charging system. The emphasis is on how each component effects the system's overall operation.</p> <p><b>Demonstrate/emphasize</b> the ability to isolate problems using voltage drops and other diagnostic methods.</p> <p><b>Demonstrate understanding of 5V reference voltage and its effect on all sensors in the same circuit.</b></p> <p>Demonstrate the ability to properly test, <b>evaluate</b> and replace the following components using manufacturers' service publications and specifications.</p> <ul style="list-style-type: none"><li>1. Conductors</li><li>2. Alternators</li><li>3. Regulators</li></ul>

## 2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
2.5 Lighting, accessory and control systems	a. Components.	<b>Describe</b> the basic components that make up the various types of <b>lighting, accessory, and control</b> systems.
	b. Operation.	Demonstrate the sequence of operation of the components contained within various <b>lighting, accessory, and control</b> systems. <b>The emphasis is on how each component effects the system's overall operation.</b>
	c. Troubleshooting.	Demonstrate the ability to isolate problems within various <b>lighting, accessory and control</b> systems <b>emphasizing</b> voltage drops and other diagnostic methods.
	d. Test and Replace if Required	<p>Demonstrate the ability to <b>correctly</b> test, replace, or repair lighting, accessory and control system components using manufacturers' service publications and specifications. Examples of the components are as follows.</p> <ol style="list-style-type: none"> <li>1. Wiring harness/connectors</li> <li>2. Fuses/circuit breakers</li> <li>3. Lights/bulbs</li> <li>4. <b>Electrical components; switches, gauges, relays, etc.</b></li> </ol>

## 2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
2.6 Electrical schematics/diagrams	<ul style="list-style-type: none"> <li>a. How to read schematics/diagrams.</li> <li>b. How to use schematics/diagrams.</li> <li>c. <b>Review different styles of schematics used in the industry, including system function schematic vs theory schematics vs. wiring diagrams. Know where to find connector info, splices, and source of power (controller vs batt) and ground.</b></li> </ul>	<p>Demonstrate the ability to identify basic electrical/electronic symbols. <b>Ensure newer symbols like hall effect sensors are covered.</b></p> <p>Demonstrate the ability to trace various circuits using wiring schematics/diagrams.</p> <p>Demonstrate a <b>working</b> knowledge of diagnosing and troubleshooting electrical systems using schematics/diagrams.</p>
2.7 SAE computer Can-Bus standards	<ul style="list-style-type: none"> <li>a. <b>Explain</b> communication standards.</li> <li>b. <b>Explain</b> published error codes per SAE standards.</li> </ul>	<p><b>Demonstrate a working knowledge of the different systems used on computer-controlled machinery. Ex. LIN, CAN</b></p> <p><b>Understand the logic of wake-up and timed shut-down circuits.</b></p> <p><b>Understand the importance of twisted and shielded wire systems.</b></p> <p><b>Demonstrate a working knowledge of the codes to identify errors within the different systems. Demonstrate understanding of the logic and theory of how a processor generates a code. Inputs vs. Outputs.</b></p>

## 2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
<p><b>2.8 Telematics and Emerging Technologies</b></p>	<p>Telematics, Recognize and understand how basic systems communicate through telematics. Hybrid Systems, recognize hybrid and electric drive systems as they relate to safety concerns.</p>	<p>Define remote monitoring systems and their capabilities.</p> <p>Define the ability to remotely diagnose electrical/electronic issues.</p> <p>Understand and identify the dangers of working with high voltage and stored energy in hybrid systems.</p>
<p><b>2.9 Diagnostics</b></p> <p><b>Systems troubleshooting</b></p> <p><b>Note:</b> for "d." and "e." in key activities to the right, please cross-reference to Hydraulics/Hydrostatics Section 3.1 of this document: Theory and operation, understand hydraulic and hydrostatic theory. <b>Reference the requirement for access to an owned or unowned hydraulic/hydrostatic trainer in Section 3.6.</b></p> <p><b>Also cross-reference to Power Trains Section 4.1 of this document: Theory and Operation, Theory, and principles of hydrostatic transmissions.</b></p>	<p><b>Ask the proper questions before beginning to diagnose; capture the customer complaint.</b></p> <p>Follow technical manuals/service information to perform operational checks and troubleshooting procedures to properly diagnose an electrical malfunction in each of the following areas:</p> <ol style="list-style-type: none"> <li>Cranking systems</li> <li>Charging systems</li> <li>Lighting systems</li> <li>Electric and electronic controlled hydraulic systems</li> <li>Electric and electronic controlled hydrostatic systems</li> <li><b>Analog vs. digital sensors</b></li> </ol> <p><b>Given owned or unowned</b> pieces of training equipment, exhibit the ability to solve malfunctions in each of the listed systems that have been installed or established for troubleshooting practice using proper procedures.</p> <p><b>Technical write-up competency</b></p>	<p><b>Describe the complaint prior to beginning diagnostic tests.</b></p> <p><b>Demonstrate the ability to perform a diagnostic procedure with emphasis on arriving at the root cause of failure.</b></p> <p><b>Demonstrate</b> the ability to reason about a specific malfunction in the system.</p> <p><b>Demonstrate the use of proper tools, including flex probes and back probing.</b></p> <p><b>Demonstrate</b> mastering the use of all test equipment including digital volt ohm meter (D.V.O.M.), lap top computers, and other system specific troubleshooting devices.</p> <p><b>Demonstrate the ability to do voltage drop testing to determine available vs. potential voltage</b></p> <p>Demonstrate the ability to use schematic diagrams and follow troubleshooting flow charts in selected technical manuals.</p> <p><b>Utilize an interactive equipment diagnostic program.</b></p> <p><b>Demonstrate technical write-up competency</b></p>

## 2. Electronics/Electrical Systems

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### Critical Functions

### Key Activities

### Performance Descriptions

- Demonstrate logic and critical thinking in identifying, evaluating, and diagnosing customer complaint.
- Identify the root cause of failure
- Correction procedure

# The Standards

## 3. Hydraulics/Hydrostatics

3.1	Theory and operation, hydraulic and hydrostatic	p. 35
-	Understand hydraulic theory	p. 35
-	Understand hydrostatic theory	p. 36
-	Pump identification and operation	p. 36
-	Motor identification and operation	p. 38
-	Function and operation of hydraulic valves	p. 38
-	<b>Electro-hydraulics</b>	p. 39
-	Cylinder identification and operation	p. 39
-	Accumulator identification and operation	p. 40
3.2	Fluids, transfer components and filtering	p. 40
3.3	Maintenance procedures	p. 41
3.4	Component repair and replacement	p. 43
3.5	Hydraulic schematics	p. 44
3.6	Diagnostics	p. 44

### 3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p><b>3.1 Theory and operation, hydraulic and hydrostatic</b></p> <p>Understand hydraulic theory</p> <p><b>See also 3.6 Troubleshooting of load-sensing hydraulics.</b></p>	<p>Learn basic hydraulic principles.</p> <p>Understand a basic hydraulic system.</p> <p>Understand and differentiate between open and closed center systems.</p> <p>Understand a basic hydraulic system.</p> <p>Applications of hydraulic systems.</p>	<p>Demonstrate knowledge that fluids have no shape of their own, are practically incompressible, apply equal pressure in all directions, and provide great increases in work force.</p> <p><b>Describe</b> the function of a reservoir, pump, filters, relief valve, control valve, and cylinder in relation to each other.</p> <p><b>Describe how</b> open and closed center systems are determined by one or all of the following: a) the type of control valve, b) the type of pump, c) use of unloading valve, d) path of oil return to reservoir from pump.</p> <p>Describe a basic, but complete, open center hydraulic system, explaining the operation of the system, the route of fluid during the use of a function, and the route of the fluid while the machine is running when no hydraulic function is being used.</p> <p>Describe a basic, but complete, closed center <b>load sensing</b> hydraulic system, explaining the operation of the system, the route of fluid during the use of a function, and the route of the fluid while the machine is running when no hydraulic function is being used.</p> <p><b>Identify</b> applications, and the benefits of those applications on construction equipment.</p>

### 3. Hydraulics/Hydrostatics

#### 3.1 *Theory and operation, hydraulic and hydrostatic (cont.)*

Understand hydrostatic theory

**Note:** for this section, please cross-reference to Electronics/Electrical Systems Section 2.8, "d." and "e." of this document: **Diagnostics, Systems troubleshooting (hydrostatics)**.

**Also, cross-reference to Power Trains Section 4.1 of this document: Theory and Operation, Theory and principles of hydrostatic transmissions.**

Pump identification and operation

Learn the principles of hydrostatics.

Applications of hydrostatic systems.

**Understand the difference between fixed, variable, positive, and non-positive displacement pumps.**

Identify a gear pump, its parts, and know its operation.

Demonstrate knowledge of hydrostatic systems, including closed-loop and open-loop systems.

**Understand the various types of cooling circuits.**

Understand the purpose of a charge circuit **and how charge pressure relates to hydrostatic system efficiency.**

**Explain the differences between hydraulic and hydrostatic systems.**

**Demonstrate the ability** to identify applications, and the benefits of those applications on construction equipment.

Explain the different characteristics between **various types of** pumps, exhibit the ability to follow the oil flow through each pump both while using a hydraulic function and with no hydraulic function being used.

**Demonstrate the ability** to identify a gear pump, name all parts, follow the oil flow through a gear pump, identify inlet and outlet ports, and identify the direction of rotation of the pump.

### 3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<b>3.1 Theory and operation, hydraulic and hydrostatic (cont.)</b>	Identify a vane pump, its parts, and know its operation.	<b>Identify</b> a vane pump, name all parts of a vane pump, follow the oil flow through a vane pump, identify inlet and outlet ports of a vane pump, and identify the direction of rotation of the pump. Explain how a vane pump can be changed to operate in the opposite direction, when applicable.
	Identify a piston pump, its parts, and know its operation.	<b>Identify</b> various piston pumps, name all parts of a piston pump, follow the oil flow through a piston pump, identify inlet and outlet ports of a piston pump (both variable and fixed), and identify the direction of rotation of the pump.
	Identify types of swash plate control.	Identify types of swash plate control (manual, servo piston, electronic, etc.).
	<b>Understand the difference between fixed or variable displacement, and 2-speed motors.</b>	Explain the different characteristics between the <b>various</b> motors; exhibit the ability to follow the oil flow through each motor while using a hydraulic function.
	Identify a gear motor, its parts and know its operation.	<b>Identify</b> a gear motor, name all parts of a gear motor, follow the oil flow through a gear motor, identify inlet and outlet ports of a gear motor, and identify the direction of rotation of the motor.
	Identify a vane motor, its parts, and know its operation.	<b>Identify</b> a vane motor, name all parts of a vane motor, follow the oil flow through a vane motor, identify inlet and outlet ports of a vane motor, and identify the direction of rotation of the motor.

### 3. Hydraulics/Hydrostatics

#### 3.1 Theory and operation, hydraulic and hydrostatic; (cont.)

Motor identification and operation

Function and operation of hydraulic valves

Identify radial and axial piston motors, their parts, and know their operation.

Identify a gerotor motor, its parts, and know its operation.

Understand the three major types of hydraulic valves.

Understand the functions and uses of pressure control valves.

**Identify** radial and axial piston motors, name all parts of these piston motors, follow the oil flow through these piston motors, identify inlet and outlet ports of these piston motors (both variable and fixed), and identify the direction of rotation of the motors.

**Identify** a gerotor motor, name all parts, and understand its operation.

**Describe** the differences between these three major valve types:

- a.) Pressure control valves
- b.) Directional control valves
- c.) **Flow** control valves

Exhibit knowledge of the uses and functions of the following valves:

- a.) Direct acting relief valves
- b.) Pilot operated relief valves
- c.) Cartridge relief valves
- d.) Pilot operated valves
- e.) Sequence valves
- f.) Unloading valves
- g.) Multi-function valves
- h.) Counterbalance valves
- i.) **Pressure reducing valves**
- j.) **Pressure limiting valves**
- k.) **Pressure differential valves**
- l.) **Crossover relief valves**

### 3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p><b>3.1</b> <i>Theory and operation, hydraulic and hydrostatic; Function and operation of hydraulic valves (cont.)</i></p> <p><b>Electro-hydraulics</b></p>	<p>Understand the functions and uses of directional control valves.</p> <p><b>Electro-hydraulic valves</b>  <b>Electro-hydraulic control systems</b>  <b>Pulse width modulation (PWM)</b></p> <p>Understand the functions and uses of volume control valves.</p>	<p>Exhibit knowledge of the uses and functions of the following valves:</p> <ul style="list-style-type: none"> <li>a.) Check valves</li> <li>b.) Rotary valves</li> <li>c.) Spool valves</li> <li>d.) Pilot controlled poppet valves</li> <li>e.) Electro-hydraulic valves</li> <li><b>f.) Electro-hydraulic control systems</b></li> <li><b>g.) Pulse width modulated valves</b></li> </ul> <p>Exhibit knowledge of the uses and functions of the following valves:</p> <ul style="list-style-type: none"> <li>a.) Flow control valves <ul style="list-style-type: none"> <li>1. Compensated</li> <li>2. Non-compensated</li> </ul> </li> <li>b.) Flow divider valves <ul style="list-style-type: none"> <li>1. Priority</li> <li>2. Non-priority</li> <li>3. Proportional</li> </ul> </li> </ul>
<p>Cylinder identification and operation</p>	<p><b>Understand the difference between single acting and dual acting cylinders.</b></p> <p>Identify a single acting cylinder, its parts and know its operation.</p>	<p>Explain the uses and movements of the two types of cylinders.</p> <p><b>Identify</b> a single acting cylinder; name all of its parts, and follow the oil flow through the cylinder.</p> <p><b>Demonstrate understanding of the operation of a cushioned cylinder.</b></p>

### 3. Hydraulics/Hydrostatics

<p><b>3.1</b> <i>Theory and operation, hydraulic and hydrostatic. Cylinder identification and operation (cont.)</i></p> <p>Accumulator identification and operation</p>	<p>Identify a double acting cylinder, its parts and know its operation.</p> <p>Understand the uses of accumulators.</p> <p>Identify types of accumulators.</p> <p>Understand accumulator safety.</p>	<p><b>Identify</b> a double acting cylinder, name all of its parts, and follow the oil flow through the cylinder. <b>(deleted in sentence i.e. vane type cylinder – rotary actuator)</b></p> <p>Explain how accumulators store energy, absorb shocks, build pressure, and maintain a constant pressure within a system.</p> <p>Explain where and why gas, pneumatic, spring loaded, and weighted accumulators are used.</p> <p>Explain and <b>demonstrate</b> all accumulator safety practices.</p>
<p><b>3.2</b> Fluids, transfer components and filtering</p>	<p>Know the construction of hoses and understand the wide variety of fittings used in hydraulic systems, and the effects of these on noise and vibration.</p>	<p>Exhibit the ability to select the proper hose for a given function, taking into consideration the flow needed, pressures to be used, routing, clamping, fittings required and pulsating of lines.</p> <p>Exhibit knowledge of the understanding of hydraulic fittings, the importance of selecting the proper fitting, and their relationship to noise and vibration.</p> <p>Demonstrate the ability to identify various fittings and thread styles, examples: o-ring boss, NPT, NPTF, British Metric, o-ring flange, ORFS, etc. Proper procedure to torque fittings and flanges.</p> <p>Demonstrate the ability to crimp hydraulic fittings onto hose.</p>

### 3. Hydraulics/Hydrostatics

#### 3.2 Fluids, transfer components and filtering (cont.)

Know the construction and function of filters used in hydraulic/hydrostatic systems

Hydraulic filters:

1. Pressure, return line & suction filters
2. Filter efficiency
3. Beta ratings/ISO cleanliness codes
4. **Auxiliary by-pass filtration**

Describe the use of various filters in hydraulic and hydrostatic systems.

**Demonstrate an understanding of the concept of auxiliary by-pass filtration and its benefits to total system cleanliness.**

#### 3.3 Maintenance procedures

Understand the importance of maintenance

Know and practice safety.

Understand the importance of cleanliness.

Flushing systems.

Demonstrate familiarity with, and practice good hydraulic maintenance/safety practices.

Perform all hydraulic functions and repairs in a clean atmosphere.

Exhibit the ability to follow the proper flushing procedure using the correct technical manual/service information.

Preventing leaks.

Exhibit the proper maintenance techniques to prevent internal and external leaks.

**Demonstrate the procedure for cleaning hoses after cutting and crimping.**

Prevent overheating.

Demonstrate knowledge of overheating conditions. Prevent overheating by keeping the oil at the proper levels, cleaning dirt and mud from around lines and cylinder rods, keep relief valves adjusted properly, do not overload or overspeed systems, and do not hold control valves in a **stalled** position longer than necessary.

Identify defective or worn hoses.

**Identify and** recognize the root causes of "blistering" or frayed hoses and procedures to avoid these problems.

### 3. Hydraulics/Hydrostatics

#### 3.3 Maintenance procedures (cont.)

Know the characteristics of oils

#### Fluid Cleanliness

Understand the usage and types of seals and gasket materials

Hydraulic oils:

1. Viscosity-effects of temperature on viscosity
2. Types: mineral, synthetic, water/oil emulsions, **bio-oil**, etc.
3. Characteristics of: VI improvers, anti-foaming, etc.
4. Recommended viscosity for hydraulic components
5. **Explain the flash point of oil**

**ISO cleanliness codes**  
**Interpreting fluid analysis reports**

**Demonstrate the ability to identify aeration in a hydraulic system**

Know the variety of materials and types of seals/gaskets used in a hydraulic system

Understand oils and show familiarity with various fluids and their effects on hydraulic systems.

**Understand the effects of mixing oil types.**

**Understand ISO cleanliness code principles. Identify key elemental categories.**

**Understand the proper way to obtain fluid samples from a system.**

**Identify key elements found in oil analysis and the types of failures related to each.**

**Identify key indicators on a fluid analysis report that illustrate:**

1. The proper fluid type is being used.
2. Fluid types have not been mixed.
3. Indicators of fluid degradation.
4. Trend analysis.

**Demonstrate the ability to identify aeration and determine the root cause.**

**Describe** how reactions of some sealant materials differ among types of hydraulic fluids.

Describe the applications of various types of sealants.

**Demonstrate that** safety practices are followed.

### 3. Hydraulics/Hydrostatics

<p>3.4 Component <b>repair</b> and Replacement</p> <p>Component <b>repair</b></p>	<p>Understand the procedure to properly <b>repair</b> hydraulic components.</p> <p>Be sure safety practices are followed.</p>	<p>Following the proper technical manual/service information, exhibit the ability to remove, disassemble, diagnose failure, <b>evaluate, repair or replace/reinstall</b>, and test operate any given component including but not limited to:</p> <ul style="list-style-type: none"><li>• Gear, vane, and piston pumps</li><li>• Gear, vane, and piston motors</li><li>• Pressure control valves</li><li>• Directional control valves</li><li>• <b>Flow</b> control valves</li><li>• Single acting, double acting cylinders</li></ul> <p>(If OEM recommends or allows: gas, pneumatic, spring, and weight loaded accumulators.</p>
<p>Component replacement</p>	<p>Understand the procedures to properly remove and replace hydraulic components.</p> <p>Ensure safety practices are followed.</p>	<p>Following the proper technical manual/service information, exhibit the ability to remove and replace any given component including but not limited to:</p> <ul style="list-style-type: none"><li>• Gear, vane, and piston pumps</li><li>• Gear, vane, and piston motors</li><li>• Pressure control valves</li><li>• Directional control valves</li><li>• <b>Flow</b> control valves</li><li>• Single acting, double acting cylinders</li><li>• Gas, pneumatic, spring, and weight loaded accumulators</li><li>• Hoses, steel lines, and fittings</li><li>• Oil coolers</li><li>• Reservoirs</li></ul> <p><b>Describe proper system flushing/cleanup procedures to achieve ISO cleanliness code.</b></p> <p><b>Follow proper bleeding and priming procedures.</b></p>

### 3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p><b>3.5</b> Hydraulic schematics</p>	<p>Identify JIC, ANSI and ISO hydraulic symbols in relation to the component they represent.</p> <p>Identify the position of any given component by reading a schematic.</p> <p>Follow flow of fluid through a hydraulic system with the use of a schematic.</p>	<p>Exhibit knowledge of symbol identification through demonstration.</p> <p>Given a selected schematic, exhibit your knowledge of schematics by using JIC, ISO and various symbols to identify locations of various components.</p>
<p><b>3.6</b> Diagnostics</p> <p>Systems and component troubleshooting</p> <p><b>Note:</b> for this section, please cross-reference to Electronics/Electrical Systems Section 2.8, "d." and "e." of this document: Diagnostics, Systems troubleshooting (hydrostatics).</p> <p>Also, cross-reference to Power Trains Section 4.1 of this document: Theory and Operation, Theory and principles of hydrostatic transmissions.</p>	<p>Follow technical manuals/service information to perform operational checks and troubleshooting procedures to properly diagnose a hydraulic/hydrostatic malfunction.</p> <p><b>The school must have access to at least one engine-driven simulator or machine that meets the following requirements:</b></p> <ol style="list-style-type: none"> <li><b>Must be electronically controlled via EDC- Electronic Displacement Control systems.</b></li> <li><b>Must be easily accessible, both visually and mechanically.</b></li> <li><b>Must allow for faculty/students to effectively perform operational checks, test procedures and diagnostics using appropriate manuals and procedures.</b></li> <li><b>Schools must have an assortment of failed/faulty components (wiring, sensors, bugs, etc.) that can be removed or replaced for testing, diagnostics or demonstrations.</b></li> </ol> <p><u>Incorporate Trainer into Curriculum</u></p> <p>Technical write-up competency</p>	<p>Exhibit the ability to reason with regard to a specific malfunction.</p> <p><b>Use proper oils and fluids as per manufacturer specifications.</b></p> <p>Exhibit <b>proficiency in</b> the use of all test equipment including flow meters, pressure gauges, vacuum gauges, and temperature measuring devices, in both the metric and standard scales.</p> <p>Demonstrate the ability to use schematic diagrams and follow a troubleshooting flow chart using a selected technical manual.</p> <p>Demonstrate the ability to follow an operational check procedure using a selected technical manual.</p> <p><b>Troubleshooting of load-sensing hydraulics.</b></p> <p><b>Demonstrate technical write-up competency</b></p> <ul style="list-style-type: none"> <li><b>Demonstrate logic and critical thinking in identifying, evaluating and diagnosing customer complaint.</b></li> <li><b>Identify the root cause of failure</b></li> <li><b>Correction procedure</b></li> <li><b>Machine inspection</b></li> </ul>

# The Standards

## 4. Power Trains

4.1	Theory and operation	p. 46
4.2	Driveshaft function and construction	p. 53
4.3	Fundamental theory of hydraulic and pneumatic braking systems	p. 54
4.4	Understanding maintenance practices in power trains	p. 55
4.5	Power train schematics <b>and flow diagrams</b>	p. 56
4.6	Troubleshooting and failure analysis	p. 56

## 4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p><b>4.1 Theory and operation</b></p> <p>Basic principles of power train</p>	<p>Learn theory of power train:</p> <ol style="list-style-type: none"> <li>1. Clutches</li> <li>2. Manual transmissions</li> <li>3. Power shift transmissions</li> <li>4. Hydrostatic drives</li> <li>5. Hybrid and electric drive systems</li> <li>6. Differential steering</li> <li>7. Torque converters</li> <li>8. Differentials</li> <li>9. Dry brakes</li> <li>10. Wet brakes</li> <li>11. Final drives</li> <li>12. Powertrain/hydraulic oil coolers</li> </ol> <p>Learn principles of the following:</p> <p>Types of gears:</p> <ol style="list-style-type: none"> <li>1. Straight cut spur</li> <li>2. Helical</li> <li>3. Herringbone</li> <li>4. Bevel</li> <li>5. Spiral bevel</li> <li>6. Hypoid</li> <li>7. Planetary               <ol style="list-style-type: none"> <li>a. Basic operation                   <ul style="list-style-type: none"> <li>• Sun drive</li> <li>• Carrier drive</li> <li>• Compound gear</li> </ul> </li> <li>b. Ratios</li> </ol> </li> </ol>	<p>Demonstrate knowledge of basic power train components and how those components, as a whole, relate to one another. Demonstrate by following a power flow chart from flywheel to ground.</p> <p><b>Recognize hybrid and electric drive systems and/or machines as they relate to safety concerns.</b></p> <p><b>Demonstrate understanding of theory of hybrid and electric drive component technology.</b></p> <p>Demonstrate knowledge by identifying the various types of gears using a matching test.</p> <p>Explain the benefit of one type of gear versus other types of gears using factors such as cost, strength, quietness, bulkiness, and capability of ratios.</p>

## 4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<b>4.1 Theory and operation; Basic principles of power train (cont.)</b>	<ul style="list-style-type: none"> <li>8. Worm</li> <li>9. Ring and pinion</li> </ul> <p>Anti-friction bearings and plain bearings:</p> <ul style="list-style-type: none"> <li>1. Ball</li> <li>2. Roller</li> <li>3. Needle</li> </ul> <p>Torque converter:</p> <ul style="list-style-type: none"> <li>1. Components:               <ul style="list-style-type: none"> <li>a. Impeller</li> <li>b. Turbine</li> <li>c. Stator</li> </ul> </li> <li>2. Operation:               <ul style="list-style-type: none"> <li>a. Vortex flow</li> <li>b. Stall</li> <li>c. Torque multiplication</li> <li>d. Lock-up clutches</li> <li>e. Rotary flow</li> <li>f. Cooler flow</li> </ul> </li> <li>3. Testing and troubleshooting:               <ul style="list-style-type: none"> <li>a. Converter in pressures</li> <li>b. Converter out pressures</li> <li>c. <b>Lock-up clutch pressures</b></li> </ul> </li> </ul>	<p>Identify types of bearings through matching tests.</p> <p><b>Demonstrate understanding of various types of bearings and proper adjustment procedures.</b></p> <p>Identify components of a torque converter and describe the relationship of those components to one another.</p> <p>Describe the operation of a given torque converter and various stages of operation.</p> <p>Use OEM manuals/service information to test a torque converter unit and determine if operation is within specifications.</p>

## 4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<b>4.1 Theory and operation (cont.)</b>  Theory and principles of manual transmissions	<ol style="list-style-type: none"><li>1. General principles:<ol style="list-style-type: none"><li>a. Sliding gear:<ol style="list-style-type: none"><li>1. Components</li><li>2. Operation</li><li>3. Powerflow</li></ol></li><li>b. Collar shift:<ol style="list-style-type: none"><li>1. Components</li><li>2. Operation</li><li>3. Powerflow</li></ol></li><li>c. Syncromesh:<ol style="list-style-type: none"><li>1. Components</li><li>2. Operation</li><li>3. Powerflow</li></ol></li></ol></li><li>2. Manual shifting controls:<ol style="list-style-type: none"><li>a. Forks</li><li>b. Rails</li><li>c. Cams</li></ol></li><li>3. Adjustments:<ol style="list-style-type: none"><li>a. Endplay, preload, backlash</li><li>b. Fork adjustments</li><li>c. Rail adjustments</li><li>d. Cam adjustments</li></ol></li></ol>	<p>Exhibit your understanding of "sliding gear" transmissions by identifying components, explaining operation, and demonstrating power flow through all gear sets.</p> <p>Same as above substituting "collar shift."</p> <p>Same as above substituting "syncromesh."</p> <p>Identify shifting control components and explain their operation.</p> <p><b>Demonstrate ability to perform adjustments to transmissions as instructed in the OEM service manual/information.</b></p>

#### **4.1 Theory and operation (cont.)**

Theory and principles of powershift transmissions

Theory and principles of clutches

**The college program must own at least two off-highway powershift transmissions for student disassembly and assembly.**

1. General principles:
  - a. Review multiple discs
  - b. Review planetary gearing
  - c. Identify planetary and countershaft transmissions.**
  - d. Multiple clutch operation:
    - Clutch engagement chart
    - Power flow through transmission
    - Control of clutch engagement
  - e. Accumulator operations
  - f. Rate of shift controls
  - g. Clutch pressures:
    - On-coming clutch
    - Off-going clutch
    - Pressure gauge testing
  - h. Hydraulic valving
  - i. Oil flow to clutches:
    - Hydraulic reverses
    - Counter shaft (constant mesh)
    - Planetary transmissions
    - Troubleshooting methods
    - Preload, endplay, and backlash

Demonstrate your understanding of the operation of powershift transmissions by explaining which clutches and/or brakes are engaged, and which planetary gear sets are being used during a specific gear selection.

**Explain the differences, advantages and disadvantages of planetary and countershaft transmissions.**

**Use service information to test and/or troubleshoot a powershift transmission and verify it is or is not within OEM specifications.**

**Demonstrate ability to set and measure preload, endplay and backlash for a specific component using OEM manuals/service information.**

## 4. Power Trains

Critical Functions	Key Activities	
<p><b>4.1 Theory and operation (cont.)</b></p> <p>Theory and principles of clutches</p>	<p>Clutch identification and operation:</p> <ol style="list-style-type: none"> <li>1. Disk and plate:               <ol style="list-style-type: none"> <li>a. Disc:                   <ul style="list-style-type: none"> <li>• Solid</li> <li>• Button</li> </ul> </li> <li>b. Pressure plate:                   <ul style="list-style-type: none"> <li>• Springs</li> <li>• Plate</li> <li>• Release levers</li> </ul> </li> <li>c. Operation</li> </ol> </li> <li>2. Multiple disc clutches:               <ol style="list-style-type: none"> <li>a. Components</li> <li>b. Relationship of number of discs to application</li> <li>c. Effect of pressure on torque</li> <li>d. Wet and dry clutches</li> <li>e. Clutch/plate material</li> <li>f. Wear patterns</li> </ol> </li> <li>3. Overrunning clutches:               <ol style="list-style-type: none"> <li>a. Types:                   <ul style="list-style-type: none"> <li>• Roller</li> <li>• Cam</li> <li>• Sprag</li> </ul> </li> <li>b. Operation</li> <li>c. Application</li> </ol> </li> <li>4. Magnetic clutches:               <ol style="list-style-type: none"> <li>a. Operation</li> <li>b. Application</li> </ol> </li> </ol> <p><b>5. Modulating clutch</b></p>	<p>Identify all components in a single and multiple disc and plate-type clutch, including flywheel, pilot and release bearings, disc and pressure plate parts, and power train input shaft. Also, explain differences and benefits of solid and button-type clutches.</p> <p>Explain operation of a selected clutch.</p> <p>Demonstrate knowledge and operation of single and multiple-disc clutches by explaining the relationship of the clutch components to each other and their roles in the transfer of power.</p> <p>Describe the relationship of the number of discs, types of discs (wet or dry), and type of clutch material to the transfer of torque and horsepower to the ground.</p> <p>Demonstrate understanding of overrunning clutches by identifying the different types of clutches, their operation and various applications.</p> <p>Explain the operation of magnetic clutches and name various applications.</p> <p><b>Explain operation and applications.</b></p>

## 4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p><b>4.1 Theory and operation (cont.)</b></p> <p>Theory and principles of electronic controlled transmissions</p>	<ol style="list-style-type: none"><li>1. Basic principles:<ol style="list-style-type: none"><li>a. Electronically-controlled hydraulic valves:<ul style="list-style-type: none"><li>• <math>F = P \times A</math></li><li>• Pressure drop through an orifice</li><li>• Fundamentals of spring operation</li><li>• Fundamentals of solenoid operation</li></ul></li></ol></li><li>2. Electronic over hydraulic systems.</li><li>3. <b>Diagnosis and Troubleshooting:</b><ol style="list-style-type: none"><li>a. With diagnostic unit</li><li>b. Without diagnostic unit</li><li>c. Component isolation procedures</li><li>d. <b>Clutch modulation pressures</b></li><li>e. <b>Lubrication pressure</b></li><li>f. <b>Pump pressure</b></li></ol></li></ol>	<p>Exhibit knowledge of electronic control systems by identifying components used on a specific unit.</p> <p><b>Demonstrate understanding of a specific unit's operation by explaining the functions of all components and their relationships to one another.</b></p> <p><b>Demonstrate ability to follow flow and troubleshooting charts to correctly identify the operation of a specific unit's system and troubleshooting methods used by the OEM.</b></p>

## 4.. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p><b>4.1 Theory and operation (cont.)</b></p> <p>Theory and principles of hydrostatic transmissions</p> <p><b>Note: for this section, please cross-reference to Electronics/Electrical Systems Section 2.8, "d." and "e." of this document: Diagnostics, Systems troubleshooting (hydrostatics).</b></p> <p><b>Also, cross-reference to Hydraulics/Hydrostatics Section 3.1 of this document: Theory and operation, understand hydraulic and hydrostatic theory. Reference the requirement to have a hydraulic/hydrostatic trainer available in Section 3.6.</b></p>	<ol style="list-style-type: none"><li>1. Basic principles:<ol style="list-style-type: none"><li>a. Displacement/flow relationships</li><li>b. Types:<ul style="list-style-type: none"><li>• Gear</li><li>• Axial piston swash plate</li><li>• Cam lobe</li></ul></li><li>c. Open loop hydrostatics</li><li>d. Closed loop hydrostatics:<ul style="list-style-type: none"><li>• Fixed-fixed combinations</li><li>• Variable-fixed combinations</li><li>• Fixed-variable combinations</li><li>• Variable-variable combinations</li><li>• <b>Charge/cooling circuit</b></li><li>• Lubrication circuit</li></ul></li><li>e. Pump</li><li>f. Motor</li><li>g. Forward</li><li>h. Neutral</li><li>i. Reverse</li><li>j. <b>Cooling circuit</b></li></ol></li><li>2. Hydrostatic control systems:<ol style="list-style-type: none"><li>a. Manual feedback control</li><li>b. Electronically controlled</li><li>c. Braking system:<ul style="list-style-type: none"><li>• Fail safe</li><li>• Manual systems</li></ul></li></ol></li></ol>	<p>Demonstrate understanding of theory and principals of hydrostatic systems by explaining, in writing, how a basic hydrostatic system function.</p> <p>Exhibit knowledge of hydrostatic transmission operation by explaining the flow of fluids through the charge circuit, pump, motor, control, and loop circuits.</p> <p>Explain the differences between fixed and variable pumps and motors, and the effects of their various combinations.</p> <p><b>Explain various adjustment procedures for straight travel.</b></p>

## 4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
4.2 Driveshaft function and construction	<ol style="list-style-type: none"> <li>Connections: <ol style="list-style-type: none"> <li>U Joint / Hooke joint</li> <li>Constant velocity joint</li> </ol> </li> <li>Effects of angle of shaft</li> <li>Multiple joint timing</li> <li>Mid-ship supports</li> <li>Repairs</li> <li>Failure analysis</li> </ol>	<p>Demonstrate knowledge of driveshafts by recognizing components, realizing the effects of driveline angle, and studying why driveline failures occur.</p>
Theory and principles of differentials	<ol style="list-style-type: none"> <li>Basic operation and components: <ol style="list-style-type: none"> <li>Pinion gear</li> <li>Ring gear</li> <li>Bevel gear</li> </ol> </li> <li>Differential locking methods: <ol style="list-style-type: none"> <li>Mechanical</li> <li>Hydraulic</li> <li>Automatic no-spin</li> </ol> </li> <li>Adjustments: <ol style="list-style-type: none"> <li>Preload</li> <li>Backlash</li> <li>Gear tooth pattern</li> </ol> </li> </ol>	<p>Exhibit understanding of basic differential operation by identifying the components and explaining how pinion, ring and bevel gears operate in relationship to each other.</p> <p>Identify each type of differential locking device and explain in detail how each one operates.</p> <p>Given a specific <b>component and proper manuals/information</b>, perform all adjustments on a differential with a new ring and pinion, and also perform all adjustments with original ring and pinion but with new bearings.</p> <p>Identify the most common <b>root</b> causes of failure with differentials.</p>

<p><b>4.2 Driveshaft function and construction (cont.)</b></p> <p>Theory and principles of final drives</p>	<ol style="list-style-type: none"> <li>1. Types: <ol style="list-style-type: none"> <li>a. Rigid axle: <ul style="list-style-type: none"> <li>• Full-floating</li> <li>• Semi-floating</li> </ul> </li> <li>b. Flexible axle shaft</li> <li>c. Pinion drives: <ul style="list-style-type: none"> <li>• Pinion/bull gear</li> <li>• Inboard planetary</li> <li>• Outboard planetary</li> <li>• <b>Double reduction planetary</b></li> </ul> </li> </ol> </li> <li>2. Front wheel drives: <ol style="list-style-type: none"> <li>a. Mechanical</li> <li>b. Hydrostatic</li> <li>c. Speed lock-outs</li> </ol> </li> <li>3. Four-wheel drive: <ol style="list-style-type: none"> <li>a. Front to rear ratios</li> <li>b. Tires and rolling radius</li> <li>c. Front or rear disconnects</li> </ol> </li> <li>4. <b>Adjustments</b> <ol style="list-style-type: none"> <li>a. <b>Rolling torque</b></li> <li>b. <b>Bearing Preload</b></li> <li>c. <b>Endplay</b></li> </ol> </li> </ol>	<p>Exhibit knowledge of final drives by identifying the different types, and the components that make up final drives.</p> <p><b>Perform adjustments according to OEM standards.</b></p>
<p><b>4.3</b> Fundamental theory of hydraulic and pneumatic braking systems</p>	<ol style="list-style-type: none"> <li>1. Study the components of hydraulic <b>and pneumatic</b> braking systems: <ol style="list-style-type: none"> <li>a. Functions</li> <li>b. Construction</li> <li>c. Operating principles</li> <li>d. Define and explain Pascal's law</li> </ol> </li> </ol>	<p><b>Describe</b> fundamental theory, adjustments and repair of hydraulic and pneumatic braking systems used primarily in mobile construction equipment.</p> <p>Demonstrate knowledge of basic brake components, both wet internal and dry external.</p> <p>Explain and sketch hydraulic <b>and pneumatic</b> brake systems, internal and external.</p>

Critical Functions	Key Activities	Performance Descriptions
<b>4.3 Fundamental theory of hydraulic and pneumatic braking systems (cont.)</b>	<ol style="list-style-type: none"> <li>2. Study hydraulic wheel cylinders:               <ol style="list-style-type: none"> <li>a. Functions</li> <li>b. Construction</li> <li>c. Single/double piston</li> <li>d. Discuss and explain the mechanical working of a hydraulic wheel cylinder</li> </ol> </li> <li>3. Study master cylinders:               <ol style="list-style-type: none"> <li>a. Functions</li> <li>b. Construction</li> <li>c. Operating principles</li> </ol> </li> <li>4. Air system maintenance               <ol style="list-style-type: none"> <li>a. Air dryers</li> <li>b. Alcohol injectors</li> </ol> </li> <li>5. Internal wet disc brakes               <ol style="list-style-type: none"> <li>a. Actuation</li> <li>b. Sealing</li> <li>c. Friction material</li> </ol> </li> <li>6. Brake retarders               <ol style="list-style-type: none"> <li>a. Hydraulically actuated</li> <li>b. Engine exhaust brake</li> <li>c. Dynamics</li> </ol> </li> </ol>	
<b>4.4 Understanding maintenance practices in power trains</b>	<p>Cleanliness.</p> <p>Proper flushing.</p> <p>Scheduled oil sampling.</p>	<p>Demonstrate procedures to follow in keeping a work area, and the parts worked with, clean.</p> <p>Describe proper flushing procedures, <b>including when components are replaced.</b></p> <p>Describe scheduled oil sampling and cite several reasons why it is necessary.</p>

#### 4. Power Trains

##### 4.5 Power train schematics and flow diagrams

1. Identify symbols.
2. Technical manual/service information:
  - a. Problem solving
  - b. Decision making
  - c. Problem analysis

Be able to identify all electrical/hydraulic, pneumatic and mechanical symbols used in power train units.

Demonstrate ability to use schematics **and flow diagrams** to follow both control circuits and power flow of a given piece of equipment using the corresponding OEM manual/service information.

##### 4.6 Troubleshooting and failure analysis

1. Steps in problem solving

Describe steps in solving a problem related to a power train system, decisions required to perform work and analysis as to why problem occurred and how it could have been prevented.

##### Failure analysis

2. Understanding why parts fail:
  - a. Bending fractures
  - b. Torsional failures
  - c. Adhesive and abrasive wear
  - d. Pitting and spalling failures
  - e. Fretting, cavitation, and corrosion
  - f. **Lack of lubrication**
  - g. **Contamination**
  - h. **Lack of cooling/overheating**

Describe common reasons for parts failure and be able to discuss symptoms of wear, corrosion, etc., of actual parts.

**Demonstrate ability to follow reference information, test, and determine if unit is within specifications for a hydraulic/hydrostatic trainer or equipment with a hydrostatic drive using service manuals/information/software; demonstrate ability to follow a diagnostic troubleshooting chart for a specific system.**

##### Troubleshooting

3. **Testing/ troubleshooting:**
  - a. **Proper use of gauges**
  - b. **Accuracy of gauges**
  - c. **Oil sampling**
4. Repair cautions: cleanliness, oil types, filling oil lines, **bleeding pumps/motors**
5. **Technical write-up competency**

**Use proper oils and fluids as per manufacturer specifications.**

**Demonstrate technical write-up competency**

- **Demonstrate logic and critical thinking in identifying, evaluating and diagnosing customer complaint.**
- **Identify the root cause of failure**
- **Correction procedure**
- **Machine inspection**

# The Standards

## 5. Diesel Engines

5.1	Safety	p. 58
5.2	Theory and operation	p. 58
5.3	Maintenance practices	p. 60
5.4	Component repair	p. 60
5.5	Engine subsystems	p. 61
5.6	Fuel and governing systems, mechanical and electronic systems	p. 63
5.7	Diagnostics	p. 65

## 5. Diesel Engines

### 5.1 Safety

Instruction in proper safety practices.

**Emphasis on the extremely high fuel pressures we see today.**

**Explain safety issues** specifically related to engine applications.

Review assignments, evaluation of identification exercises. **Successfully complete written exams** that will determine the competency on many items unable to check by hands-on exercises. Emphasis on safety is to be demonstrated with all tool usage.

**How to safely diagnose a misfiring cylinder on a high-pressure fuel system.**

### 5.2 Theory and Operation

Understand the following engine theory, terminology and operation guidelines:

- Four stroke engine cycle
- Intake stroke/event
- Compression stroke/event
- Exhaust stroke/event
- Power stroke/event
- Diesel combustion
- Detonation, pre-ignition
- Valve overlap
- Crankshaft degrees

**Demonstrate** competency in the application of engine theory of operation. Written tests designed for this purpose. Possible task list.

**Understanding and comprehension of formulas to calculate engine performance criteria.**

**Understand the relationship between engine HP and torque.**

**Describe** the differences between spark ignited and compression ignition engines.

**Determine engine/component motion and speed ratios.**

**Explain** diesel 4-stroke engine cycle.

Memorize the order of strokes. Identify the specific stroke of each cylinder during engine rotation.

Determine the number of degrees between power strokes on various engines.

Understand diesel combustion principles, and the effects of pre-ignition, detonation and misfire.

**Demonstrate glow plug operation & testing.**

**Determine engine rotation by valve overlap.**

## 5. Diesel Engines

### 5.2 Theory and operation cont'd

- Combustion chambers
- Understand polar timing diagrams
- Cooling systems
- Lubrication systems

- **Fuel injection systems**

- Emission controls
  - a. **EPA regulations**
  - b. **Penalties for non-compliance**
  - c. **Emissions**

**Identify the various combustion chambers and know the advantages/disadvantages of each type.**

Perform basic valve and injection timing tasks.

**Understand the theory of injection pump timing.**

Understand the functions of various cooling system components.

Understanding measurement and properties of **the engine** fluids. **Understand cross contamination root causes and effects of each.**

Understand the functions and components of diesel engine lubrication systems **and the effects of machine operating angle versus oil pan and pump design.**

**Understand effects of lubrication system levels (over and under).**

Understand the functions and components of diesel engine fuel and governing systems, **including mechanical, electronic and computer controlled systems.**

**Understand common rail fuel systems.**

Understand the functions and components of emission control systems and governmental regulations (i.e. EPA **and CARB**).

**Understand penalties for non-compliance to emission regulations to the dealer, equipment owner and the technician.**

**Understand how emissions systems impact engine life and repairs.**

## 5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<b>5.3 Maintenance practices</b> Understanding industry and OEM <b>planned</b> maintenance procedures	<ul style="list-style-type: none"> <li>Service literature</li> <li>Fluid analysis</li> <li><b>Fuel types and grades</b> <b>Bio-fuels</b> <b>Low sulphur</b> <b>Ultra-low sulphur</b></li> <li>Filter dissection / inspection</li> </ul> <p>Proper component <b>repair</b> procedures:</p> <ul style="list-style-type: none"> <li>Parts reusability guidelines</li> </ul>	<p><b>Locate</b> maintenance specifications including fluid change intervals, fluid specifications (SAE/API, etc.), fuel specifications, filter replacement intervals, <b>proper filter replacement procedures</b>, other maintenance guidelines, etc.</p> <p><b>Understand commonly used methods for maintenance records keeping and their importance.</b></p> <p><b>Demonstrate</b> how to obtain proper oil, fuel and coolant samples.</p> <p><b>Demonstrate</b> understanding in how to interpret fluid analysis results.</p> <p><b>Demonstrate</b> how to inspect used filters for early warning signs of potential problems.</p> <p><b>Demonstrate</b> preventive maintenance tasks performed to industry standards; completion of an inspection task sheet.</p> <p><b>Demonstrate</b>, via practical exercises, parts reusability procedures and guidelines.</p>
<b>5.4 Component repair</b> Understanding proper component <b>repair</b> procedures		

## 5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p><b>5.4 Component <i>repair</i> (cont.)</b></p>	<ul style="list-style-type: none"> <li>Remanufactured components</li> </ul>	<p><b>Demonstrate understanding</b> of industry remanufactured component guidelines and how to determine when to use remanufactured components.</p> <p><b>Remove</b> and replace commonly serviced external components. Know the inspection, service, and cleaning techniques associated with replacement of these items.</p>
<p><b>5.5 Engine subsystems</b></p> <p>Engine identification of external components</p>	<p>Be able to identify and understand the function of the following components:</p> <ul style="list-style-type: none"> <li>Radiator</li> <li>Timing gear/front cover</li> <li>Flywheel housing</li> <li>Coolant manifolds</li> <li>Intake manifolds</li> <li><b>Clean air system components</b></li> <li>Aftercooler/intercooler</li> <li>Exhaust manifolds</li> <li><b>Turbocharger: fixed &amp; variable Displacement, series, and dual setups.</b></li> <li>Water pump</li> <li>Thermostat housing</li> <li>Vibration damper</li> <li>Oil cooler</li> <li><b>EGR system</b></li> <li><b>Exhaust after treatment systems</b></li> <li><b>Heat exchanger</b></li> <li><b>Valve covers</b></li> <li><b>Oil pan</b></li> <li><b>Crankcase ventilation filter</b></li> </ul>	<p>Locate and identify various external components.</p> <p><b>Demonstrate understanding of the basic theory of exhaust after treatment systems like:</b></p> <ul style="list-style-type: none"> <li><b>Diesel Particulate Filters (DPF)</b></li> <li><b>Diesel Oxidation Catalyst (DOC)</b></li> <li><b>Selective Catalytic Reduction (SCR)</b></li> <li><b>Diesel exhaust fluid (DEF)</b></li> <li><b>Regeneration process</b></li> </ul>

## 5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<b>5.5 Engine subsystems, Engine</b> <i>identification of external components (cont.)</i>	<ul style="list-style-type: none"> <li>Oil filters</li> <li>Fuel filters</li> <li>Coolant filters</li> <li>Power takes off/<b>accessory drive</b></li> <li>Cold start aids</li> <li>Fan drives and controls</li> </ul>	
Understanding internal engine components	<p>Be able to identify basic internal engine components and understand the purpose of each:</p> <ul style="list-style-type: none"> <li>Cylinder block</li> <li>Cylinder head</li> <li>Valvetrain</li> <li>Crankshaft</li> <li>Camshaft</li> <li>Piston</li> <li>Wrist pin</li> <li>Piston rings</li> <li>Cylinder liner/sleeve</li> <li>Connecting rods</li> <li>Bearings</li> <li>Timing gear/chain/belt</li> <li><b>Balancer shafts</b></li> </ul>	<p>Demonstrate comprehension of the removal, inspection and installation techniques associated with basic internal components.</p> <p>Perform identification and inspection of all internal components.</p> <p><b>Describe</b> tasks associated with the removal, inspection and installation of internal engine components (i.e., cylinder packs).</p> <p><b>Describe</b> bearing "roll-in" and tasks associated with in-frame overhauls.</p> <p><b>Describe</b> valve and injector adjustments, as well as timing and idler gear installations.</p>
Understanding basic engine subsystems	<p>Comprehension of the key external engine driven systems:</p> <ul style="list-style-type: none"> <li>Hydraulic systems</li> <li>Accessory systems</li> </ul>	<p><b>Demonstrate knowledge</b> of hydraulic accessories driven or operated by the engine.</p> <p><b>Demonstrate understanding</b> of cold weather starting aids and block heaters.</p>

## 5. Diesel Engines

### 5.6 Fuel and governing systems, mechanical and electronic systems

Understanding basic fuel systems

Understand the basic functions of a fuel delivery system. **Identify** and service the different fuel systems used in various applications.

Comprehension of basic terms and principles used when discussing fuel systems.

- Fuel delivery and performance tests
- Priming/bleeding the basic system
- Injector/nozzle testing
- Injection pump replacement

Perform basic maintenance and diagnosis of the different fuel delivery systems available today. Demonstrate a basic understanding of the adjustment and repair of various governing systems used by the major manufacturers. **Demonstrate the use of OEM software to determine governor type and make necessary adjustments.**

Understand basic hydraulic principles and fluid transfer technology.

**Measure** specific gravity of fuel and determine proper grade and/or contamination. Understand the use of fuel conditioners, fuel coolers and heaters.

Measure fuel pressure/volume **with correct diagnostic tools** and compare to specifications. Determine and understand the problems with the basic supply systems.

**Explain how contamination, such as air, water and dirt, can enter a fuel system and the effect it can have.**

## 5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p><b>5.6 Fuel and governing systems, understanding basic fuel systems (cont.)</b></p> <p>Understanding governor fundamentals</p>	<p>Exercises designed to illustrate governor principles. Identification of the various fuel governing systems including mechanical, pneumatic, hydraulic and electronic controls.</p> <p><b>Comprehension of</b> governor terminology.</p>	<p>Proper replacement of fuel transfer pumps, filters, lines, and hoses including proper bleeding/priming procedures.</p> <p><b>Identify misfiring cylinders with appropriate tooling. Emphasis on cleanliness and safety.</b></p> <p>Replacement and timing of various injection pumps including inline, distributor and unit injector pumps, <b>high pressure common rail pumps (including correct OEM bleed-down procedures).</b></p> <p><b>Perform</b> tasks associated with troubleshooting, adjusting and replacing governor components.</p> <p><b>Identification exercises</b> and demonstrations of system operation.</p>

## 5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<b>5.6 Fuel and governing systems</b> <i>understanding governor fundamentals (cont.)</i>	<p>Competency demonstrated on the following fuel governing systems:</p> <ul style="list-style-type: none"> <li>• Mechanical systems</li> <li>• <b>Aneroid/smoke controls</b></li> <li>• Hydraulic/servo systems</li> <li>• Electronic/electric systems</li> </ul>	<p><b>Understand operation of mechanical governors and hydraulic/servo systems.</b></p> <p>Troubleshooting and programming principles of electronic governors should be emphasized. Use of scantools and PCs should be demonstrated to illustrate the self-diagnosing capabilities of this system.</p> <p><b>Be able to demonstrate the ability to locate and test appropriate fuel system sensors.</b></p>
<b>5.7 Diagnostics</b>  Understand proper diesel engine diagnostic procedures	<ul style="list-style-type: none"> <li>• Troubleshooting</li> <li>• Failure analysis</li> <li>• Tools – <b>including PC based and onboard diagnostic systems</b></li> </ul> <p><b>The ability to extract fault codes and then follow a troubleshooting procedure to a practical resolution of the problem.</b></p>	<p>Tasks associated with troubleshooting emission controls and basic adjustments.</p> <p><b>Visual basic exhaust analysis; white, gray or black; as applicable.</b></p> <p>Practical exercises in identification of common diesel <b>engine</b> problems using proper diagnostic <b>tools and</b> procedures.</p>

## 6. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p><b>5.7 Diagnostics,</b>  <i>Understand proper diesel engine diagnostic procedures (cont.)</i></p>	<p>Technical write-up competency</p>	<p>Determine root causes of failure, <b>establish reusability</b>, and know the recommended repair options available.</p> <p>Demonstrate proper use of special tools and equipment utilized in engine repair.</p> <p>Tasks using technical service manuals, service information, bulletins and special instructions. Proficient use of service manuals, <b>desktop</b> PCs, and laptops for retrieval of specifications and service procedures.</p> <p>Troubleshooting common problems caused by a malfunctioning engine subsystem.</p> <p><b>Testing of the engine cooling system, including overheating issues and testing procedures; especially the flow through the radiator; correct temperature drops.</b></p> <p><b>Use proper oils and fluids as per manufacturer specifications.</b></p> <p><b>Demonstrate technical write-up competency</b></p> <ul style="list-style-type: none"> <li>• <b>Demonstrate logic and critical thinking in identifying, evaluating, and diagnosing customer complaint.</b></li> <li>• <b>Identify the root cause of failure</b></li> <li>• <b>Correction procedure</b></li> <li>• <b>Machine inspection</b></li> </ul>

# The Standards

## 6. Air Conditioning/Heating

6.1	Fundamental knowledge	p. 68
6.2	AC systems operation	p. 69
6.3	Servicing AC systems	p. 70
6.4	Testing, troubleshooting, diagnosing and repairing AC systems	p. 71
6.5	Heating system operation	p. 73
6.6	Servicing heating systems	p. 73
6.7	Pressurized cabs	p. 73

## 7. Air Conditioning/Heating

### Critical Functions

### Key Activities

### Performance Descriptions

#### 6.1 Fundamental knowledge

- a. Heat and heat energy.
- b. Pressure/temperature relationship of refrigerants.
- c. Refrigerants and refrigerant characteristics.

**Demonstrate knowledge** of heat sources, types of heat transfer, and how humidity affects heat transfer. Emphasis will be placed on factors that affect heat transfer and how to measure heat energy.

**Demonstrate knowledge** of the following terms:

1. Sensible heat
2. Change of state
3. Saturation temperature
4. Latent heat (Hidden heat)
5. Latent heat of fusion
6. Latent heat of evaporation
7. Latent heat of condensation
8. **Super heated**
9. **Sub-cooled**
10. Vapor
11. Gas

**Measure** and calculate the effects of pressures on liquids. Emphasis will be placed on understanding and using pressure and temperature (P/T) charts.

**Describe** refrigerant characteristics in relation to environmental damage. Emphasis will be placed on identification, labeling, and handling of refrigerants **in accordance with EPA 609 regulations.**

## 6.1 Fundamental knowledge (cont.)

d. Refrigerant oils.

e. Refrigerant recovery, recycle, reclaim.

## 6.2 AC systems operation

a. Basic system components.

b. Refrigerant cycle.

**c. Refrigerant state.**

**Demonstrate knowledge** of the types of oils used in AC systems.

**Demonstrate knowledge** on handling and storing of refrigerant oils.

**Demonstrate knowledge** on recovery, recycle, and reclaiming of refrigerants with respect to **identifying the refrigerant currently in the system**, the amounts of oil, water and particulates that are removed.

**Demonstrate knowledge** of the following system components:

1. Compressor
2. Condenser
3. Metering device
4. Evaporator
5. Service valves
6. Schrader valves
7. Receiver-drier
8. Accumulator
9. Lines

**Demonstrate knowledge** of refrigerant flow **and states** through an AC system.

**Demonstrate the knowledge of the state (super-heated vapor, saturated mixture, and sub-cooled liquid) of the refrigerant at various points in an AC system. Emphasis will be placed on the locations in the system that the refrigerant exists as a saturated mixture.**

6.3  
***Servicing AC systems***

a. Section 609 Certification

**Any Person who repairs or services a motor Vehicle air conditioning (MVAC) system for consideration (payment or bartering) must be properly trained and certified under section 609 of the Clean Air Act by an EPA-approved program. All technicians servicing MVAC-like appliances must be certified.**

**EPA-approved technician training and certification (TT&C) programs provide education on the proper use of MVAC servicing equipment, the applicable regulatory requirements, the importance of refrigerant recovery, as well as the effects of technicians must be trained by an EPA-approved program and pass a test demonstrating their knowledge in these areas.**

**Be aware of changes in refrigerant's standards as they change.**

**Identify** various types and refrigerant capacities of AC systems. Emphasis will be placed on the ability to identify types and capacities by using manufacturers' service publications along with equipment tags, labels, and specifications.

**Demonstrate use of a refrigerant ID tool (gas analyzer).**

Demonstrate the ability to properly connect and disconnect gauge manifold sets. Emphasis will be placed on using proper procedures to purge hoses to prevent cross-contamination and introduction of non-condensable.

Demonstrate the ability to connect gauge sets to systems having either Schrader or **quick disconnect** type service valves.

Demonstrate the ability to properly evacuate and dehydrate an AC system.

6.4  
**Testing, troubleshooting, diagnosing, and repairing AC systems**

b. System identification.

c. Connecting and disconnecting gauge manifold sets.

d. System evacuation and dehydration.

### 6.3 Servicing AC systems (cont.)

- e. Refrigerant recovery and charging **the system**.

Demonstrate knowledge of the damage caused to AC systems by non-condensable and moisture. Emphasis will be placed on having knowledge of using micron gauges and establishing minimum **evacuation pressure based on altitude as well as** maximum evacuation time periods to completely dehydrate AC systems.

Demonstrate the ability to properly recover and charge AC systems with refrigerants.

Emphasis **placed** on properly connecting and operating gauge manifold sets, recovery and charging equipment.

Demonstrate the knowledge and ability to describe the conditions that need to exist to charge AC systems with refrigerant existing as a liquid or vapor into the high or low side.

Demonstrate the ability to add oil, dye, and refrigerants to operating AC systems.

**Describe the complaint prior to beginning diagnostic tests. Describe and utilize an industry-accepted diagnostic process.**

**Demonstrate the ability to perform a visual inspection of an AC system.**

- a. **Loose or missing service caps**
- b. **Oily spots – connections – evaporator drain tube**
- c. **Belt tension**
- d. **Condenser condition**
- e. **Cab filter condition**
- f. **Determine refrigerant type**

**Demonstrate the ability to visually identify the type of AC system and determine the amount of refrigerant charge.**

- a. **TXV (H-Block) – Receiver-drier**
- b. **Metered orifice – accumulator**

**Demonstrate the ability to identify climate control systems and components.**

- f. Adding oil, dye, and refrigerants to AC systems.

- a. **Ask the proper questions before beginning to diagnose; capture customer complaint.**

- b. **Visual inspection of system**

- c. **Identify type of system and determine system capacity of refrigerant – weight**

**Identify climate control systems devices and components**

### 6.4 Testing, troubleshooting, diagnosing, and repairing AC systems



#### 6.4 Testing, troubleshooting, Diagnosing, and repairing AC systems (cont.)

- g. Interpreting pressure and temperature readings.
- h. Metering devices and limit switches.
- i. Leak detection.
- j. **Contaminated system**
- k. Component replacement/repair.
- l. Performance testing **including control systems**.
- m. **Understand the relationship between AC systems and hydraulically controlled and reversing fans circuits.**
- i. **Technical write-up competency**

Demonstrate the ability to troubleshoot and diagnose AC systems by converting system pressures to **saturated mixture** temperatures and comparing this to temperature readings taken at key points in the system.

Demonstrate the ability to troubleshoot and diagnose metering devices and limit switch malfunctions.

Demonstrate the ability to detect refrigerant leaks.

**Demonstrate to ability to determine contaminates in a system due to system component failure e.g. hoses, desiccants or compressor seal material.**

Replace or repair AC system components i.e. compressor, compressor clutch, seals, metering valves, condenser, receiver-drier, accumulator, limit switches and lines.

Demonstrate the ability to test the cooling capabilities of an AC system **including controls**. Emphasis will be placed on demonstrating the knowledge to determine the operational conditions needed to validate a performance test.

#### **Demonstrate technical write-up competency**

- **Demonstrate logic and critical thinking in identifying, evaluating, and diagnosing customer complaint.**
- **Identify the root cause of failure**
- **Correction procedure**
- **Machine inspection**

Critical Functions	Key Activities	Performance Descriptions
6.5 Heating system operation	<ul style="list-style-type: none"> <li>a. Basic system components.</li> <li>b. Water pumps.</li> <li>c. Coolant flow.</li> <li>d. Thermostats.</li> </ul>	<p><b>Describe</b> the following system components:</p> <ol style="list-style-type: none"> <li>1. Water pump</li> <li>2. Heater core</li> <li>3. Coolant control valve</li> <li>4. Coolant lines</li> <li>5. Engine thermostat</li> <li>6. <b>Temperature control valve</b></li> </ol> <p><b>Describe how different</b> water pumps work.</p> <p><b>Describe</b> coolant flow direction.</p> <p>Demonstrate knowledge of the function of <b>different</b> thermostats <b>and designs, and common troubleshooting methods.</b></p>
6.6 Servicing heating systems	<ul style="list-style-type: none"> <li>a. Heater core replacement.</li> <li>b. Control valve.</li> <li>c. Thermostats.</li> </ul>	<p><b>Describe</b> how to correctly remove and install heater core and coolant lines.</p> <p><b>Describe</b> how to correctly remove and install heater system control valves.</p> <p><b>Demonstrate</b> how to correctly remove, test and install engine thermostats.</p>
6.7 Pressurized cabs	<ul style="list-style-type: none"> <li>a. Purpose and function.</li> <li>b. Remove, clean and install filters.</li> </ul>	<p><b>State</b> the purpose and function of pressurized cab systems.</p> <p><b>Demonstrate knowledge of</b> how to correctly remove, <b>inspect and replace</b> cab air filters.</p>

## APPENDIX – TERMINOLOGY

### Electrical/Electronics

Accumulator	- Hydraulic energy	- Vane	- Variable displacement	- Variable displacement	- Flushing valve
Actuator	- Kinetic energy	- Variable displacement		<b>Regenerative/quick drop</b>	- Needle
<b>Aeration</b>	- Potential energy	Open-center system	<b>Orbital steering valve</b>	Reservoir	- Open-center
<b>Air entrainment</b>	Filter (oil)	Orifice		Restriction	- Pilot
Articulate	- By-pass filter	Out-of-stroke		<b>Rotating groups</b>	- Pilot operated
<b>Attenuation</b>	- Full-flow filter	Packing		<b>Sampling Ports</b>	- Poppet
Bleed	<b>Filter cart</b>	<b>Pintle shaft</b>		Seat	- <b>Pressure compensating</b>
<b>Breakout force</b>	Flow meter	Pipe		Servo	- Pressure control
Bypass	Flow rate	Piston		<b>Servo piston</b>	- Pressure reducing
Cam	Fluid power	Port		Solenoid	- Pressure sequence
<b>Case drain</b>	Force	Pour point		<b>Sponge gun</b>	- <b>Priority valve</b>
Cavitation	Friction	Power beyond		Starvation	- Proportional flow divider
<b>Charge relief</b>	Heat exchanger	Power lift		Strainer	- <b>Quick drop</b>
Charge system	Horsepower	Pressure		<b>Steering control unit</b>	- Relief
Closed-center system	Hydraulics	- Back pressure		Stroke	- <b>Replenishing/relief</b>
Closed-loop system	- Hydrodynamics	- Charge pressure		<b>Supply/feed line</b>	- Rotary directional
<b>Compensator</b>	- Hydrostatics	- Cracking pressure		Surge	- Selector
Controller	Inert gas	- <b>Differential pressure/Delta P</b>		Swash plate	- Sequence
Cooler (oil)	Load	- Full-flow pressure		<b>Swivel joint/center joint</b>	- Shuttle
Coupler	Load sense	- Operating pressure		Symbols, schematic	- Shutoff
Cushion	Load check	- Pilot pressure		System	- Spool directional
Cycle <b>time</b>	Lift check	- <b>Pressure limiting</b>		Thermal expansion	- Stroke control
Cylinder	<b>Manifold</b>	- Rated pressure		Torque	- Thermal relief
- Double-acting cylinder	- <b>Distribution</b>	- Static pressure		<b>Torque limiter</b>	- <b>Tow valve</b>
- Single acting cylinder	- <b>Return</b>	- <b>Surge pressure/pressure spike</b>		Tube	- <b>Two stage relief</b>
- <b>Telescopic cylinder</b>	- <b>Rotary</b>	- System pressure		Valve	- Two-three-four-six-way
<b>Delta P</b>	<b>Micron</b>	- Working pressure		- <b>Anti-cavitation valve</b>	- Unloading
<b>Detent</b>	Motor (hydraulic)	Pulsation		- <b>Buildup valve</b>	- Volume control
Displacement	<b>Motors</b>	<b>PSI</b>		- Bypass regulator	<b>Valve plate</b>
<b>Drain shuttle</b>	- <b>Axial piston</b>	Pumps		- Check valve	Valve stack
Drift <b>rate</b>	- <b>Fixed displacement</b>	- Fixed displacement		- Closed-center	Velocity
<b>EDC – Electronic Displacement</b>	- <b>Gear</b>	- <b>Gear</b>		- Directional control	Vent
Efficiency	- Gerotor	- <b>Piston</b>		- Electro-hydraulic	Viscosity
Energy	- <b>Radial piston</b>	- <b>Vane</b>		- Flow control	Volume
- Heat energy	- <b>Two-speed</b>			- Flow divider	Work port

Students are required to have a thorough understanding and comprehension of terms and abbreviations related to this Appendix. Here are some examples. The list is not exhaustive, but provides selected basic terminology; feel free to add terms as you deem appropriate.

**A**

Actuator Solenoid  
Air Flow Sensor  
Alternator  
Alternating Current (AC)  
Ambient Temperature  
Ammeter  
Ampere (Amp)  
Ampere-Hour  
Amplifier  
Amplitude  
Armature  
Artificial Magnets  
Atom  
Auxiliary Speed Sensor

**B**

Battery  
Battery Terminals  
Bendix Drive

**C**

Calibration  
Capacitor  
Carbon Tracks  
Charge  
Charging System  
Coil  
Current  
Current Flow  
Cycle  
Cycling

**D**

Diagnostic Code  
Diode  
Direct Current (DC)  
Discharge  
Distributor (Ignition)  
Distributor Lead Connector  
Dyer Drive

**E**

ECM  
Electrical Field

kVA - Kilo Volt Amperes  
kW - Kilo Watts  
kWH - Kilowatt Hour  
V - Volts  
I - Ampere or Current  
1Ø - Single Phase (One Phase)

Electricity  
Electrochemical  
Electro-Hydraulic Valve  
Electrolyte  
Electromagnet  
Electromagnetic Clutch  
Electromagnetic Field  
Electromagnetic Induction  
Electron  
Electronic Ignition  
Electronic Sensor  
Electron Theory  
Electronics  
Electronic Control Unit (ECU)  
Electronic Governor  
Electronic Ignition System  
Element

**F**

Fixed Resistor  
Frequency  
Fundamental Law of Magnetism  
Fuse

**G**

Gate  
Generator  
Grid  
Ground  
Grounded Circuit  
Growler

**H**

Hydrometer

**I**

Ignition Control Unit  
Ignition Fire  
Ignition System  
Ignition Timing  
Inductance  
Inductor  
Transistor (LGFET)  
Insulator  
Integrated Circuit (IC)

3Ø - Three Phase  
ATS - Automatic Transfer Switch  
AVR - Automatic Voltage Regulator  
Hz - Hertz (Frequency)  
kV - Kilovolt

Integrator Circuit  
Inverter  
Ion  
Isolation Diode

**K**

Knock Sensor

**L**

Light Emitting Diode (LED)  
Lines of Force  
Liquid Crystal Display (LCD)

**M**

Magnet  
Magnetic Field  
Magnetic Flux Magnetic Induction  
Magnetic Lines of Force  
Magnetic Material  
Magnetic North  
Magnetic Pickup Assembly  
Magnetic South  
Magnetic Switch  
Magnetism  
Map Sensor  
Mass Airflow Sensor  
Microprocessor  
Milliampere  
Molecule  
Motor  
Multimeter  
Mutual Induction

**N**

Natural Magnet  
Negative  
Negative Terminal  
Neutron  
Non-Magnetic Material  
Normally Open  
Normally Closed

Ohm  
Ohmmeter

Ohm'S Law  
Oil Light  
Open or Open Circuit  
Overrunning Clutch  
Oxygen Sensor

**P**

Parallel Circuit  
Pcv Valve  
Permanent Magnet  
Piezo Electric Device  
Plate  
Polarity  
Pole  
Pole Shoes  
Positive  
Positive Terminal  
Potentiometer.  
Power Switch Transistor  
Primary Speed Sensor  
Principle Of Turning Force  
Printed Circuit Board  
Proton  
Pulse  
Pulse-Width-Modulated (PWM)

**R**

Rectifier  
Recharge  
Regulator  
Relay  
Reluctance  
Reluctor  
Resistance  
Resistor  
Rheostat  
Right-Hand Rule  
Rotor

**S**

Self-Induction  
Semiconductor  
Sending Unit  
Sensor  
Separator

Series Circuit  
Series-Parallel Circuit  
Short (Or Short Circuit)  
Shunt  
Slip Ring  
Solenoid  
Solid-State Circuits  
Spark Plugs  
Specific Gravity  
Sprag Clutch Drive  
Starter Motor  
Starter Solenoid  
Stator  
Storage Battery  
Sulfation  
Switch

**T**

Tachometer  
Temporary Magnet  
Thermistor  
Throttle Sensor  
Transformer  
Module (TVP)  
Transistor

**V**

Vacuum Florescent Display (VDC)  
Variable Resistor

Volt

Voltage  
Voltage Regulator  
Voltmeter

**W**

Watt  
Watt-Hour  
Wave  
Waveform  
Winding  
Wiring Harness

**Z**

Zener Diode (Reverse Bias Direction Diode)

## Hydraulics/Hydrostatics

### Hydraulics/Hydrostatics Abbreviations

ANSI:	American National Standards Institute	lb-ft:	Pounds-foot, torque or turning effort
ASAE:	American Society of Agricultural Engineers	lb-in:	Pounds-inch, torque or turning effort
bar:	Metric unit of measure for pressure	L/m:	Liters per minute
C:	Degrees Celsius, temperature	Mpa:	Megapascal, ISO standard measurement for pressure
F:	Degrees Fahrenheit, temperature	O.D.:	Outside diameter
gpm:	Gallons per minute, fluid flow	OEM:	Original Equipment Manufacturer
Nm:	Newton meters, metric unit of measure for torque	<b>ppm:</b>	<b>Parts per million</b>
hp:	Horsepower	psi:	Pounds per square inch, pressure
I.D.:	Inside diameter	<b>psia:</b>	<b>Pounds per square inch absolute</b>
ISO:	International Organization for Standardization	<b>psig:</b>	<b>Pounds per square inch gauge</b>
Kg/cm2:	Kilograms per square centimeter, metric unit for pressure	<b>PWM:</b>	<b>Pulse width modulation</b>
kPa:	Kilo Pascals, metric unit of measure for pressure	rpm:	Revolutions per minute
kW:	Kilowatts, metric unit of measure for power	SAE:	Society of Automotive Engineers

## Power Trains

Axle  
 Axle, hydrostatic drive  
 Backlash  
 Band-type clutches  
 Barrel cylinder  
 Bearing loads  
 Bearing  
 Bearings, ball  
 Bearings, roller  
 Belt alignment  
 Belt drives  
 Belt friction  
 Belt tension  
 Belts  
 Bevel gears, plain  
 Bevel gears, spiral  
 Cam drives  
**Carrier**  
**Carrier Gear**  
 Carrier bearing for midship support  
 Chain drives  
 Calipers  
 Clutch  
 Clutch pack  
 Collar shift transmission  
 Countershaft  
 Coolers  
**Coupler**  
 CV Joints  
 Dampeners  
 Differentials  
**Differential pressure**  
**Differential steering**  
 Direct drive transmission  
 Disk clutch

Drop box / transfer case  
 Dry brakes  
**Electronic Control Module (ECM)**  
**Electronic Modulation Controlled Valve**  
 Electrical clutch controls  
 Endplay  
 Final drive  
**Fixed displacement**  
 Fluids  
 Fluid coupling  
 Flywheel  
 Gear  
 Gear train  
 Gear pump **/Motor-Piston type**  
**Hybrid**  
 Hydraulic  
 Hydrostatic  
 Hydrostatic drive  
 Idler gear  
 Impeller  
 Inching/modulation pedal  
**Infinitely variable transmission**  
 Input shaft  
 Lubrication  
 Manual transmissions  
**Modulation**  
**Modulation control valve**  
 Output shaft  
 Overdrives  
 Pinion drives  
 Pinion drives  
 Planetary drives  
 Planetary gears  
 Pneumatic clutches  
**Positive traction differential**

Power shift transmissions  
 Power take-off **(PTO)**  
 Power train  
**Pressure reducing valves**  
**Proportional valve**  
 Pump  
 Ratio  
**Reduced slip differential**  
 Repair indicators  
 Reverser unit  
 Rim  
 Ring gear  
**Ring and pinion gears**  
 Roller chains  
 Servo cylinder  
 Shear pins  
 Slip clutches  
 Spur  
 Sun gear  
 Swash plate  
 Synchromesh transmission  
 Tension  
 Torque  
 Torque Converter  
**Torque Multiplier**  
 Universal joints / Hooke joints  
 V-belts  
**Variable Displacement Piston Pump**  
 Variable-speed belt drives  
 Wear  
 Wear plate  
 Wet disc brakes  
**Wet disc clutch**  
 Worm gears

## Diesel Engines

### Diesel Engines

Aftercooled  
 Back pressure  
 Barometric pressure  
 Blow-by  
 Bore/stroke  
 BTDC  
 Cavitation erosion  
**Common rail fuel systems**  
 Compression ratio  
 Compression ignition  
 Dynamometer  
 ECM  
 Emissions  
 Engine displacement  
 Firing order  
 Glow plug  
 Heat exchanger  
 Horsepower  
**Injection system theory &**  
 Mechanical efficiency  
 Naturally aspirated  
 RPM  
 Specific gravity  
 Supercharged / blower  
 Temperature  
 Thermocouple  
 Torque  
 Turbocharged  
 Vibration  
 Viscosity

### Additional

**AC** Volts of Alternating Current  
**API** American Petroleum Institute  
**BTU** British Thermal Unit  
**BTDC** Before Top Dead Center  
**°C** Celsius  
**CCA** Cold Cranking Amperes  
**CO** Carbon Monoxide  
**C.I.D.** Cubic Inch Displacement  
**DC** Volts of Direct Current  
**DEF** Diesel Exhaust Fluid  
**DOC** Diesel Oxidation Catalyst  
**DPF** Diesel Particulate Filter  
**EGR** Exhaust Gas Recirculation  
**° F** Fahrenheit  
**FT-LB** Foot-Pound Force  
**Hg** Mercury  
**HP** Horsepower  
**H<sub>2</sub>O** Water  
**inHg** Inches of Mercury  
**In H<sub>2</sub>O** Inches of Water  
**kPa** Kilopascal  
**N\*m** Newton-meter  
**NO<sub>x</sub>** Mono-nitrogen oxides  
**O<sub>2</sub>** Oxygen  
**RPM** Revolutions per minute  
**SCA** Supplemental Coolant  
**SCR** Selective Catalytic Reduction  
**VS** Variable Speed

### Emissions Terminology

**ACM** After Treatment Control Module  
**AM** Atomization Module  
**APM Filter** Active Particulate Matter Filter (Not Automatic. Manually Activated)  
**ASU** Aftertreatment Support Module  
**BAT** Best Available Technology  
**BACT** Best Available Control Technology  
**BART** Best Available Retro fit technology  
**CO<sub>x</sub>** Carbon Oxides, Mono x 1 (atom of Oxygen,) Di x 2 (atoms of Oxygen,) Tri x 3 (atoms of Oxygen.)  
**DEF** Diesel Exhaust Fluid  
**DECS** Diesel Emissions Control Strategy  
**DPF** Diesel Particulate Filter  
**EATS** Exhaust After Treatment System  
**ECU** Electronic Control Unit  
**E-ECU** Engine-Electronic Control Unit  
**EGR** Exhaust Gas Recirculation  
**E-EGR** External Exhaust Gas Recirculation  
**EMC** Electromagnetic Compatibility  
**EMS** Engine Management System  
**EPA** Environmental Protection Agency  
**HC** Hydrocarbons (Fuels)  
**I - EGR** Internal Exhaust Gas Recirculation  
**LSD** Low Sulfur Diesel 350 – 500 ppm, sulfur content  
**NO<sub>x</sub>** Nitrogen Oxides, Mono x 1 (atom of Oxygen,) Di x 2 (atoms of Oxygen,) Tri x 3 (atoms of Oxygen.)  
**PM** Particulate Matter  
**PPM Filter** Passive Particulate Matter (Automatic, requires no active manual  
**SCR** Selective Catalytic Reduction  
**SOV** Shut Off Valve  
**SO<sub>x</sub>** Sulfur Oxides  
**ULSD** Ultra Low Sulfur Diesel < 15 ppm sulfur content  
**VGT** Variable geometry Turbo

## Air Conditioning/Heating

### Air Conditioning/Heating Basic Terminology

Ambient temperature	Drier	Hg.	Thermo siphon
Atmospheric pressure	Evaporation	Joule	Torque
Bleeding	Evaporator coil	Kpa	Vacuum
Blower	Expansion valve	Potentiometer	Watt
Boiling point	Fahrenheit	Pressure	<b>Sunlight sensor</b>
BTU	Gas	PSI	<b>A/C controllers</b>
Celsius	Heater coil	Purging	<b>Servo motors</b>
Condensation	Heater evaporator blower	Radiation	<b>Climate controls</b>
Density	Heater/evaporator unit	Receiver – Drier	<b>Inside/outside temperature sensors</b>
Displacement	Heater valve	Thermostat	

### Air Conditioning Terminology

Absolute Zero	Density	Liquid line	Substance
Air conditioning	Desiccant	Low side	Suction side
Ambient temperature	Evaporation	Pressure drop	Superheat
Atmospheric pressure	Fahrenheit	PSI	Sweeping
Bleeding	Head pressure	Purging	Tail pipe
Boiling point	Hg.	Radiation	Total heat load
BTU	High side	Ram air	Torque
Celsius	Hydrolizing action	Receiver – Drier	Vacuum
Compressor displacement	Joule	Saturated mixture	<b>Section 609 Certification</b>
Condensation	Kpa	Schrader valve	<b>R12 Refrigerants</b>
Condensing temperature	Latent heat	Sensible heat	<b>R134a Refrigerants</b>
Condensing pressure	Latent heat of condensation	Specific heat	
Conduction of heat	Latent heat of vaporization	Standard ton	<b>R1234YF Refrigerants</b>

# Standards Book, November 2021 Edition – Technical Training Committee

The following industry leaders and educators, all members of The AED Foundation Technical Training Committee (TTC), participated in the 2021 review and revision of this standards document:

**TTC Chairman:** Paul Anderson, Ziegler CAT (Retired), Minneapolis, MN

The Technical Standards Committee met May 23-24, 2021, in Las Vegas during the AED Summit. The committee members representing industry, academics and evaluators attending were Ed Fredrick, Tony Tice, Doug Hammond, Gary Wenter, Steve Don and Tayte Askelsen

Because of the variances in hybrid and telematics it was felt that students need to have a basic understanding of these systems but training in this area need to be left up to the employers/ dealers

## **Administration.**

No changes

## **Safety.**

Industry has reenforced the need for continued focus on safety. Minor changes to wording

## **Electrical.**

Most of the changes were minor, rather than listing specific electrical components to test such as diodes, transistor, hall effect switches we simply said

### **Electrical components, switches, gauges, relays, etc.**

- Telematics and Emerging Technologies; Recognize and understand how basic systems communicate through telematics.
- Recognize hybrid and electric drive systems as they relate to safety concerns.

## **Hydraulics.**

No changes to this section

## **Engines**

- Greater emphasis on the extremely high fuel pressures we see today.
  - Know how to safely diagnose a misfiring cylinder on a high-pressure fuel system.
  - high-pressure common rail pumps (including correct OEM bleed-down procedures).

## **Powertrain.**

- Theory of Operation, demonstrate understanding of theory of hybrid and electric drive component technology.
- The college program must own at least two off-highway powershift transmissions for student disassembly and assembly.
  - Use service information to test and/or troubleshoot a powershift transmission and verify whether it is or is not within OEM specifications.

**Staff Liaison:** Sean Fitzgerald, AED, Schaumburg, IL

## Standards Book, November 2017 Edition – Technical Training Committee

The following industry leaders and educators, all members of The AED Foundation Technical Training Committee (TTC), participated in the 2017 review and revision of this standards document:

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## Standards Book, November 2014 Edition - Task Force Leaders

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## Standards Book, August 2011 Edition - Task Force Leaders

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### **About The AED Foundation**

The AED Foundation is an affiliate of Associated Equipment Distributors, the international association of distributors, suppliers, and manufacturers serving the construction equipment industry since 1919. Established in 1991, The Foundation's programs and services strengthen the equipment industry through workforce development and professional education initiatives.

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