



2014 Edition Rev2/12/16

Standards For Construction Equipment Technology

Skill standards for post-secondary
schools preparing for careers as
equipment technicians.

AED
FOUNDATION

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 **eighth 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 school faculty. The standards cover six areas that the industry considers most important for the training of entry-level technicians:

- Safety/Administrative
- Electronics/Electrical
- 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.

**2014 Edition
Rev 2/12/16**

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About the AED Technical Standards Project

Educational institutions and businesses must work together to develop a world-class equipment industry workforce. Significant progress is being made in developing these relationships with the goal of identifying interested students and providing them with the technical training they will need when entering the workforce. In 2001, The AED Foundation introduced the AED Accreditation Program for post-secondary schools. Accreditation requirements are based on the 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 train 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. Such skills are required in order to service and repair

construction equipment that is increasingly complex and sophisticated. Our industry faces a shortage of these highly skilled people. Occasional business downturns cannot hide the long-term need for well-trained 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 needed by AED members.

At the end of this book is a list of present and past standards project participants. We would like to thank all of these industry experts for their time and efforts, and their commitment to industry workforce excellence. Without this type of 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,

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The AED Foundation
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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. A number of 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 in order 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 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 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.AEDCareers.com, 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 training investment and less need for additional entry-level and/or remedial training.
- 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 particular 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 Standards:

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

Note: AED 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.

College degree and certificate programs that meet the standards prescribed in this publication can apply for AED Accreditation from The AED Foundation. **As you review these technical standards, be advised that the delivery of technical core courses must be split among two (minimum) or more onsite full-time instructors.**

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

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Job Description – Equipment Service Technician

An equipment technician maintains, services and repairs the machines and equipment used in all segments of the construction industry, and machines and equipment used in related industries.

Equipment and machines range from fuel and electrically powered hand tools used in construction to giant, diesel-powered earthmovers, cranes and road pavers. To work on these expensive assets, service technicians must have a good base of knowledge in math, science and language prior to acquiring advanced knowledge in construction equipment technology: safety/administrative, electronics/electrical, hydraulics/hydrostatics, power trains, diesel engines and air conditioning/heating.

Fast, accurate work, done "right the first time," is essential for the equipment service technician. Most use sophisticated diagnostic equipment and personal computers to communicate with their shops, offices and customers.

As a front-line employee with direct customer contact, today's equipment service technician position also requires people skills to communicate with customers, peers and company management. A technician must realize that technology advances rapidly, and continuous training will be required in order to stay current in his/her field.

Typical career path and related opportunities for successful technicians:

- Entry-level service technician
- Journeyman (often with progressive pay and seniority classifications)
- Field technician
- Specialist/ master technician
- Parts/ parts manager
- Service manager
- Trainer/ training manager
- Foreman/supervisor
- Opportunity for movement to: product support sales, advanced technology, and new/used equipment sales or rentals
- Potential advancement to upper management

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.

Notes:

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

Standards changes made in the: 2005 edition are in bold black font.
2008 edition are in bold red font.
2011 edition are in bold blue font.
2014 edition are in bold green font.

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	Use of hand tools	p. 14	1a.7	Use of fluid pressure testing equipment	p. 16
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1a.3	Use of air tools	p. 14	1a.9	Machine identification and operation	p. 17
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1a.5	Use of lifting equipment	p. 15	1a.11	Shop and in-field practices	p. 20
1a.6	Use of various cleaning equipment	p. 15	1a.12	Hazard identification and prevention	p. 20

1b. Administrative

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1b.4	Define basic business practices	p. 22
1b.5	Describe functions of the dealership service department; explain department goals and procedures	p. 23

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
1a.1 Use of hand tools	<p>Proper and safe use of basic hand tools used by a technician.</p> <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	<p>Can identify and correctly name the basic hand tools.</p> <p>Demonstrates the proper use of the designed application and safe operating procedure for each.</p> <p>Demonstrates a proper source for calibration of precision hand tools.</p>
1a.2 Use of electric tools	<p>Proper and safe use of basic electric hand tools used by a technician.</p> <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	<p>Can identify and correctly name the electrical tool.</p> <p>Demonstrates the proper use of the designed application and safe operating procedure for each.</p> <p>Demonstrates the proper inspection, care and storage for electric hand tools.</p> <p>Understands and exhibits 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>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	<p>Can identify and correctly name the basic air tool.</p> <p>Demonstrates the proper use of the designed application and safe operating procedure for each.</p> <p>Demonstrates 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, such as:</p> <ul style="list-style-type: none">a. Porta powers and pullersb. Hydraulic pressesc. Hydraulic pullersd. Hydraulic jackse. Hydraulic torque wrenches <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	<p>Can identify and correctly name the basic hydraulic tools.</p> <p>Demonstrates the proper inspection, care, maintenance, and storage as applicable.</p> <p>Demonstrates the proper use of the designed application and safe operating procedure as applicable.</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> <ul style="list-style-type: none">a. Jack standsb. Hoists (overhead and floor type)c. Hydraulic jacksd. Blocking and cribbinge. Come-A-Long (chain and cable type)f. Lifting chains – lifting eyes, links, spreader bars, etc.g. Slingsh. Securing chains <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	<p>Can identify and correctly name the various types of lifting equipment.</p> <p>Demonstrates the proper inspection, care, maintenance, and storage for each.</p> <p>Demonstrates the proper use of the designed application and safe operating procedure for each.</p> <p>Students understand current regulations and standards for use, inspection and certification of lifting equipment.</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>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	<p>Can 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>

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<p><i>1a.6 Use of various cleaning equipment (cont.)</i></p>		<p>Can identify the various solvents and solutions used in the cleaning process.</p> <p>Can 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>
<p>1a.7 Use of fluid pressure testing equipment</p>	<p>Proper and safe use of various types of fluid pressure test equipment and accessories:</p> <p>Bench testers and testing equipment, such as:</p> <ul style="list-style-type: none">a. Gaugesb. Transducersc. Flow rating equipmentd. Hydraulic cylinder teste. Hydraulic pump and motor <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	<p>Can identify and correctly name the various types of fluid pressure test equipment and the accessories required for proper testing.</p> <p>Can explain the proper use of the designed application and safe operation of each type of equipment.</p> <p>Demonstrates a proper source for calibration of precision test equipment and accessories.</p> <p>Can identify, correctly name and demonstrate the use of the personal protective equipment required for the various types of fluid pressure testing equipment.</p> <p>Can explain at least three dangers of working with fluids under pressure.</p>

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<p>1a.8 Environment of service facility</p> <div data-bbox="113 354 625 678" style="border: 2px solid black; padding: 5px;"><p>IMPORTANT NOTE: It is the responsibility of the educational institution to provide a classroom and lab facility that provides an acceptable, safe learning environment for students.</p></div>	<p>Proper and safe use of ventilation and building exhaust systems.</p> <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	<p>Can 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>Can explain why carbon monoxide and diesel smoke can be hazardous to your health and the precautions required for eliminating injury or death.</p> <p>Recognize symptoms of exposure to carbon monoxide, diesel smoke and other hazardous materials.</p>
<p>1a.9 Machine identification and operation</p>	<p>Proper and safe operation of the machinery the technicians will be involved with. Examples:</p> <ul style="list-style-type: none">a. Excavatorsb. Skid steersc. Backhoesd. Compaction equipmente. Paving equipmentf. Crawlers and track type loadersg. Scrapersh. Cranesi. Scissor liftsj. Fork lifts and material handlersk. Wheel loadersl. Haul trucksm. Motor gradersn. Trencherso. Horizontal directional drills <p>*** Hybrid drives ***</p>	<p>Can 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>Can understand 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>Recognize hybrid systems and/or machines as they relate to safety concerns.</p>

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<p><i>1a.9 Machine identification and operation (cont.)</i></p>	<p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.10.</p>	
<p>1a.10 Mandated regulations</p>	<p>Various federal and state OSHA and MSHA regulations.</p> <p>a. Personal protection equipment (PPE):</p> <ul style="list-style-type: none"> • Safety glasses and shoes • Fire protection • Ear protection • Respirators • Head protection • Loose clothing hazard • Proper gloves/hand protection • Protective clothing <p>b. Hazardous material:</p> <ul style="list-style-type: none"> • Right-to-know <p>c. Proper handling of hazardous material</p> <p>d. Lock-out, Tag-out as it pertains to construction machinery</p> <p>e. Proper use of wheel chocks</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"> • Methods of fire protection • Proper handling of various types of fires; electrical grease, etc. • Use of fire extinguishers <p>j. Safety Data Sheets (SDS)</p> <p>k. Machine guarding</p>	<p>Can identify and correctly name the various types of equipment required for these regulations.</p> <p>Can exhibit 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 federal and state OSHA and MSHA regulations.</p> <p>Identify the different types of fire extinguishers and know the applications and correct use of each type.</p> <p>Demonstrates how to find, explain and use an SDS for a product.</p>

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<p><i>1a.10 Mandated regulations (cont.)</i></p>	<ul style="list-style-type: none"> l. Handling of flammable liquids and materials. m. Handling of machinery with fluid leaks. n. Back-up alarm requirements for construction machinery. o. Rollover protective equipment for construction machinery (ROPS). p. Electrical ground fault protection. q. Underground utility hazard – standard markings for each type. r. Falling objects protection for construction machinery. (FOPS) s. Fall protection for workers. t. Sub-surface, trench, excavation safety. u. Workman's compensation and accident prevention: <ul style="list-style-type: none"> 1. Cost of accidents 2. Lost time injury 3. Proper accident and injury reporting 	<p>Understand and identify underground utility hazard marking that would commonly be encountered on a job site.</p> <p>Can 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
<p>1a.11 Shop and in-field practices</p>	<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>Proper shop/facility cleanliness and housekeeping practices.</p>	<p>Can identify safe work practices in each situation.</p> <p>Can demonstrate safe work practices in the shop or in the field.</p> <p>Can identify proper lifting and pulling techniques to avoid personal injury.</p> <p>Demonstrate proper lifting and pulling techniques.</p> <p>Demonstrate proper shop/facility cleanliness/appearance to dealer standards.</p>
<p>1a.12 Hazard identification and prevention</p>	<p>Proper mounting and dismounting of machinery.</p> <p>Load securement for transportation of components.</p> <p>General knowledge of safety practices.</p> <p>Hazard Communication (HazCom) Standard</p> <p>Proper wheel assembly handling procedures.</p> <p>Proper tethering techniques.</p>	<p>Demonstrate safe mounting and dismounting practices on construction machinery.</p> <p>Explain proper types of chains and binders used in securing loads.</p> <p>Demonstrate proper lock out tag out procedures.</p> <p>Demonstrate understanding of the HazCom standard and how to use Safety Data Sheets and Chemical Labels.</p> <p>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> <p>Demonstrate proper work procedures in handling wheel assemblies. Refer to industry standard procedures.</p> <p>Know 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 vehicles.

1b. Administrative

Critical Functions	Key Activities	Performance Descriptions
<p>1b.1 Comprehend basic academic functions</p>	<p>Read, write and comprehend written language; and math, science, and social studies at the minimum assessment level.</p>	<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, time cards, 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>1b.2 Utilize industry software and electronic communications systems and reference resources</p>	<p>Demonstrate the use of communication technology options.</p> <p>Adequate keyboard skills.</p>	<p>Develop and exhibit good listening skills.</p> <p>Exhibit the ability to use a computer, and related hardware, current software, Internet, and technology currently in use.</p> <p>Demonstrate efficient, effective, correct and timely communications to a customer and co-worker utilizing telephone, fax, computer, word processing and E-mail.</p> <p>Using a computer, demonstrate the ability to retrieve specifications, part numbers, bulletins, schematics, produce reports, and similar types of information using manufacturers' software and internet based resources.</p>

1b. Administrative

Critical Functions	Key Activities	Performance Descriptions
<p>1b.3 Awareness of dealership goals, objectives and policies</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>Review and understand typical examples of potential dealership and college program mission statements, core values, policies/procedures manuals, hand books, 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>Demonstrate understanding of how product support activities contribute to the overall profitability of the company.</p> <p>Identify expense control requirements.</p> <p>Maintain awareness of 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>1b.4 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>

The Standards

2. Electronics/Electrical Systems

2.1	Fundamental knowledge	p. 25
2.2	Ohm's law	p. 26
2.3	12/24 volt <u>cranking</u> circuits	p. 26
2.4	12/24 volt <u>charging</u> circuits	p. 27
2.5	Lighting, accessory and control systems	p. 28
2.6	Electrical schematics/diagrams	p. 29
2.7	SAE computer Can-Buss standards	p. 29
2.8	Diagnostics	p. 30

2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
2.1 Fundamental knowledge	<p>a. Atomic structure.</p> <p>b. Electron theory of electricity.</p> <p>1. Testing conductors, semi-conductors, and insulators.</p> <p>2. Magnetism.</p> <p>3. Construction and operation of storage batteries.</p> <p>c. Telematics – remote monitoring.</p>	<p>Know the basic structure of conductors, insulators, and semi-conductors.</p> <p>Know the reaction of like and unlike charges.</p> <p>Describe the differences of conventional and electron theory current flow.</p> <p>Define resistance and its effect on current flow.</p> <p>Demonstrate the principles of operation and the correct usage of the various types of meters to measure volts, amps, and ohms.</p> <p>Demonstrate ability to convert between kilo, milli, and micro units.</p> <p>Demonstrate knowledge of the laws governing permanent magnets, electromagnets, and magnetic fields.</p> <p>Demonstrate knowledge of the effects of magnetic forces on current carrying conductors.</p> <p>Know the basic parts and operation of the basic types of storage batteries.</p> <p>Understand remote monitoring systems and the ability to remotely diagnose electrical/electronic issues.</p>

2. Electronics/Electrical Systems

Critical functions	Key Activities	Performance Descriptions
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 the voltage, amperage, and resistance values in series, parallel, and series/parallel DC circuits.
2.3 12/24 volt <u>cranking</u> circuits	a. Components. b. Operation. c. Troubleshooting. d. Test and Replace if Required.	Know 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 using voltage drops and other diagnostic methods. The proper use of testing equipment is paramount. Demonstrate the ability to properly test, evaluate and replace the following components using manufacturers' service publications and specifications. <ol style="list-style-type: none">1. Conductors2. Relays/ Solenoids3. Starters

2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
2.4 12/24 volt <u>charging</u> circuits	<ul style="list-style-type: none">a. Components. b. Operation. c. Troubleshooting. d. Test and Replace if Required.	<p>Know 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>Demonstrate the ability to isolate problems using voltage drops and other diagnostic methods. The proper use of testing equipment is paramount.</p> <p>Demonstrate the ability to properly test, evaluate and replace the following components using manufacturers' service publications and specifications.</p> <ul style="list-style-type: none">1. Conductors2. Alternators3. Regulators

2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
2.5 Lighting, accessory and control systems	<ul style="list-style-type: none">a. Components.b. Operation.c. Troubleshooting.d. Repair.	<p>Know the basic components that make up the various types of lighting, accessory and control systems.</p> <p>Demonstrate the sequence of operation of the components contained within various lighting, accessory and control systems. The emphasis is on how each component effects the system's overall operation.</p> <p>Demonstrate the ability to isolate problems within various lighting, accessory and control systems using voltage drops and other diagnostic methods. The proper use of testing equipment is paramount.</p> <p>Demonstrate the ability to properly disassemble, test, assemble, replace, or repair lighting, accessory and control system components using manufacturers' service publications and specifications. Examples of the components are as follows:</p> <ul style="list-style-type: none">1. Wiring harness/connectors2. Fuses/circuit breakers3. Lights/bulbs4. Electromagnetic devices5. Gauges6. Meters7. Horns and buzzers8. Relays9. Diodes10. Resisters11. Potentiometers

2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
<p><i>2.5 Lighting, accessory and control systems (cont.)</i></p>		<p>12. Solenoids 13. Rheostats 14. Switches 15. Electric motors 16. Transformers/converters 17. Pre-heat devices - ie Glow plugs, intake heaters 18. Sensors 19. Monitors 20. Controllers 21. HID/LED 22. Transducers 23. Transistors</p>
<p>2.6 Electrical schematics/diagrams</p>	<p>a. How to read schematics/diagrams. b. How to use schematics/diagrams.</p>	<p>Demonstrate the ability to identify basic electrical/electronic symbols. Demonstrate the ability to trace various circuits using wiring schematics/diagrams. Demonstrate a working knowledge of diagnosing and troubleshooting electrical systems using schematics/diagrams.</p>
<p>2.7 SAE computer Can-Buss standards</p>	<p>a. Understand communication standards. b. Understand published error codes per SAE standards.</p>	<p>Demonstrate the knowledge of the different systems used to communicate on computer controlled machinery. SAE J1587 & J1939. Understanding the importance of twisted and shielded wire systems. Demonstrate the knowledge of the codes to identify errors within the different systems.</p>

2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="126 284 346 316">2.8 Diagnostics</p> <p data-bbox="178 349 535 381">Systems troubleshooting</p> <p data-bbox="126 479 598 820">Note: 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. Reference the requirement for a school-owned hydraulic/hydrostatic trainer in Section 3.6.</p> <p data-bbox="126 852 598 1015">Also cross-reference to Power Trains Section 4.1 of this document: Theory and Operation, Theory and principles of hydrostatic transmissions.</p>	<p data-bbox="672 349 1165 446">Ask the proper questions before beginning to diagnose; capture the customer complaint.</p> <p data-bbox="672 479 1270 665">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 data-bbox="672 698 1186 917" style="list-style-type: none"> a. Cranking systems b. Charging systems c. Lighting systems d. Electric and electronic controlled hydraulic systems e. Electric and electronic controlled hydrostatic systems <p data-bbox="672 950 1270 1144">Given school owned 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 data-bbox="672 1177 1123 1209">Technical write-up competency</p>	<p data-bbox="1344 349 1963 414">Understand the complaint prior to beginning diagnostic tests.</p> <p data-bbox="1344 479 1858 544">Demonstrate the ability to perform a diagnostic procedure.</p> <p data-bbox="1344 576 1879 665">Demonstrate the ability to reason with regard to a specific malfunction in the system.</p> <p data-bbox="1344 698 1942 828">Demonstrate 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 data-bbox="1344 860 1921 950">Demonstrate the ability to use schematic diagrams and follow troubleshooting flow charts in selected technical manuals.</p> <p data-bbox="1344 982 1942 1047">Utilize an interactive equipment diagnostic program.</p> <p data-bbox="1344 1177 1963 1209">Demonstrate technical write-up competency</p> <ul data-bbox="1344 1209 1963 1396" style="list-style-type: none"> • Demonstrate logic and critical thinking in identifying, evaluating and diagnosing customer complaint. • Identify the root cause of failure • Correction procedure • Machine inspection

The Standards

3. Hydraulics/Hydrostatics

3.1	Theory and operation, hydraulic and hydrostatic	p. 32
-	Understand hydraulic theory	p. 32
-	Understand hydrostatic theory	p. 33
-	Pump identification and operation	p. 33
-	Motor identification and operation	p. 34
-	Function and operation of hydraulic valves	p. 35
-	Electro-hydraulics	p. 36
-	Cylinder identification and operation	p. 36
-	Accumulator identification and operation	p. 37
3.2	Fluids, transfer components and filtering	p. 37
3.3	Maintenance procedures	p. 38
3.4	Component repair and replacement	p. 40
3.5	Hydraulic schematics	p. 41
3.6	Diagnostics	p. 41

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p>3.1 Theory and operation, hydraulic and hydrostatic</p> <p>Understand hydraulic theory</p> <p>See also 3.6 Troubleshooting of load-sensing hydraulics.</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>Demonstrate the understanding of the function of a reservoir, pump, filters, relief valve, control valve, and cylinder in relation to each other.</p> <p>Know that 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 load sensing 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>Be able to identify applications, and the benefits of those applications on construction equipment.</p>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p><i>3.1 Theory and operation, hydraulic and hydrostatic (cont.)</i></p> <p>Understand hydrostatic theory</p> <p>Note: 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>Pump identification and operation</p>	<p>Learn the principles of hydrostatics.</p> <p>Applications of hydrostatic systems.</p> <p>Understand the difference between fixed, variable, positive, and non-positive displacement pumps.</p> <p>Identify a gear pump, its parts, and know its operation.</p>	<p>Demonstrate knowledge of hydrostatic systems, including closed-loop and open-loop systems.</p> <p>Understand the various types of cooling circuits.</p> <p>Understand the purpose of a charge circuit and how charge pressure relates to hydrostatic system efficiency.</p> <p>Explain the differences between hydraulic and hydrostatic systems.</p> <p>Be able to identify applications, and the benefits of those applications on construction equipment.</p> <p>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.</p> <p>Be able 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.</p>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="130 248 569 378"><i>3.1 Theory and operation, hydraulic and hydrostatic; Pump identification and operation (cont.)</i></p> <p data-bbox="184 854 512 919">Motor identification and operation</p>	<p data-bbox="678 248 1262 313">Identify a vane pump, its parts, and know its operation.</p> <p data-bbox="678 537 1192 602">Identify a piston pump, its parts, and know its operation.</p> <p data-bbox="678 756 1192 789">Identify types of swash plate control.</p> <p data-bbox="678 854 1251 951">Understand the difference between fixed or variable displacement, and 2-speed motors.</p> <p data-bbox="678 1016 1247 1081">Identify a gear motor, its parts and know its operation.</p> <p data-bbox="678 1203 1262 1268">Identify a vane motor, its parts, and know its operation.</p>	<p data-bbox="1346 248 1969 508">Be able to identify 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.</p> <p data-bbox="1346 537 1969 732">Be able to identify 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.</p> <p data-bbox="1346 756 1892 821">Identify types of swash plate control (manual, servo piston, electronic, etc.).</p> <p data-bbox="1346 854 1969 984">Explain the different characteristics between the various motors; exhibit the ability to follow the oil flow through each motor while using a hydraulic function.</p> <p data-bbox="1346 1016 1969 1179">Be able to identify 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.</p> <p data-bbox="1346 1203 1969 1365">Be able to identify 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.</p>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="130 248 569 378"><i>3.1 Theory and operation, hydraulic and hydrostatic; Motor identification and operation (cont.)</i></p> <p data-bbox="201 597 569 662">Function and operation of hydraulic valves</p>	<p data-bbox="678 248 1213 313">Identify radial and axial piston motors, their parts, and know their operation.</p> <p data-bbox="678 505 1213 570">Identify a gerotor motor, its parts, and know its operation.</p> <p data-bbox="678 599 1213 664">Understand the three major types of hydraulic valves.</p> <p data-bbox="678 855 1213 920">Understand the functions and uses of pressure control valves.</p>	<p data-bbox="1350 248 1959 475">Be able to 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.</p> <p data-bbox="1350 505 1969 570">Be able to identify a gerotor motor, name all parts, and understand its operation.</p> <p data-bbox="1350 599 1959 664">Exhibit the differences between these three major types:</p> <ul style="list-style-type: none"> <li data-bbox="1350 693 1738 725">a.) Pressure control valves <li data-bbox="1350 725 1759 758">b.) Directional control valves <li data-bbox="1350 758 1717 790">c.) Volume control valves <p data-bbox="1350 855 1969 920">Exhibit knowledge of the uses and functions of the following valves:</p> <ul style="list-style-type: none"> <li data-bbox="1350 950 1749 982">a.) Direct acting relief valves <li data-bbox="1350 982 1770 1015">b.) Pilot operated relief valves <li data-bbox="1350 1015 1707 1047">c.) Cartridge relief valves <li data-bbox="1350 1047 1696 1079">d.) Pilot operated valves <li data-bbox="1350 1079 1644 1112">e.) Sequence valves <li data-bbox="1350 1112 1644 1144">f.) Unloading valves <li data-bbox="1350 1144 1686 1177">g.) Multi-function valves <li data-bbox="1350 1177 1728 1209">h.) Counterbalance valves <li data-bbox="1350 1209 1759 1242">i.) Pressure reducing valves <li data-bbox="1350 1242 1738 1274">j.) Pressure limiting valves

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="130 289 562 415"><i>3.1 Theory and operation, hydraulic and hydrostatic; Function and operation of hydraulic valves (cont.)</i></p> <p data-bbox="191 477 449 509">Electro-hydraulics</p> <p data-bbox="191 987 558 1052">Cylinder identification and operation</p>	<p data-bbox="676 289 1209 354">Understand the functions and uses of directional control valves.</p> <p data-bbox="676 477 1150 574">Electro-hydraulic valves Electro-hydraulic control systems Pulse width modulation (PWM)</p> <p data-bbox="676 639 1209 704">Understand the functions and uses of volume control valves.</p> <p data-bbox="676 987 1272 1052">Understand the difference between single acting and dual acting cylinders.</p> <p data-bbox="676 1084 1243 1149">Identify a single acting cylinder, its parts and know its operation.</p>	<p data-bbox="1346 289 1969 354">Exhibit knowledge of the uses and functions of the following valves:</p> <ul style="list-style-type: none"> <li data-bbox="1346 354 1612 386">a.) Check valves <li data-bbox="1346 386 1612 418">b.) Rotary valves <li data-bbox="1346 418 1612 451">c.) Spool valves <li data-bbox="1346 451 1835 483">d.) Pilot controlled poppet valves <li data-bbox="1346 483 1759 516">e.) Electro-hydraulic valves <li data-bbox="1346 516 1892 548">f.) Electro-hydraulic control systems <li data-bbox="1346 548 1843 581">g.) Pulse width modulated valves <p data-bbox="1346 639 1969 704">Exhibit knowledge of the uses and functions of the following valves:</p> <ul style="list-style-type: none"> <li data-bbox="1346 704 1688 737">a.) Flow control valves <ul style="list-style-type: none"> <li data-bbox="1415 737 1667 769">1. Compensated <li data-bbox="1415 769 1724 802">2. Non-compensated <li data-bbox="1346 802 1688 834">b.) Flow divider valves <ul style="list-style-type: none"> <li data-bbox="1415 834 1562 867">1. Priority <li data-bbox="1415 867 1633 899">2. Non-priority <li data-bbox="1415 899 1640 932">3. Proportional <p data-bbox="1346 987 1969 1052">Explain the uses and movements of the two types of cylinders.</p> <p data-bbox="1346 1084 1948 1182">Be able to identify a single acting cylinder, name all of its parts, and follow the oil flow through the cylinder.</p> <p data-bbox="1346 1214 1877 1279">Understand operation of a cushioned cylinder.</p>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p>3.1 <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>Be able to identify a double acting cylinder, name all of its parts, and follow the oil flow through the cylinder. (deleted in sentence ie. vane type cylinder - rotary actuator)</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 practice all accumulator safety practices.</p>
<p>3.2 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

Critical Functions	Key Activities	Performance Descriptions
<p>3.2 Fluids, transfer components and filtering (cont.)</p> <p>Know the construction and function of filters used in hydraulic/hydrostatic systems</p>	<p>Hydraulic filters:</p> <ol style="list-style-type: none"> 1. Pressure, return line & suction filters 2. Filter efficiency 3. Beta ratings/ISO cleanliness codes 4. Auxiliary by-pass filtration 	<p>Describe the use of various filters in hydraulic and hydrostatic systems.</p> <p>Demonstrate an understanding of the concept of auxiliary by-pass filtration and its benefits to total system cleanliness.</p>
<p>3.3 Maintenance procedures</p> <p>Understand the importance of maintenance</p>	<p>Know and practice safety.</p> <p>Understand the importance of cleanliness.</p> <p>Flushing systems.</p> <p>Preventing leaks.</p> <p>Prevent overheating.</p> <p>Identify defective or worn hoses.</p>	<p>Demonstrate familiarity with, and practice good hydraulic maintenance/safety practices.</p> <p>Perform all hydraulic functions and repairs in a clean atmosphere.</p> <p>Exhibit the ability to follow the proper flushing procedure using the correct technical manual/service information.</p> <p>Exhibit the proper maintenance techniques to prevent internal and external leaks.</p> <p>Demonstrate the procedure for cleaning hoses after cutting and crimping.</p> <p>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 position longer than necessary.</p> <p>Recognize the root causes of "blistering" or frayed hoses and procedures to avoid these problems.</p>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p>3.3 Maintenance procedures (cont.)</p> <p>Know the characteristics of oils</p> <p>Fluid Cleanliness</p> <p>Understand the usage and types of seals and gasket materials</p>	<p>Hydraulic oils:</p> <ol style="list-style-type: none"> 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 <p>ISO cleanliness codes Interpreting fluid analysis reports</p> <p>Be able to identify aeration</p> <p>Know the variety of materials and types of seals/gaskets used in a hydraulic system</p>	<p>Understand oils and show familiarity with various fluids and their effects on hydraulic systems.</p> <p>Understand the effects of mixing oil types.</p> <p>Understand ISO cleanliness code principles. Identify key elemental categories.</p> <p>Understand the proper way to obtain fluid samples from a system.</p> <p>Identify key elements found in oil analysis and the types of failures related to each.</p> <p>Identify key indicators on a fluid analysis report that illustrate:</p> <ol style="list-style-type: none"> 1. The proper fluid type is being used. 2. Fluid types have not been mixed. 3. Indicators of fluid degradation. 4. Trend analysis. <p>Be able to identify aeration and determine the root cause.</p> <p>Show understanding of how reactions of some sealant materials differ among types of hydraulic fluids.</p> <p>Describe the applications of various types of sealants.</p> <p>Ensure safety practices are followed.</p>

The Standards

4. Power Trains

4.1	Theory and operation	p. 43
4.2	Driveshaft function and construction	p. 50
4.3	Fundamental theory of hydraulic and pneumatic braking systems	p. 51
4.4	Understanding maintenance practices in power trains	p. 52
4.5	Power train schematics and flow diagrams	p. 53
4.6	Troubleshooting and failure analysis	p. 53

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
4.1 Theory and operation	Learn theory of power train: <ol style="list-style-type: none">1. Clutches2. Manual transmissions3. Power shift transmissions4. Hydrostatic drives5. Hybrid drives6. Differential steering7. Torque converters8. Differentials9. Dry brakes10. Wet brakes11. Final drives	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. Recognize hybrid systems and/or machines as they relate to safety concerns.
Basic principles of power train	Learn principles of the following: Types of gears: <ol style="list-style-type: none">1. Straight cut spur2. Helical3. Herringbone4. Bevel5. Spiral bevel6. Hypoid7. Planetary<ol style="list-style-type: none">a. Basic operation<ul style="list-style-type: none">• Sun drive• Carrier drive• Compound gearb. Ratios	Demonstrate knowledge by identifying the various types of gears using a matching test. 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.

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p><i>4.1 Theory and operation; Basic principles of power train (cont.)</i></p>	<p>8. Worm 9. Ring and pinion</p> <p>Anti-friction bearings and plain bearings:</p> <ol style="list-style-type: none">1. Ball2. Roller3. Needle <p>Torque converter:</p> <ol style="list-style-type: none">1. Components:<ol style="list-style-type: none">a. Impellerb. Turbinec. Stator2. Operation:<ol style="list-style-type: none">a. Vortex flowb. Stallc. Torque multiplicationd. Lock-up clutchese. Rotary flowf. Cooler flow3. Testing and troubleshooting:<ol style="list-style-type: none">a. Converter in pressuresb. Converter out pressuresc. Lock-up clutch pressures	<p>Identify types of bearings through matching tests.</p> <p>Demonstrate understanding of various types of bearings and proper adjustment procedures.</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
<p><i>4.1 Theory and operation (cont.)</i></p> <p>Theory and principles of manual transmissions</p>	<ol style="list-style-type: none">1. General principals:<ol style="list-style-type: none">a. Sliding gear:<ol style="list-style-type: none">1. Components2. Operation3. Powerflowb. Collar shift:<ol style="list-style-type: none">1. Components2. Operation3. Powerflowc. Syncromesh:<ol style="list-style-type: none">1. Components2. Operation3. Powerflow2. Manual shifting controls:<ol style="list-style-type: none">a. Forksb. Railsc. Cams3. Adjustments:<ol style="list-style-type: none">a. Endplay, preload, backlashb. Fork adjustmentsc. Rail adjustmentsd. Cam adjustments	<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>Demonstrate ability to perform adjustments to transmissions as instructed in the OEM service manual/information.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p><i>4.1 Theory and operation (cont.)</i></p> <p>Theory and principles of powershift transmissions</p> <p>Theory and principles of clutches</p> <p>The college program must have at least two school-owned static powershift transmissions (on-highway truck transmissions do not qualify) for student disassembly and assembly. Depending on the number of students in the program, more may be required.</p>	<ol style="list-style-type: none"> 1. General principals: <ol style="list-style-type: none"> a. Review multiple discs b. Review planetary gearing c. Identify planetary and countershaft transmissions. d. Multiple clutch operation: <ul style="list-style-type: none"> • Clutch engagement chart • Power flow through transmission • Control of clutch engagement e. Accumulator operations f. Rate of shift controls g. Clutch pressures: <ul style="list-style-type: none"> • On-coming clutch • Off-going clutch • Pressure gauge testing h. Hydraulic valving i. Oil flow to clutches: <ul style="list-style-type: none"> • Hydraulic reverses • Counter shaft (constant mesh) • Planetary transmissions • Troubleshooting methods • Preload, endplay, and backlash 	<p>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.</p> <p>Explain the differences, advantages and disadvantages of planetary and countershaft transmissions.</p> <p>Use service manual/information to test and/or troubleshoot a powershift transmission (on-highway truck transmissions do not qualify), and verify if it is within OEM specifications.</p> <p>Demonstrate ability to set and measure preload, endplay and backlash for a specific component using OEM manuals/service information.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p><i>4.1 Theory and operation (cont.)</i></p> <p>Theory and principles of clutches</p>	<p>Clutch identification and operation:</p> <ol style="list-style-type: none">1. Disk and plate:<ol style="list-style-type: none">a. Disc:<ul style="list-style-type: none">• Solid• Buttonb. Pressure plate:<ul style="list-style-type: none">• Springs• Plate• Release leversc. Operation2. Multiple disc clutches:<ol style="list-style-type: none">a. Componentsb. Relationship of number of discs to applicationc. Effect of pressure on torqued. Wet and dry clutchese. Clutch/plate materialf. Wear patterns3. Overrunning clutches:<ol style="list-style-type: none">a. Types:<ul style="list-style-type: none">• Roller• Cam• Spragb. Operationc. Application4. Magnetic clutches:<ol style="list-style-type: none">a. Operationb. Application5. Modulating clutch	<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>Explain operation and applications.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p>4.1 Theory and operation (cont.)</p> <p>Theory and principles of electronic-controlled transmissions</p>	<ol style="list-style-type: none">1. Basic principals:<ol style="list-style-type: none">a. Electronically-controlled hydraulic valves:<ul style="list-style-type: none">• $F = P \times A$• Pressure drop through an orifice• Fundamentals of spring operation• Fundamentals of solenoid operation• Current vs. spring force vs. orifice relationship• Current vs. pressure relationships2. Electronic over hydraulic systems.3. Electronic over air systems.4. Sensing and operational control:<ol style="list-style-type: none">a. Load sensingb. Engine fuel control interfacec. Speed sensingd. Torque sensinge. Manual controlf. Automatic control5. Diagnosis and Troubleshooting:<ol style="list-style-type: none">a. With diagnostic unitb. Without diagnostic unitc. Component isolation proceduresd. Clutch modulation pressurese. Lubrication pressuref. Pump pressure	<p>Exhibit knowledge of electronic control systems by identifying components used on a specific unit.</p> <p>Demonstrate understanding of a specific unit's operation by explaining the functions of all components and their relationships to one another.</p> <p>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.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p><i>4.1 Theory and operation (cont.)</i></p> <p>Theory and principles of hydrostatic transmissions</p> <p>Note: 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 Hydraulics/Hydrostatics Section 3.1 of this document: Theory and operation, understand hydraulic and hydrostatic theory. Reference the requirement for a school-owned hydraulic/hydrostatic trainer in Section 3.6.</p>	<ol style="list-style-type: none">1. Basic principals:<ol style="list-style-type: none">a. Displacement/flow relationshipsb. Types:<ul style="list-style-type: none">• Gear• Axial piston swash plate• Cam lobec. Open loop hydrostaticsd. Closed loop hydrostatics:<ul style="list-style-type: none">• Fixed-fixed combinations• Variable-fixed combinations• Fixed-variable combinations• Variable-variable combinations• Charge circuit• Lubrication circuite. Pumpf. Motorg. Forwardh. Neutrali. Reverse2. Hydrostatic control systems:<ol style="list-style-type: none">a. Manual feedback controlb. Electronically controlledc. Braking system:<ul style="list-style-type: none">• Fail safe• Manual systems	<p>Demonstrate understanding of theory and principals of hydrostatic systems by explaining, in writing, how a basic hydrostatic system functions.</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>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
4.2 Driveshaft function and construction	<ol style="list-style-type: none">1. Connections:<ol style="list-style-type: none">a. U Joint / Hooke jointb. Constant velocity joint2. Effects of angle of shaft3. Multiple joint timing4. Mid-ship supports5. Repairs6. Failure analysis	<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">1. Basic operation and components:<ol style="list-style-type: none">a. Pinion gearb. Ring gearc. Bevel gear2. Differential locking methods:<ol style="list-style-type: none">a. Mechanicalb. Hydraulicc. Automatic no-spin3. Adjustments:<ol style="list-style-type: none">a. Preloadb. Backlashc. Gear tooth pattern	<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 component and proper manuals/information, 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 root causes of failure with differentials.</p>

4. Power Trains

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

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p><i>4.3 Fundamental theory of hydraulic and pneumatic braking systems (cont.)</i></p>	<ul style="list-style-type: none">2. Study hydraulic wheel cylinders:<ul style="list-style-type: none">a. Functionsb. Constructionc. Single/double pistond. Discuss and explain the mechanical working of a hydraulic wheel cylinder3. Study master cylinders:<ul style="list-style-type: none">a. Functionsb. Constructionc. Operating principles4. Air system maintenance<ul style="list-style-type: none">a. Air dryersb. Alcohol injectors5. Internal wet disc brakes<ul style="list-style-type: none">a. Actuationb. Sealingc. Friction material6. Brake retarders<ul style="list-style-type: none">a. Hydraulically actuatedb. Engine exhaust brakec. Dynamics	
<p>4.4 Understanding maintenance practices in power trains</p>	<p>Cleanliness.</p> <p>Proper flushing.</p> <p>Scheduled oil sampling.</p>	<p>Describe, in writing, procedures to follow in keeping a work area and the parts worked with clean.</p> <p>Describe proper flushing procedures, including when components are replaced.</p> <p>Describe scheduled oil sampling and cite several reasons why it is necessary.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p>4.5 Power train schematics and flow diagrams</p>	<ol style="list-style-type: none"> 1. Identify symbols. 2. Technical manual/service information: <ol style="list-style-type: none"> a. Problem solving b. Decision making c. Problem analysis 	<p>Be able to identify all electrical/hydraulic, pneumatic and mechanical symbols used in power train units.</p> <p>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.</p>
<p>4.6 Troubleshooting and failure analysis</p> <p>Failure analysis</p>	<ol style="list-style-type: none"> 1. Steps in problem solving 2. Understanding why parts fail: <ol style="list-style-type: none"> a. Importance of stress b. Planning for strength c. Failure modes d. Bending fractures e. Torsional failures f. Adhesive and abrasive wear g. Pitting and spalling failures h. Fretting, cavitation, and corrosion i. Lack of lubrication j. Contamination 	<p>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.</p> <p>Describe common reasons for parts failure and be able to discuss symptoms of wear, corrosion, etc., of actual parts.</p> <p>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.</p>
<p>Troubleshooting</p>	<ol style="list-style-type: none"> 3. Testing/ troubleshooting: <ol style="list-style-type: none"> a. Proper use of gauges b. Accuracy of gauges 4. Repair cautions: cleanliness, oil types, filling oil lines 5. Technical write-up competency 	<p>Demonstrate technical write-up competency</p> <ul style="list-style-type: none"> • 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. 55
5.2	Identification and use of basic tools	p. 55
5.3	Theory and operation	p. 57
5.4	Maintenance practices	p. 59
5.5	Component repair	p. 59
5.6	Engine subsystems	p. 60
5.7	Fuel and governing systems, mechanical and electronic systems	p. 62
5.8	Diagnostics	p. 64

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
5.1 Safety	Instruction in proper safety practices. Emphasis on the extremely high fuel pressures we are seeing today.	Safety instruction specifically related to engine applications, including OSHA regulations.
5.2 Identification and use of basic tools	Use of tools and equipment: <ul style="list-style-type: none">• Identify basic hand tools• Proper use and care of hand tools• Maintain/sharpen drills and punches• Use of taps, dies, thread chasers, thread identification and thread gauges• Use of cleaners, solvents, hot tanks, parts cleaners, glass bead machines including reading SDS sheets and understanding regulations governing solvents• Use of hydraulic and mechanical presses, pullers and pushers.	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. Performance testing of tool/equipment to check comprehension. Demonstrate all torque and de-torque methods with hands-on exercises.

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p><i>5.2 Identification and use of basic tools (cont.)</i></p>	<ul style="list-style-type: none">• 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.• Straight edges, feeler gauges, transfer gauges.• Micrometers, dial indicators, calipers and bore gauges.• Speed/RPM indicators, magnetic/optical tachometers and pulse generators.• Pressure/flow gauges and meters, manometers, vacuum gauges.• Temperature gauges, pyrometers, thermocouples, and infrared thermometers.• Hydrometers/refractrometers.• Special tools - diagnostic tool groups.• TECHNICAL RESEARCH - proper use of Tech Service Manuals /personal computers/laptops.	<p>The student should be able to read accurately all precision measuring tools and gauges.</p> <p>Be able to demonstrate the ability to convert standard to and from metric measurements, both pressure and distance.</p> <p>Be able to determine engine speed and pulses per revolution.</p> <p>Tasks related to measuring, understanding and recording pressure, flows and temperature.</p> <p>Tasks related to measuring specific gravity of fuel, coolant and electrolyte.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>5.3 Theory and operation</p> <p>Understand the following engine theory, terminology and operation guidelines:</p> <ul style="list-style-type: none"> • 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 • Combustion chambers • Understand polar timing diagrams • Cooling systems • Lubrication systems 		<p>Competency demonstrated in the application of engine theory of operation. Written tests designed for this purpose. Possible task list.</p> <p>Understanding and comprehension of formulas to calculate engine performance criteria.</p> <p>Understand the relationship between engine HP and torque.</p> <p>Know the differences between spark ignited and compression ignition engines.</p> <p>Determine engine/component motion and speed ratios.</p> <p>Be able to explain diesel 4-stroke engine cycle.</p> <p>Memorize the order of strokes. Identify the specific stroke of each cylinder during engine rotation.</p> <p>Determine the number of degrees between power strokes on various engines.</p> <p>Understand diesel combustion principles, and the effects of pre-ignition, detonation and misfire.</p> <p>Demonstrate glow plug operation & testing.</p> <p>Determine engine rotation by valve overlap.</p> <p>Identify the various combustion chambers and know the advantages/disadvantages of each type.</p> <p>Perform basic valve and injection timing tasks.</p> <p>Understand the theory of injection pump timing.</p> <p>Understand the functions of various cooling system components.</p> <p>Understanding measurement and properties of the engine fluids. Understand cross contamination root causes and effects of each.</p> <p>Understand the functions and components of diesel engine lubrication systems and the effects of machine operating angle.</p> <p>Understand effects of lubrication system levels (over and under).</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p><i>5.3 Theory and operation (cont.)</i></p>	<ul style="list-style-type: none"><li data-bbox="688 289 1052 321">• Fuel injection systems <li data-bbox="688 565 1037 732">• Emission controls<ul style="list-style-type: none"><li data-bbox="737 605 1016 638">a. EPA regulations<li data-bbox="737 638 1037 703">b. Penalties for non-compliance<li data-bbox="737 703 932 732">c. Emissions	<p data-bbox="1297 280 1955 410">Understand the functions and components of diesel engine fuel and governing systems, including mechanical, electronic and computer controlled systems.</p> <p data-bbox="1297 440 1843 472">Understand common rail fuel systems.</p> <p data-bbox="1297 570 1940 667">Understand the functions and components of emission control systems and governmental regulations (i.e. EPA).</p> <p data-bbox="1297 696 1948 794">Understand penalties for non-compliance to emission regulations to the dealer, equipment owner and the technician.</p> <p data-bbox="1297 823 1940 888">Understand how emissions impact engine life and repairs.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>5.4 Maintenance practices</p> <p>Understanding industry and OEM planned maintenance procedures</p>	<ul style="list-style-type: none"> • Service literature • Fluid analysis • Fuel types and grades Bio-fuels Low sulphur Ultra-low sulphur • Filter dissection / inspection 	<p>Be able to locate maintenance specifications including fluid change intervals, fluid specifications (SAE/API, etc.), fuel specifications, filter replacement intervals, proper filter replacement procedures, other maintenance guidelines, etc.</p> <p>Understand commonly used methods for maintenance records keeping and their importance.</p> <p>Hands on experience in how to obtain proper oil, fuel and coolant samples.</p> <p>Practical understanding in how to interpret fluid analysis results.</p> <p>Hands on experience in how to inspect used filters for early warning signs of potential problems.</p> <p>Preventive maintenance tasks performed to industry standards; completion of an inspection task sheet.</p>
<p>5.5 Component repair</p> <p>Understanding proper component repair procedures</p>	<p>Proper component repair procedures:</p> <ul style="list-style-type: none"> • Parts reusability guidelines 	<p>Practical exercises in parts reusability procedures and guidelines.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p><i>5.5 Component repair (cont.)</i></p>	<ul style="list-style-type: none">• Remanufactured components	<p>Understanding industry remanufactured component guidelines and how to determine when to use remanufactured components.</p> <p>Be able to remove and replace commonly serviced external components. Know the inspection, service, and cleaning techniques associated with replacement of these items.</p>
<p>5.6 Engine subsystems</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">• Radiator• Timing gear/front cover• Flywheel housing• Coolant manifolds• Intake manifolds• Clean air system components• Aftercooler/intercooler• Exhaust manifolds• Turbocharger: fixed & variable displacement• Water pump• Thermostat housing• Vibration damper• Oil cooler• EGR system• Exhaust after treatment systems• Heat exchanger• Valve covers• Oil pan• Crankcase ventilation filter	<p>Locate and identify various external components.</p> <p>Knowledge of vibration fundamentals.</p> <ul style="list-style-type: none">• Linear characteristics• Rotational characteristics <p>Understanding of the basic theory of exhaust after treatment systems like:</p> <ul style="list-style-type: none">• Diesel Particulate Filters (DPF)• Diesel Oxidation Catalyst (DOC)• Selective Catalytic Reduction (SCR)• Diesel exhaust fluid (DEF)• Regeneration process

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="142 227 604 324"><i>5.6 Engine subsystems, Engine identification of external components (cont.)</i></p> <p data-bbox="199 479 525 544">Understanding internal engine components</p>	<ul data-bbox="682 227 1171 414" style="list-style-type: none"> • Oil filters • Fuel filters • Coolant filters • Power take off/accessory drive • Cold start aids • Fan drives and controls <p data-bbox="682 479 1260 576">Be able to identify basic internal engine components and understand the purpose of each:</p> <ul data-bbox="682 609 1050 1023" style="list-style-type: none"> • Cylinder block • Cylinder head • Valvetrain • Crankshaft • Camshaft • Piston • Wrist pin • Piston rings • Cylinder liner/sleeve • Connecting rods • Bearings • Timing gear/chain/belt • Balancer shafts 	<p data-bbox="1344 479 1942 609">Demonstrate comprehension of the removal, inspection and installation techniques associated with basic internal components.</p> <p data-bbox="1344 641 1942 706">Perform identification and inspection of all internal components.</p> <p data-bbox="1344 738 1963 836">Tasks associated with the removal, inspection and installation of internal engine components (i.e., cylinder packs).</p> <p data-bbox="1344 860 1879 925">Understand bearing "roll-in" and tasks associated with in-frame overhauls.</p> <p data-bbox="1344 958 1963 1023">Valve and injector adjustments. Timing and idler gear installations.</p>
<p data-bbox="199 1088 598 1153">Understanding basic engine subsystems</p>	<p data-bbox="682 1088 1171 1153">Comprehension of the key external engine driven systems:</p> <ul data-bbox="682 1153 1008 1218" style="list-style-type: none"> • Hydraulic systems • Accessory systems 	<p data-bbox="1344 1088 1953 1153">Knowledge of hydraulic accessories driven or operated by the engine.</p> <p data-bbox="1344 1185 1963 1250">Understanding of cold weather starting aids and block heaters.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="136 332 562 430">5.7 Fuel and governing systems, mechanical and electronic systems</p> <p data-bbox="205 462 562 527">Understanding basic fuel systems</p>	<p data-bbox="676 462 1243 592">Understand the basic functions of a fuel delivery system. Be able to identify and service the different fuel systems commonly used in various applications.</p> <p data-bbox="676 779 1192 876">Comprehension of basic terms and principles used when discussing fuel systems.</p> <ul data-bbox="676 876 1234 998" style="list-style-type: none">• Fuel delivery and performance tests• Priming/bleeding the basic system• Injector/nozzle testing• Injection pump replacement	<p data-bbox="1348 462 1942 657">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.</p> <p data-bbox="1348 682 1942 747">Understand basic hydraulic principles and fluid transfer technology.</p> <p data-bbox="1348 771 1974 933">Measure specific gravity of fuel and determine proper grade and/or contamination. Understand the use of fuel conditioners, fuel coolers and heaters. Recognize waste oil/fuel blends.</p> <p data-bbox="1348 966 1974 1161">Measure fuel pressure/volume with correct diagnostic tools and compare to specifications. Determine and understand the problems with the basic supply systems. Understand the affects of air, moisture and contamination on the basic fuel system.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="130 305 550 397"><i>5.7 Fuel and governing systems, understanding basic fuel systems (cont.)</i></p> <p data-bbox="199 781 546 841">Understanding governor fundamentals</p>	<p data-bbox="676 781 1272 938">Exercises designed to illustrate governor principles. Identification of the various fuel governing systems including mechanical, pneumatic, hydraulic and electronic controls.</p> <p data-bbox="676 1003 1255 1036">Comprehension of governor terminology.</p>	<p data-bbox="1346 399 1955 495">Proper replacement of fuel transfer pumps, filters, lines, and hoses including proper bleeding/priming procedures.</p> <p data-bbox="1346 526 1976 589">Identify misfiring cylinders with appropriate tooling. Emphasis on cleanliness and safety.</p> <p data-bbox="1346 623 1965 719">Replacement and timing of various injection pumps including inline, distributor and unit injector pumps.</p> <p data-bbox="1346 781 1892 876">Tasks associated with troubleshooting, adjusting and replacing governor components.</p> <p data-bbox="1346 1003 1961 1066">Identification exercises and demonstrations of system operation.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p><i>5.7 Fuel and governing systems understanding governor fundamentals (cont.)</i></p>	<p>Competency demonstrated on the following fuel governing systems:</p> <ul style="list-style-type: none"> • Mechanical systems • Hydraulic/servo systems • Electronic/electric systems • Aneroid/smoke controls 	<p>Inspection and testing of proper mechanical governor operation. Rack settings and low idle adjustments should be emphasized.</p> <p>Troubleshoot hydraulic/servo governors.</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>Be able to demonstrate the ability to locate and test the following sensors: boost pressure, engine position, engine speed, throttle position, manifold pressure, fuel pressure, and high pressure oil sensor.</p>
<p>5.8 Diagnostics</p> <p>Understand proper diesel engine diagnostic procedures</p>	<ul style="list-style-type: none"> • Troubleshooting • Failure analysis • Tools – including PC based and onboard diagnostic systems <p>The ability to extract fault codes and then follow a troubleshooting procedure to a practical resolution of the problem.</p>	<p>Tasks associated with troubleshooting emission controls and basic adjustments.</p> <p>Visual basic exhaust analysis; white, gray or black; as applicable.</p> <p>Practical exercises in identification of common diesel engine problems using proper diagnostic tools and procedures.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p><i>5.8 Diagnostics, understand proper diesel engine diagnostic procedures (cont.)</i></p>	<p>Technical write-up competency</p>	<p>Determine root causes of failure, establish reusability, 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, desktop PCs, and laptops for retrieval of specifications and service procedures.</p> <p>Troubleshooting common problems caused by a malfunctioning engine subsystem.</p> <p>Have a basic understanding of EGR , SCR, DEF, DPF and exhaust after-treatment systems and how their use affects performance.</p> <p>Testing of the engine cooling system, including overheating issues and testing procedures; especially the flow through the radiator; correct temperature drops.</p> <p>Demonstrate technical write-up competency</p> <ul style="list-style-type: none">• Demonstrate logic and critical thinking in identifying, evaluating and diagnosing customer complaint.• Identify the root cause of failure• Correction procedure• Machine inspection

The Standards

6. Air Conditioning/Heating

6.1	Fundamental knowledge	p. 67
6.2	AC systems operation	p. 68
6.3	Servicing AC systems	p. 69
6.4	Testing, troubleshooting, diagnosing and repairing AC systems	p. 70
6.5	Heating system operation	p. 72
6.6	Servicing heating systems	p. 72
6.7	Pressurized cabs	p. 72

6. Air Conditioning/Heating

Critical Functions	Key Activities	Performance Descriptions
6.1 Fundamental knowledge	<p>a. Heat and heat energy.</p> <p>b. Pressure/temperature relationship of refrigerants.</p> <p>c. Refrigerants and refrigerant characteristics.</p>	<p>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.</p> <p>Demonstrate knowledge of the following terms:</p> <ol style="list-style-type: none">1. Sensible heat2. Change of state3. Saturation temperature4. Latent heat (Hidden heat)5. Latent heat of fusion6. Latent heat of evaporation7. Latent heat of condensation8. Super heated9. Sub-cooled10. Vapor11. Gas <p>Demonstrate the knowledge to measure and calculate the effects of pressures on liquids. Emphasis will be placed on understanding and using pressure and temperature (P/T) charts.</p> <p>Demonstrate knowledge of refrigerant characteristics in relation to environmental damage. Emphasis will be placed on identification, labeling, and handling of refrigerants in accordance with EPA regulations.</p>

6. Air Conditioning/Heating

Critical Functions	Key Activities	Performance Descriptions
<p><i>6.1 Fundamental knowledge (cont.)</i></p>	<p>d. Refrigerant oils.</p> <p>e. Refrigerant recovery, recycle, reclaim.</p>	<p>Demonstrate knowledge of the types of oils used in AC systems.</p> <p>Demonstrate knowledge on handling and storing of refrigerant oils.</p> <p>Demonstrate knowledge on recovery, recycle, and reclaiming of refrigerants with respect to the amounts of oil, water and particulates that are removed.</p>
<p>6.2 AC systems operation</p>	<p>a. Basic system components.</p> <p>b. Refrigerant cycle.</p> <p>c. Refrigerant state.</p>	<p>Demonstrate knowledge of the following system components:</p> <ol style="list-style-type: none"> 1. Compressor 2. Condenser 3. Metering device 4. Evaporator 5. Service valves 6. Schrader valves 7. Receiver-drier 8. Accumulator 9. Lines <p>Demonstrate knowledge of refrigerant flow through an AC system.</p> <p>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.</p>

6. Air Conditioning/Heating

Critical Functions	Key Activities	Performance Descriptions
<p>6.3 Servicing AC systems</p>	<p>a. System identification.</p> <p>b. Connecting and disconnecting gauge manifold sets.</p> <p>c. System evacuation and dehydration.</p>	<p>Demonstrate knowledge of how to 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.</p> <p>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-condensables.</p> <p>Demonstrate the ability to connect gauge sets to systems having either Schrader or Stem type service valves.</p> <p>Demonstrate the ability to properly evacuate and dehydrate an AC system.</p> <p>Demonstrate knowledge of the damage caused to AC systems by non-condensables and moisture. Emphasis will be placed on having knowledge of using micron gauges and establishing minimum and maximum evacuation time periods to completely dehydrate AC systems.</p>

6. Air Conditioning/Heating

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="142 211 520 276">6.3 Servicing AC systems (cont.)</p> <p data-bbox="142 690 556 787">6.4 Testing, troubleshooting, diagnosing, and repairing AC systems</p>	<p data-bbox="646 211 1045 276">d. Refrigerant recovery and charging the system.</p> <p data-bbox="646 592 1075 657">e. Adding oil, dye, and refrigerants to AC systems.</p> <p data-bbox="646 690 1075 722">a. Visual inspection of system</p> <p data-bbox="646 941 1108 1039">b. Identify type of system and determine system capacity of refrigerant – weight</p> <p data-bbox="646 1161 1045 1226">c. Identify control systems devices and components</p>	<p data-bbox="1220 211 1879 276">Demonstrate the ability to properly recover and charge AC systems with refrigerants.</p> <p data-bbox="1220 308 1978 406">Emphasis placed on properly connecting and operating gauge manifold sets, recovery and charging equipment.</p> <p data-bbox="1220 438 1953 560">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.</p> <p data-bbox="1220 592 1816 657">Demonstrate the ability to add oil, dye, and refrigerants to operating AC systems.</p> <p data-bbox="1220 690 1969 755">Demonstrate the ability to perform a visual inspection of an AC system.</p> <p data-bbox="1220 755 1957 917"> a. Loose or missing service caps. b. Oily spots – connections – evaporator drain tube. c. Belt tension d. Condensor condition e. Determine refrigerant type. </p> <p data-bbox="1220 941 1963 1039">Demonstrate the ability to visually identify the type of AC system and determine the amount of refrigerant charge.</p> <p data-bbox="1220 1039 1690 1104"> a. TXV(H-Block) – Receiver/drier b. Metered orifice - accumulator </p> <p data-bbox="1220 1161 1921 1226">Demonstrate the ability to identify control systems and components.</p>

6. Air Conditioning/Heating

Critical Functions	Key Activities	Performance Descriptions
<p><i>6.4 Testing, troubleshooting, Diagnosing, and repairing AC systems (cont.)</i></p>	<p>d. Interpreting pressure and temperature readings.</p> <p>e. Metering devices and limit switches.</p> <p>f. Leak detection.</p> <p>g. Component replacement/repair.</p> <p>h. Performance testing including control systems.</p> <p>i. Technical write-up competency</p>	<p>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.</p> <p>Demonstrate the ability to troubleshoot and diagnose metering devices and limit switch malfunctions.</p> <p>Demonstrate the ability to detect refrigerant leaks.</p> <p>Demonstrate the knowledge and/or ability to replace or repair AC system components i.e. compressor, compressor clutch, seals, metering valves, condenser, receiver-drier, accumulator, limit switches and lines.</p> <p>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.</p> <p>Demonstrate technical write-up competency</p> <ul style="list-style-type: none"> • Demonstrate logic and critical thinking in identifying, evaluating and diagnosing customer complaint. • Identify the root cause of failure • Correction procedure • Machine inspection

6. Air Conditioning/Heating

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

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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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APPENDIX – TERMINOLOGY

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.

Hydraulics/Hydrostatics

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

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	ppm:	Parts per million
hp:	Horsepower	psi:	Pounds per square inch, pressure
I.D.:	Inside diameter	psia:	Pounds per square inch absolute
ISO:	International Organization for Standardization	psig:	Pounds per square inch gauge
Kg/cm ² :	Kilograms per square centimeter, metric unit for pressure	PWM:	Pulse width modulation
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 (ECMV)
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
Synchronesh 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
 Blowby
 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 & timing
 Mechanical efficiency
 Naturally aspirated
 RPM
 Specific gravity
 Supercharged / blower
 Temperature
 Thermocouple
 Torque
 Turbocharged
 Vibration
 Viscosity

Additional Acronyms/Abbreviations

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
 H₂O Water
 inHg Inches of Mercury
 In H₂O Inches of Water
 kPa Kilopascal
 N*m Newton-meter
 NO_x Mono-nitrogen oxides
 O₂ Oxygen
 RPM Revolutions per minute
 SCA Supplemental Coolant Additive
 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_x 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_x 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 involvement)
 SCR Selective Catalytic Reduction
 SOV Shut Off Valve
 SO_x 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	Sunlight sensor
BTU	Gas	PSI	A/C controllers
Celsius	Heater coil	Purging	Servo motors
Condensation	Heater evaporator blower	Radiation	Climate controls
Density	Heater/evaporator unit	Receiver – Drier	Inside/outside temperature sensors
Displacement	Heater valve	Thermostat	

Air Conditioning Terminology

Absolute Zero	Density	Liquid line	Substance
Air conditioning	Dessicant	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	
Condensation	Kpa	Schrader valve	
Condensing temperature	Latent heat	Sensible heat	
Condensing pressure	Latent heat of condensation	Specific heat	
Conduction of heat	Latent heat of vaporization	Standard ton	