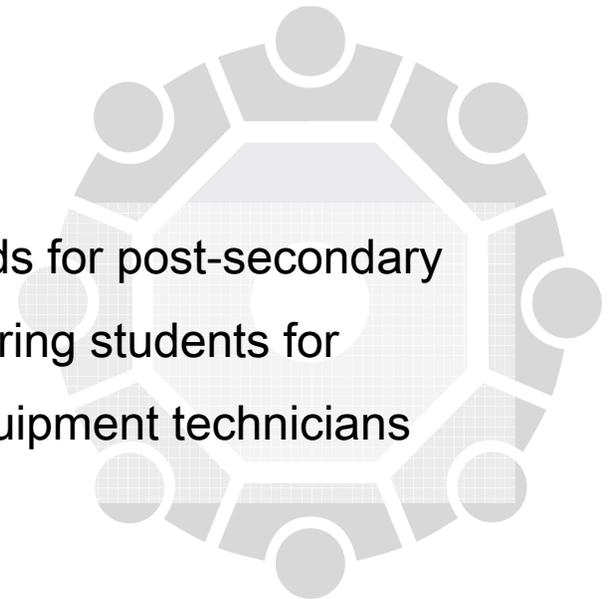


2008 Edition

The AED Foundation
An affiliate of Associated Equipment Distributors

Standards for Construction Equipment Technology

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



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 sixth 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 educational affiliate of Associated Equipment Distributors (AED), an international association of the construction equipment industry representing over 1,000 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.

2008 Edition

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About the 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. Accreditation is available to schools that offer two-year AS or AAS degrees, or four-year schools offering BS or BAS degrees. These degrees must be issued/conferred by the AED Accredited school only. Schools can apply for accreditation by contacting The AED Foundation.

As an important note, as you review these technical standards, please be advised that the delivery of technical core courses must be split among two or more onsite instructors.

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. That is 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,

Glenn C. Williamson
Volunteer, Evaluation Team Leader (ETL)
Chairman, Technical Training Committee
The AED Foundation
Slaton, TX

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Deputy Director
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Oak Brook, IL

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 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 develop a world-class workforce.

Background

The standards answer these important questions:

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

The following section describes why the six specified disciplines are so important. Yes, 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 or a related business, should keep in mind that these standards aim at high targets. A number of schools will meet or exceed the standards. For others, there may be difficulties as schools strive to upgrade their 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 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, 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 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 and manufacturer businesses that are 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's 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 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 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 these standards leads to technical competency, and a resulting career path that enables equipment technicians to earn a good salary and benefits, as well as 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 AEDCareers.com, a website with exciting information about the industry and its career opportunities.

Benefits

For 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.
- 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 the Standards:

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

Note: These 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.

Two and four-year colleges offering AS, AAS, BS or BAS degrees that meet the standards prescribed in this booklet can apply for AED accreditation from The AED Foundation.

AED accreditation for programs in Equipment Technology (sometimes titled Diesel, Mobile Equipment Technology, etc.) is important to the school and program funding, its students,

and industry businesses. Contact The AED Foundation for more information on 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 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**
- **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:

1
2
3

Three Key Standards Description Levels

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

For each set of standards, there first are:

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.

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.

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 application for post-secondary school accreditation from The AED Foundation.
- Changes made in the 2005 edition of the Standards are in bold black font
- Changes made in this 2008 edition of the Standards are in bold red font

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

The Standards

1a. Safety

1a.1	Use of hand tools	p. 14		1a.8	Use of blasting equipment; sand and glass bead type	p. 17
1a.2	Use of electric tools	p. 14		1a.9	Fluid pressure testing equipment	p. 17
1a.3	Use of air tools	p. 14		1a.10	Environment of service facility	p. 18
1a.4	Use of hydraulic tools	p. 15		1a.11	Machine identification and operation	p. 18
1a.5	Use of lifting equipment	p. 15		1a.12	Mandated regulations	p. 19
1a.6	Use of various cleaning equipment	p. 15		1a.13	Shop practices	p. 21
1a.7	Use of metal cutting and welding equipment	p. 16		1a.14	Hazard identification and prevention	p. 21

1b. Administrative

1b.1	Comprehend basic academic functions	p. 22
1b.2	Recognize types of communications equipment and options	p. 22
1b.3	Define the company goals and objectives	p. 23
1b.4	Define basic business practices	p. 23
1b.5	Explain department goals and procedures	p. 24

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.12.</p>	<p>Can identify and correctly name the basic hand tools.</p> <p>Exhibits the designed application and safe operating procedure for each.</p> <p>Demonstrates the proper inspection, care and storage for 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.12.</p>	<p>Can identify and correctly name the electrical tool.</p> <p>Exhibits 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.12.</p>	<p>Can identify and correctly name the basic air tool.</p> <p>Exhibits 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
<p>1a.4 Use of hydraulic tools</p>	<p>Proper and safe use of hydraulic tools used by technician:</p> <ul style="list-style-type: none"> a. Porta powers and pullers b. Hydraulic presses c. Hydraulic pullers <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.12.</p>	<p>Can identify and correctly name the basic hydraulic tools.</p>
<p>1a.5 Use of lifting equipment</p>	<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 stands b. Hoists (overhead and floor type) c. Blocking and cribbing d. Come-A-Long (chain and cable type) e. Lifting chains f. Slings g. Securing chains h. Binders <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.12.</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>1a.6 Use of various cleaning equipment</p>	<p>Proper and safe use of the various types of cleaning equipment used to wash parts and components of machines:</p> <ul style="list-style-type: none"> a. Solvent tank b. Steam cleaner c. Pressure washer d. Hot water washers e. Blow gun <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.12.</p>	<p>Can identify and correctly name the basic cleaning equipment used in our industry.</p> <p>Exhibits 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>Use of various cleaning equipment (cont.)</p> <p>1a.7 Use of metal cutting and welding equipment</p>	<p>Proper and safe use of various types of gas cutting equipment.</p> <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.12.</p> <p>Proper and safe use of various types of welding equipment:</p> <ol style="list-style-type: none"> a. Welding equipment b. Stick welder c. Wire feed welder d. Plasma cutter e. Gas welding 	<p>Can identify the various solvents and solutions used in the cleaning process and the precautions required, both personal and environmental.</p> <p>Demonstrate an understanding of Material Safety Data Sheets (MSDS) and requirements to meet OSHA standards.</p> <p>Can identify and correctly name the various types of gas cutting equipment.</p> <p>Exhibits the designed application and safe operation procedures for each type.</p> <p>Demonstrates the proper inspection, care, maintenance and storage of the equipment and the gases.</p> <p>Can identify, correctly name and demonstrate the use of the personal protective equipment required for the various types of cutting equipment.</p> <p>Demonstrates the proper inspection, care, maintenance and storage of the equipment, electrodes, and gases.</p> <p>Can identify, correctly name and demonstrate the use of the personal protective equipment required for the various types of welding.</p>

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<p>1a.8 Use of blasting equipment; sand and glass bead type</p>	<p>Proper and safe use of various types of blasting equipment used to clean parts and components.</p> <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.12.</p>	<p>Can identify and correctly name the various types of blasting equipment.</p> <p>Exhibits the designed application and safe operation for each type.</p> <p>Demonstrates the proper inspection, care, maintenance and storage of the equipment and the blasting material.</p> <p>Can identify, correctly name and demonstrate the use of the personal protective equipment required for the various types of blasting operations.</p>
<p>1a.9 Fluid pressure testing equipment</p>	<p>Proper and safe use of various types of fluid pressure test equipment and accessories:</p> <ul style="list-style-type: none"> a. Gauges b. Transducers c. Flow rating equipment d. Hydraulic cylinder test e. Benches f. Hydraulic pump and motor g. Test benches h. Fuel system <p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.12.</p>	<p>Can identify and correctly name the various types of fluid pressure test equipment and the accessories required for proper testing.</p> <p>Exhibits and can explain the designed application and safe operation of each type of equipment.</p> <p>Demonstrates the proper inspection, care, maintenance and storage of each type of testing equipment and the 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.10 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 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.12.</p>	<p>Can identify the various types of exhaust systems used in repair facility.</p> <p>Exhibits 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.11 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>Can identify the various types of construction equipment and forklifts, using the standard industry names accepted by equipment manufacturers.</p> <p>Exhibits 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>

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<p>1a.12 Mandated regulations</p>	<p>Exhibits knowledge of personal protection equipment and hazardous materials – reference section 1a.12.</p> <p>Various federal and state OSHA and MSHA regulations.</p> <p>a. Personal protection:</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. Blood-borne pathogens.</p> <p>f. Confined space regulations.</p> <p>g. Forklift operation and certification.</p> <p>h. 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>i. Material Safety Data Sheets (MSDS).</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>

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
Mandated regulations (cont.)	<ul style="list-style-type: none"> j. Handling of flammable liquids and materials. k. Handling of machinery with fluid leaks. l. Back-up alarm requirements for construction machinery. m. Rollover protective equipment for construction machinery (ROPS). n. Electrical ground fault protection. o. Underground utility hazards and standard markings for each type. p. Falling objects protection for construction machinery. q. Fall protection for workers. r. Sub-surface, trench, excavation safety. s. Federal and state labor laws: <ul style="list-style-type: none"> 1. Job safety and health protection 2. Equal opportunity employment 3. Polygraph protection 4. Minimum wage 5. Family and medical leave act of 1993 6. Whistleblower acts t. 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 	Can explain why working safely is important, and explain the procedures for reporting unsafe working conditions and practices.

1a. Safety

Critical Functions	Key Activities	Performance Descriptions
<p>1a.13 Shop 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>Can identify safe work practices in each situation.</p> <p>Can demonstrate safe work practices in the shop or in the field.</p>
<p>1a.14 Hazard identification and prevention</p>	<p>Proper lifting and pulling techniques.</p> <p>Proper mounting and dismounting of machinery.</p> <p>Proper tie-down practices.</p> <p>General knowledge of safety practices.</p> <p>Proper tire and rim handling procedures.</p> <p>Proper tethering techniques.</p>	<p>Can identify proper lifting and pulling techniques to avoid personal injury.</p> <p>Demonstrates proper lifting and pulling techniques.</p> <p>Can explain and demonstrate safe mounting and dismounting practices on construction machinery.</p> <p>Explain proper types of chains and binders used in securing machinery. Proper tie-down procedures.</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 tires. Refer to industry standard procedures.</p> <p>Know when tethering is necessary and proper use of the fall protection equipment.</p>

Note to schools: If service vehicles are used as part of training, basic safety instruction should be extended to include the vehicle as well as devices such as cranes, compressors, generators, pumps, winches, etc. Local equipment distributors may be helpful in providing training related to 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>Develop good listening skills.</p>
<p>1b.2 Recognize types of communication equipment and options</p>	<p>Demonstrate the use of communication technology options.</p> <p>Adequate keyboard 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>

1b. Administrative

Critical Functions	Key Activities	Performance Descriptions
<p>1b.3 Define the company goals and objectives</p>	<p>Read company mission statement, published philosophies, policies/procedures manuals, hand books, and safety guidelines.</p>	<p>Exhibit the ability to communicate to co-workers and customers in a courteous, professional manner.</p> <p>Exhibit the ability to work toward achieving established goals while in a diversified environment.</p> <p>Demonstrate a positive attitude towards the company and other contacts.</p> <p>Exhibit the ability to maintain a clean and safe work area.</p> <p>Exhibit the ability to listen and follow verbal and written instructions.</p> <p>Maintain confidentiality as required.</p> <p>Recognize organizational chart.</p> <p>Define sexual harassment policy, safety rules, environmental regulations, disciplinary action policy, and equal opportunity policy.</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>Demonstrate understanding of how product support activities contribute to the overall profitability of the company.</p> <p>Define impact of not meeting the customers' needs in a timely manner.</p> <p>Identify expense control requirements.</p>

1b. Administrative

Critical Functions	Key Activities	Performance Descriptions
<p>Explain department goals and procedures (cont.)</p>	<p>Demonstrate a positive attitude.</p>	<p>Demonstrate good human relations.</p> <p>Demonstrate a willingness to help.</p> <p>Work toward management's goals.</p> <p>Maintain clean and safe environment.</p> <p>Demonstrate a positive and professional attitude towards the job and others.</p> <p>Demonstrate a desire to continue learning, formally and informally, about industry changes in markets, technology and business practices.</p> <p>Demonstrate the ability to use correct industry terminology.</p> <p>Explain the need for quality performance and the impact on customer satisfaction and profitability.</p> <p>Respect authority and accept the responsibilities of the position.</p>

The Standards

2. Electronics/Electrical Systems

2.1	Fundamental knowledge	p. 27
2.2	Ohm's law	p. 28
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2.5	Lighting, accessory and control systems	p. 30
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2. Electronics/Electrical Systems

Critical Functions	Key Activities	Performance Descriptions
<p>2.1 Fundamental knowledge</p>	<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>4. GPS systems – 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>Awareness of basic GPS systems and their interface with electrical control systems.</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. Repair.	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 disassemble, test, assemble 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. Repair.	<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 disassemble, test, assemble 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 style="color: red;">Lighting, accessory and control systems (cont.)</p> <p>2.6 Electrical schematics/diagrams</p> <p>2.7 SAE computer Can-Buss standards</p>	<p>a. How to read schematics/diagrams.</p> <p>b. How to use schematics/diagrams.</p> <p>a. Understand communication standards.</p> <p>b. Understand published error codes per SAE standards.</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</p> <p>Demonstrate the ability to identify basic electrical/electronic symbols.</p> <p>Demonstrate the ability to trace various circuits using wiring schematics/diagrams.</p> <p>Demonstrate a working knowledge of diagnosing and troubleshooting electrical systems using schematics/diagrams.</p> <p>Demonstrate the knowledge of the different systems used to communicate on computer controlled machinery. SAE J1587 & J1939.</p> <p style="color: red;">Understanding the importance of twisted and shielded wire systems.</p> <p>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="128 300 352 332">2.8 Diagnostics</p> <p data-bbox="184 397 533 430">Systems troubleshooting</p>	<p data-bbox="678 397 1234 552">Follow technical manuals to perform operational checks and troubleshooting procedures to properly diagnose an electrical malfunction in each of the following areas:</p> <ul data-bbox="678 584 1186 812" style="list-style-type: none">a. Cranking systemsb. Charging systemsc. Lighting systemsd. Electric and electronic controlled hydraulic systemse. Electric and electronic controlled hydrostatic systems <p data-bbox="678 868 1270 1063">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="1346 397 1959 462">Exhibit the ability to reason with regard to a specific malfunction in the system.</p> <p data-bbox="1346 495 1942 625">Exhibit 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="1346 657 1921 747">Demonstrate the ability to use schematic diagrams and follow troubleshooting flow charts in selected technical manuals.</p>

The Standards

3. Hydraulics/Hydrostatics

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	Abbreviations	p. 35
3.1	Theory and operation	p. 36
-	Understand hydraulic theory	p. 36
-	Understand hydrostatic theory	p. 37
-	Pump identification and operation	p. 37
-	Motor identification and operation	p. 38
-	Function and operation of hydraulic valves	p. 39
-	Cylinder identification and operation	p. 40
-	Accumulator identification and operation	p. 41
3.2	Fluids, transfer components and filtering	p. 41
3.3	Maintenance procedures	p. 42
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3.5	Hydraulic schematics	p. 44
3.6	Diagnostics	p. 45

*** See also hydrostatic information in Power Train section on page 54.**

Terminology – Hydraulics/Hydrostatics

The student is required to be fully familiar with the following basic terms:

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

Abbreviations – Hydraulics/Hydrostatics

ANSI:	American National Standards Institute	kW:	Kilowatts, metric unit of measure for power
ASAE:	American Society of Agricultural Engineers	lb-ft:	Pounds-foot, torque or turning effort
bar:	Metric unit of measure for pressure	lb-in:	Pounds-inch, torque or turning effort
C:	Degrees Celsius, temperature	L/m:	Liters per minute
F:	Degrees Fahrenheit, temperature	Mpa:	Megapascal, ISO standard measurement for pressure
gpm:	Gallons per minute, fluid flow	Nm:	Newton meters, metric unit of measure for torque
hp:	Horsepower	O.D.:	Outside diameter
I.D.:	Inside diameter	psi:	Pounds per square inch, pressure
ISO:	International Organization for Standardization	ppm	Parts per million
Kg/cm ² :	Kilograms per square centimeter, metric unit for pressure	rpm:	Revolutions per minute
kPa:	Kilo Pascals, metric unit of measure for pressure	SAE:	Society of Automotive Engineers

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>Learn basic hydraulic principles.</p> <p>Understand a basic hydraulic system.</p> <p>Understand and differentiate between open and closed center systems.</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 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>Pump identification and operation (cont.)</p>	<p>Identify a vane pump, its parts, and know its operation.</p> <p>Identify a piston pump, its parts, and know its operation.</p> <p>Identify types of swash plate control.</p>	<p>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>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>Identify types of swash plate control (manual, servo piston, electronic, etc.).</p>
<p>Motor identification and operation</p>	<p>Understand the difference between fixed-displacement and variable-displacement motors.</p> <p>Identify a gear motor, its parts and know its operation.</p> <p>Identify a vane motor, its parts, and know its operation.</p>	<p>Explain the different characteristics between the two motors, exhibit the ability to follow the oil flow through each motor while using a hydraulic function.</p> <p>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>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
Motor identification and operation (cont.)	<p>Identify radial and axial piston motors, their parts, and know their operation.</p>	<p>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>
Function and operation of hydraulic valves	<p>Identify a gerotor motor, its parts, and know its operation.</p> <p>Understand the three major types of hydraulic valves.</p> <p>Understand the functions and uses of pressure control valves.</p>	<p>Be able to identify a gerotor motor, name all parts, and understand its operation.</p> <p>Exhibit the differences between these three major types:</p> <ul style="list-style-type: none"> a.) Pressure control valves b.) Directional control valves c.) Volume control valves <p>Exhibit knowledge of the uses and functions of the following valves:</p> <ul style="list-style-type: none"> a.) Direct acting relief valves b.) Pilot operated relief valves c.) Cartridge relief valves d.) Pilot operated valves e.) Sequence valves f.) Unloading valves g.) Multi-function valves h.) Counterbalance valves i.) Pressure reducing valves

3. Hydraulics/Hydrostatics

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

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
Cylinder identification and operation (cont.)	Identify a double acting cylinder, its parts and know its operation.	Be able to identify a double acting cylinder, name all of its parts, and follow the oil flow through the cylinder. Be able to do the same with a vane type cylinder (rotary actuator).
Accumulator identification and operation	<p>Understand the uses of accumulators.</p> <p>Identify types of accumulators.</p> <p>Understand accumulator safety.</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>
3.2 Fluids, transfer components and filtering	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>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>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p>Fluids, transfer components and filtering (cont.)</p> <p>Know the construction and function of filters used in hydraulic/hydrostatic systems</p> <p>3.3 Maintenance procedures</p> <p>Understand the importance of maintenance</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 <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 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>Describe the use of various filters in hydraulic and hydrostatic systems.</p> <p>Demonstrate familiarity with, and practice good hydraulic maintenance/safety practices.</p> <p>Perform all hydraulic functions in a clean atmosphere.</p> <p>Exhibit the ability to follow the proper flushing procedure using the correct technical manual.</p> <p>Exhibit the proper maintenance techniques to prevent internal and external leaks.</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 causes of "blistering" or frayed hoses and procedures to avoid these problems.</p>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p>Know the characteristics of oils</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 	<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>Fluid Cleanliness</p>	<p>ISO cleanliness codes</p> <p>Interpreting fluid sample reports</p>	<p>Understand ISO cleanliness code principles.</p> <p>Identify key elemental categories.</p>
<p>Understand the usage and types of seals and gasket materials</p>	<p>Know the variety of materials and types of seals/gaskets used in a hydraulic system.</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>3.4 Component rebuild or replacement</p>	<p>Understand the procedure to properly rebuild hydraulic components.</p> <p>Be sure safety practices are followed.</p>	<p>Following the proper technical manual, exhibit the ability to remove, disassemble, diagnose failure, rebuild or replace, reinstall, and test operate any given component including but not limited to:</p> <ul style="list-style-type: none"> • Gear, vane, and piston pumps • Gear, vane, and piston motors • Pressure control valves • Directional control valves • Volume control valves • Single acting, double acting cylinders <p>(If OEM recommends or allows) gas, pneumatic, spring, and weight loaded accumulators.</p>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p>Component replacement</p>	<p>Understand the procedures to properly remove and replace hydraulic components.</p> <p>Be sure safety practices are followed.</p>	<p>Following the proper technical manual, exhibit the ability to remove and replace any given component, including but not limited to:</p> <ul style="list-style-type: none"> • Gear, vane, and piston pumps • Gear, vane, and piston motors • Pressure control valves • Directional control valves • Volume control valves • Single acting, double acting cylinders • Gas, pneumatic, spring, and weight loaded accumulators • Hoses, steel lines, and fittings • Oil coolers • Reservoirs <p>Proper system flushing/cleanup procedures to achieve ISO cleanliness code.</p> <p>Proper bleeding and priming procedures.</p>
<p>3.5 Hydraulic schematics</p>	<p>Identify JIC, ANSI and ISO hydraulic symbols in relation to the component they represent.</p> <p>Identify the position of any given component by reading a schematic.</p> <p>Follow the flow of fluid through a hydraulic system with the use of a schematic.</p>	<p>Exhibit knowledge of symbol identification through demonstration.</p> <p>Given a selected schematic, exhibit your knowledge of schematics by using JIC, ISO and various symbols to identify locations of various components.</p>

3. Hydraulics/Hydrostatics

Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="128 375 352 410">3.6 Diagnostics</p> <p data-bbox="201 440 558 505">Systems and component troubleshooting</p>	<p data-bbox="680 440 1236 570">Follow technical manuals to perform operational checks and troubleshooting procedures to properly diagnose a hydraulic/hydrostatic malfunction.</p> <p data-bbox="680 599 1257 794">Given a school owned piece of training equipment, machine or simulator, exhibit the ability to solve a malfunction that has been installed or established for troubleshooting practice by using proper procedures.</p>	<p data-bbox="1348 440 1961 505">Exhibit the ability to reason with regard to a specific malfunction.</p> <p data-bbox="1348 534 1950 696">Exhibit mastering the use of all test equipment including flow meters, pressure gauges, vacuum gauges, and temperature measuring devices, in both the metric and standard scales.</p> <p data-bbox="1348 725 1955 823">Demonstrate the ability to use schematic diagrams and follow a troubleshooting flow chart using a selected technical manual.</p> <p data-bbox="1348 852 1864 950">Demonstrate the ability to follow an operational check procedure using a selected technical manual.</p>

The Standards

4. Power Trains

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4.2	Driveshaft function and construction	p. 55
4.3	Fundamental theory of hydraulic and pneumatic braking systems	p. 56
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4.5	Power train schematics	p. 58
4.6	Troubleshooting and failure analysis	p. 58
4.7	Component rebuild and replacement	p. 59

Terminology - Power Trains

The student is required to be fully familiar with the following basic terms:

Axle	Direct drive transmission	Power take-off
Axle, hydrostatic drive	Disk clutch	Power train
Backlash	Drop box / transfer case	Pump
Band-type clutches	Dry brakes	Ratio
Barrel cylinder	Electrical clutch controls	Repair indicators
Bearing loads	Endplay	Reverser unit
Bearing	Final drive	Rim
Bearings, ball	Fluids	Ring gear
Bearings, needle	Fluid coupling	Ring and pinion gears
Bearings, roller	Flywheel	Roller chains
Belt alignment	Gear	Servo cylinder
Belt drives	Gear train	Shear pins
Belt friction	Gear pump	Slip clutches
Belt tension	Hydraulic	Spur
Belts	Hydrostatic	Sun gear
Bevel gears, plain	Hydrostatic drive	Swash plate
Bevel gears, spiral	Idler gear	Synchromesh transmission
Cam drives	Impeller	Tension
Carrier bearing for midship support	Inching/modulation pedal	Torque
Chain drives	Input shaft	Torque converter
Calipers	Lubrication	Universal joints / Hooke joints
Clutch	Manual transmissions	V-belts
Clutch pack	Output shaft	Variable-speed belt drives
Collar shift transmission	Overdrives	Wear
Countershaft	Pinion drives	Wear plate
Coolers	Planetary drives	Wet disc brakes
CV Joints	Planetary gears	Wet disc clutch
Dampeners	Pneumatic clutches	Worm gears
Differentials	Power shift transmissions	

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p>Basic principles of power train (cont.)</p>	<ul style="list-style-type: none"> b. Ratios 8. Worm 9. Ring and pinion <p>Anti-friction bearings and plain bearings:</p> <ul style="list-style-type: none"> 1. Ball 2. Roller 3. Needle <p>Torque converter:</p> <ul style="list-style-type: none"> 1. Components: <ul style="list-style-type: none"> a. Impeller b. Turbine c. Stator 2. Operation: <ul style="list-style-type: none"> a. Vortex flow b. Stall c. Torque multiplication d. Lock-up clutches e. Rotary flow f. Cooler flow 3. Testing and troubleshooting: <ul style="list-style-type: none"> a. Converter in pressures b. Converter out pressures 	<p>Identify types of bearings through matching tests.</p> <p>Demonstrate understanding of various types of bearings and benefits of one bearing over another using factors such as size, quietness, cost, durability, and versatility.</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>Given a running piece of equipment with a torque converter, use OEM manuals to test unit and determine if operation is within specifications.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
Theory and principles of manual transmissions	<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>Given a specific transmission, demonstrate your ability to perform all adjustments to that transmission as instructed in the OEM service manual.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p>Theory and principles of powershift transmissions</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. Multiple clutch operation: <ul style="list-style-type: none"> • Clutch engagement chart • Power flow through transmission • Control of clutch engagement d. Accumulator operations e. Rate of shift controls f. Clutch pressures: <ul style="list-style-type: none"> • On-coming clutch • Off-going clutch • Pressure gauge testing g. Hydraulic valving h. 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>Given a selected piece of equipment, use the appropriate service manual to test and/or troubleshoot the powershift transmission and verify if it is within OEM specifications.</p> <p>Exhibit understanding of preload, endplay and backlash by explaining why we need and use them and, given a specific component and OEM manuals, demonstrate ability to set and measure preload, endplay and backlash.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<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 • Button b. Pressure plate: <ul style="list-style-type: none"> • Springs • Plate • Release levers c. Operation 2. Multiple disc clutches: <ol style="list-style-type: none"> a. Components b. Relationship of number of discs to application c. Effect of pressure on torque d. Wet and dry clutches e. Clutch/plate material f. Wear patterns 3. Band clutches: <ol style="list-style-type: none"> a. Basic operation b. Identify types of band clutches 4. Overrunning clutches: <ol style="list-style-type: none"> a. Types: <ul style="list-style-type: none"> • Roller • Cam • Sprag b. Operation c. Application 5. Magnetic clutches: <ol style="list-style-type: none"> a. Operation b. Application 6. 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>Identify components of various types of band clutches, explain where these clutches are used and why band clutches are used on selected systems versus other types of clutches.</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>Theory and principles of hydrostatic transmissions</p> <p>* Also see hydrostatic information in Hydraulics/ Hydrostatics section on page 33.</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 systems3. Testing/ troubleshooting:<ol style="list-style-type: none">a. Proper use of gaugesb. Accuracy of gaugesc. Failure analysis	<p>Demonstrate your understanding of theory and principals of hydrostatic systems by explaining, in writing and in your own words, 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> <p>Given a specific piece of equipment with a hydrostatic drive and the OEM service manuals, demonstrate your ability to follow and check operations to determine if the unit is within OEM specifications.</p> <p>Demonstrate ability to follow a troubleshooting chart for a specific system.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
Theory and principles of hydrostatic transmissions (cont.)	<ol style="list-style-type: none"> 4. Repair cautions: <ol style="list-style-type: none"> a. Cleanliness b. Filling oil lines c. Oil types 	
4.2 Driveshaft function and construction	<ol style="list-style-type: none"> 1. Connections: <ol style="list-style-type: none"> a. U Joint / Hooke joint b. Constant velocity joint 2. Effects of angle of shaft 3. Multiple joint timing 4. Mid-ship supports 5. Repairs 6. 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 gear b. Ring gear c. Bevel gear 2. Differential locking methods: <ol style="list-style-type: none"> a. Mechanical b. Hydraulic c. Automatic no-spin 3. Adjustments: <ol style="list-style-type: none"> a. Preload b. Backlash c. Gear tooth pattern 4. Failure analysis 	<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 piece of equipment and proper OEM manuals, 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 causes of failure with differentials.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<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>Fundamental theory of hydraulic and pneumatic braking systems (cont.)</p>	<p>2. Study hydraulic wheel cylinders: a. Functions b. Construction c. Single/double piston d. Discuss and explain the mechanical working of a hydraulic wheel cylinder</p> <p>3. Study master cylinders: a. Functions b. Construction c. Operating principles</p> <p>4. Air system maintenance a. Air dryers b. Alcohol injectors</p>	
<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 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</p>	<p>Identify symbols.</p>	<p>Be able to identify all electrical/hydraulic, pneumatic and mechanical symbols used in power train units.</p> <p>Demonstrate ability to use schematics to follow both control circuits and power flow of a given piece of equipment using the corresponding OEM manual.</p>
<p>4.6 Troubleshooting</p>	<p>1. Technical manual:</p> <ul style="list-style-type: none"> a. Problem solving b. Decision making c. Problem analysis 	<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>Failure analysis</p>	<p>2. Understanding why parts fail:</p> <ul 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 	<p>Describe common reasons for parts failure and be able to discuss symptoms of wear, corrosion, etc., of actual parts.</p>

4. Power Trains

Critical Functions	Key Activities	Performance Descriptions
<p>4.7 Component rebuild</p>	<p>Understand procedures to properly rebuild components.</p>	<p>Following the proper manual, exhibit the ability to remove, disassemble, diagnose failure, rebuild, reinstall, adjust and test operate any given component including but not limited to:</p> <ul style="list-style-type: none"> • Torque converters • Manual transmissions • Powershift transmissions • Hydrostatic transmissions • Clutches • Driveshafts • Differentials • Final drives
<p>Component replacement</p>	<p>Understand procedures to properly remove and replace power train components.</p>	<p>Following the proper manual, exhibit ability to remove and replace any given component, including but not limited to:</p> <ul style="list-style-type: none"> • Torque converters • Manual transmissions • Powershift transmissions • Hydrostatic transmissions • Clutches • Driveshafts • Differentials • Final drives

The Standards

5. Diesel Engines

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	Terminology	p. 61
	Identification and use of basic tools	p. 63
5.1	Theory and operation	p. 65
5.2	Maintenance practices	p. 68
5.3	Component rebuild	p. 68
5.4	Engine subsystems	p. 69
5.5	Fuel and governing systems, mechanical and electronic systems	p. 71
5.6	Diagnostics	p. 73

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
Safety	Instruction in proper safety practices.	Safety instruction specifically related to engine applications, including OSHA regulations.
Terminology	Define and understand basic engine terminology such as: <ul data-bbox="768 573 1150 1027" style="list-style-type: none">• Bore/stroke• Compression ratio• Compression ignition• Engine displacement• Horsepower• Mechanical efficiency• Torque• Naturally aspirated• Supercharged / blower• Turbocharged	Understanding and comprehension of formulas to calculate engine performance criteria. A possible task list may consist of the following: <ul data-bbox="1417 670 1944 881" style="list-style-type: none">• Measure bore/stroke of various engines• Understand the relationship between engine HP and torque• Record actual engine HP and torque specs from an engine on a dyno

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
Terminology (cont.)	<ul style="list-style-type: none"> • Thermocouple • Temperature • Aftercooled • Back pressure • Barometric pressure • Blowby • BTDC • Cavitation erosion • Dynamometer • ECM • Emissions • Firing order • Glow plug • Heat exchanger • RPM • Specific gravity • Viscosity • Vibration 	<p>Measure and record engine/component temperature. Know the formula to convert Fahrenheit to Celsius.</p> <p>Thorough understanding and comprehension of terms related to engine technology. Examples of recommended tasks to be given throughout this review.</p> <p>Demonstration of the proper use of a manometer to measure engine parameters.</p> <p>Written tests, tasks and exercises used to demonstrate comprehension of engine terminology.</p> <p>Basic smoke analysis exercises.</p> <p>Be able to determine the number of cylinders and firing order of various engines.</p> <p>Demonstration of glow plug operation and testing.</p> <p>Radiator/aftercooler/heater core testing.</p> <p>Determine engine/component speed.</p> <p>Understanding of combustion chamber design.</p> <p>Understanding measurement and properties of fluids.</p> <p>Knowledge of vibration fundamentals.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
Identification and use of basic tools	<p>Use of tools and equipment:</p> <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 MSDS sheets and understanding regulations governing solvents• Use of hydraulic and mechanical presses, pullers and pushers.	<p>Review assignments, evaluation of identification exercises. Written exams that will determine the competency on many items unable to check by hands-on exercises. Emphasis on safety should be demonstrated with all tool usage.</p> <p>Performance testing of tool/equipment to check comprehension. Demonstrate all torque and de-torque methods with hands-on exercises.</p>

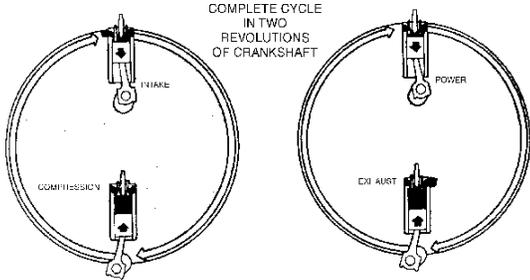
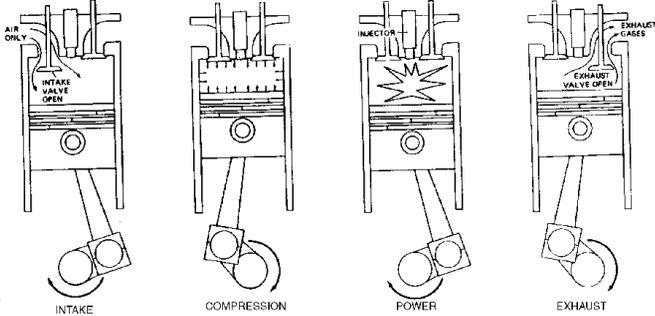
5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>Identification and use of basic tools (cont.)</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. • Hydrometers/refractrometers. • Lubrication guns and equipment. • Compression gauges, cylinder pressure differential testers (CLTs). • 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> <p>Measuring engine compression and cylinder leak-down testing.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>5.1 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 • Diesel combustion • Detonation, pre-ignition • Intake stroke/event • Compression stroke/event • Exhaust stroke/event • Power stroke/event • 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>Be able to explain diesel 4-stroke engine cycle.</p> <p>Know the differences between spark ignited and compression ignition engines.</p> <p>Understand diesel combustion principles, and the effects of pre-ignition, detonation and misfire.</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>Determine engine rotation by valve overlap.</p> <p>Perform basic valve and injection timing tasks.</p> <p>Identify the various combustion chambers and know the advantages/disadvantages of each type.</p> <p>Understand the functions of various cooling system components.</p> <p>Understand the functions and components of diesel engine lubrication systems.</p>

5. Diesel Engines

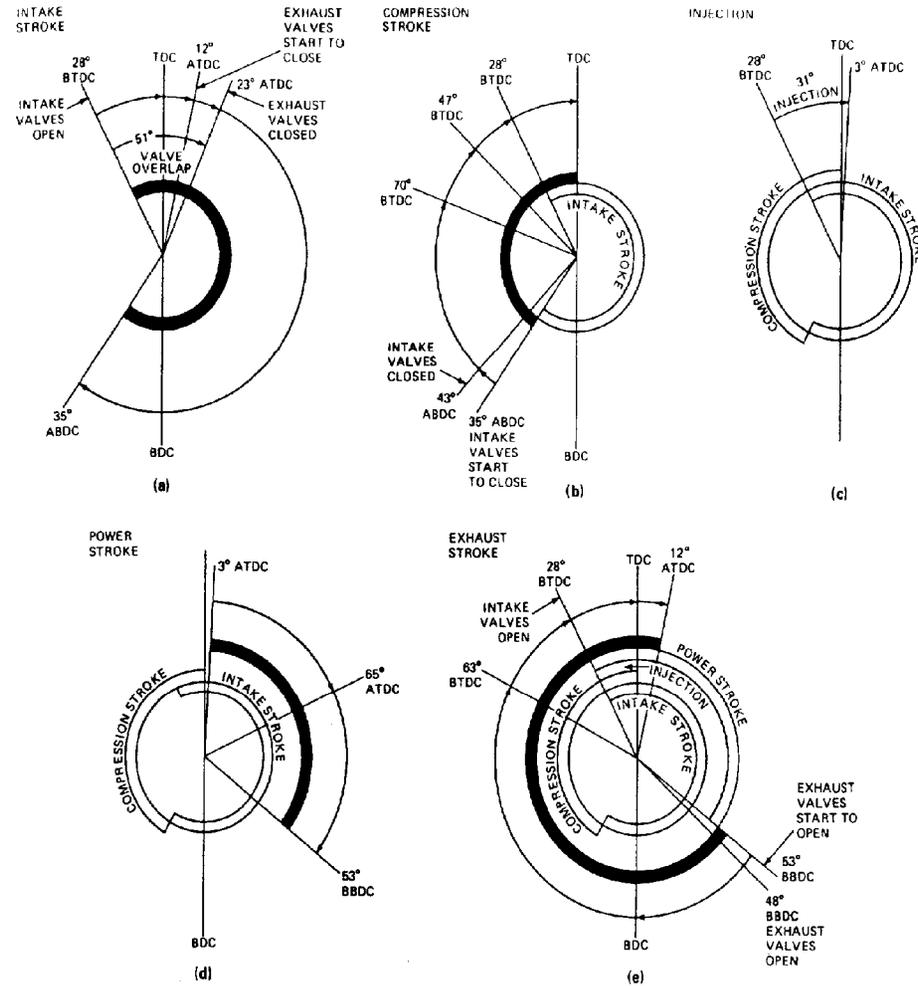
Critical Functions	Key Activities	Performance Descriptions
<p data-bbox="195 423 596 456">Theory and operation (cont.)</p> <p data-bbox="201 922 548 954">Four stroke cycle engine</p>  <p data-bbox="306 1015 422 1073">COMPLETE CYCLE IN TWO REVOLUTIONS OF CRANKSHAFT</p> <p data-bbox="239 1094 268 1105">INTAKE</p> <p data-bbox="533 1094 562 1105">POWER</p> <p data-bbox="138 1195 201 1206">COMPRESSION</p> <p data-bbox="457 1195 520 1206">EXHAUST</p>	<ul data-bbox="690 391 1037 695" style="list-style-type: none"> <li data-bbox="690 391 926 423">• Fuel systems <li data-bbox="690 448 1010 480">• Governing systems <li data-bbox="690 561 989 594">• Emission controls <ul data-bbox="737 602 1037 695" style="list-style-type: none"> <li data-bbox="737 602 1016 634">a. EPA regulations <li data-bbox="737 634 1037 695">b. Penalties for non-compliance 	<p data-bbox="1346 386 1969 516">Understand the functions and components of diesel engine fuel and governing systems (mechanical, electronic and computer controlled).</p> <p data-bbox="1346 548 1948 646">Understand the functions and components of emission control systems and governmental regulations (i.e. EPA, CARB, etc).</p>  <p data-bbox="1402 1084 1444 1096">INTAKE</p> <p data-bbox="1556 1084 1640 1096">COMPRESSION</p> <p data-bbox="1745 1084 1787 1096">POWER</p> <p data-bbox="1906 1084 1969 1096">EXHAUST</p> <p data-bbox="1352 781 1373 813">AIR ONLY</p> <p data-bbox="1352 862 1457 878">INTAKE VALVE OPEN</p> <p data-bbox="1709 781 1730 797">INJECTOR</p> <p data-bbox="1877 797 1982 813">EXHAUST VALVE OPEN</p> <p data-bbox="1961 797 2003 813">EXHAUST GASES</p> <p data-bbox="1346 1154 1976 1382">The word cycle refers to a series of events that repeat themselves. Cycle in relation to diesel engines refers to a series of events that must occur in an engine for it to operate. The somewhat separate but closely related events are intake, compression, power and exhaust.</p>

5. Diesel Engines

Critical functions

Theory and operation (cont.)

Four stroke cycle



Valve timing diagram of a four-cycle engine, showing the progressive steps in one working cycle: (a) intake stroke, (b) compression stroke, (c) injection, (d) power stroke, and (e) exhaust stroke.

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>5.2 Maintenance practices</p> <p>Understanding industry and OEM preventive maintenance procedures</p>	<ul style="list-style-type: none"> • Service literature • Fluid analysis • Fuel types and grades <ul style="list-style-type: none"> a. Bio-fuels b. Low sulphur c. Ultra-low sulphur • Filter dissection / inspection 	<p>Be able to locate OEM 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>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>Fuel analysis and cleanliness.</p>
<p>5.3 Component rebuild</p> <p>Understanding proper component rebuild procedures</p>	<p>Proper component rebuild procedures:</p> <ul style="list-style-type: none"> • Parts reusability guidelines • Cylinder block and related components • Cylinder head and related components 	<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>Practical exercises in parts reusability procedures and guidelines.</p> <p>Tasks associated with reconditioning cylinder heads such as valve grinding/cutting, pressure testing, magnaflux, knurling valve guides, etc.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>Component rebuild (cont.)</p>	<ul style="list-style-type: none"> • Remanufactured components 	<p>Understanding industry and OEM 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 the replacement of these items.</p>
<p>5.4 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 • Aftercooler/intercooler • Exhaust manifolds • Turbocharger/blower/fixed & variable displacement • Water pump • Thermostat housing • Vibration damper • Oil cooler • EGR systems • Heat exchanger 	<p>Locate and identify various external components.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>Engine subsystems (cont.)</p>	<ul style="list-style-type: none"> • Oil filters • Fuel filters • Coolant filters • Hydraulic filters • Air compressor • Hydraulic pump • Power take off • Cold start aids • Fan clutch • Injection pump 	
<p>Understanding internal engine components</p>	<p>Be able to identify basic internal engine components and understand the purpose of each:</p> <ul 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 	<p>Demonstrate comprehension of the removal, inspection and installation techniques associated with basic internal components.</p> <p>Perform identification and inspection of all internal components.</p> <p>Tasks associated with the removal, inspection and installation of internal engine components (i.e., cylinder packs).</p> <p>Perform bearing "roll-in" and tasks associated with in-frame overhauls.</p> <p>Valve and injector adjustments. Timing and idler gear installations.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>Engine subsystems (cont.)</p> <p>Understanding basic engine subsystems</p> <p>5.5 Fuel and governing systems, mechanical and electronic systems</p> <p>Understanding basic fuel systems</p>	<p>Comprehension of the key external engine driven systems:</p> <ul style="list-style-type: none"> • Air systems • Hydraulic systems • Accessory systems <p>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>Comprehension of basic terms and principles used when discussing fuel systems.</p> <ul style="list-style-type: none"> • Fuel delivery and performance tests • Priming/bleeding the basic system • Injector/nozzle testing • Injection pump replacement 	<p>Knowledge of hydraulic accessories driven or operated by the engine.</p> <p>Knowledge of air compressors, refrigerant compressors and other key engine driven accessories. Understanding of cold weather starting aids and block heaters.</p> <p>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>Understand basic hydraulic principles and fluid transfer technology.</p> <p>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>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>Fuel and governing systems (cont.)</p> <p>Understanding basic fuel systems</p>		<p>Proper replacement of fuel transfer pumps, filters, lines, and hoses including proper bleeding/priming procedures.</p> <p>Locate misfiring cylinders. Remove, test and replace injectors/nozzles. Perform basic injector/nozzle "pop" tests. Emphasis on cleanliness and safety.</p> <p>Replacement and timing of various injection pumps including inline, distributor and unit injector pumps.</p>
<p>Understanding governor fundamentals</p>	<p>Exercises designed to illustrate governor principles. Identification of the various fuel governing systems including mechanical, pneumatic, hydraulic and electronic controls.</p> <p>Demonstration of comprehension of governor terminology.</p>	<p>Tasks associated with troubleshooting, adjusting and replacing governor components.</p> <p>Written exams, identification exercises and demonstrations of system operation.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>Fuel and governing systems (cont.)</p> <p>Understanding governor fundamentals</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, low/high idle and torque adjustments should be emphasized.</p> <p>Troubleshooting and adjustment of 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>5.6 Diagnostics</p> <p>Understand proper diesel engine diagnostic procedures</p>	<ul style="list-style-type: none"> • Troubleshooting • Failure analysis • Tools – including PC based diagnostics 	<p>Tasks associated with troubleshooting emission controls and basic adjustments.</p> <p>Practical exercises in identification of common diesel problems using proper diagnostic tools and procedures.</p> <p>Competency demonstrated diagnosing problems associated with diesel engine systems. Identification of potential failures in these critical systems. Thorough understanding of the recommended maintenance performed on these systems.</p>

5. Diesel Engines

Critical Functions	Key Activities	Performance Descriptions
<p>Diagnostics (cont.)</p> <p>Understand proper diesel engine diagnostic procedures</p>		<p>Demonstrate knowledge of crack detection and re-usability guidelines. Determine causes of failure and know the recommended repair options available.</p> <p>Demonstrate proper use of special tools and equipment utilized in engine repair or overhauls.</p> <p>Tasks using technical service manuals, bulletins and special instructions. Proficient use of service manuals, desktop PCs, and laptops for retrieval of specifications and service procedures.</p> <p>Demonstrate proper use of special tools and equipment utilized in engine diagnostics including manual tools, shop manuals, electronic tools, computers.</p> <p>Troubleshooting common problems caused by a malfunctioning engine subsystem.</p>

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6. Air Conditioning/Heating

	Terminology	p. 76
6.1	Fundamental knowledge	p. 77
6.2	AC systems operation	p. 78
6.3	Servicing AC systems	p. 79
6.4	Testing, troubleshooting, diagnosing and repairing AC systems	p. 80
6.5	Heating system operation	p. 82
6.6	Servicing heating systems	p. 82
6.7	Pressurized cabs	p. 82

Terminology – Air Conditioning/Heating

The student is required to be fully familiar with the following basic terms.

Air Conditioning/Heating Basic Terminology

Ambient temperature	Evaporator coil	Pressure
Atmospheric pressure	Expansion valve	PSI
Bleeding	Fahrenheit	Purging
Blower	Gas	Radiation
Boiling point	Heater coil	Receiver – Drier
BTU	Heater evaporator blower	Thermostat
Celsius	Heater/evaporator unit	Thermo siphon
Condensation	Heater valve	Torque
Density	Hg.	Vacuum
Displacement	Joule	Watt
Drier	Kpa	
Evaporation	Potentiometer	

Air Conditioning Terminology

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

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.</p>

6. Air Conditioning/Heating

Critical Functions	Key Activities	Performance Descriptions
<p>Fundamental knowledge (cont.)</p> <p>6.2 AC systems operation</p>	<p>d. Refrigerant oils.</p> <p>e. Refrigerant recovery, recycle, reclaim.</p> <p>a. Basic system components.</p> <p>b. Refrigerant cycle.</p> <p>c. Refrigerant state.</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>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
6.3 Servicing AC systems	<ul style="list-style-type: none">a. System identification. b. Connecting and disconnecting gauge manifold sets. c. System evacuation and dehydration.	<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>Servicing AC systems (cont.)</p> <p>6.4 Testing, troubleshooting, diagnosing, and repairing AC systems</p>	<p>d. Refrigerant recovery and charging.</p> <p>e. Adding oil, dye, and refrigerants to AC systems.</p> <p>a. Visual inspection of system</p> <p>b. Identify type of system and determine system capacity of refrigerant – weight</p> <p>c. Identify control switches, pressure relief valve, fusible plug and their locations</p>	<p>Demonstrate the ability to properly recover and charge AC systems with refrigerants.</p> <p>Emphasis will be placed on properly connecting and operating gauge manifold sets, recovery and charging equipment.</p> <p>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>Demonstrate the ability to add oil, dye, and refrigerants to operating AC systems.</p> <p>Demonstrate the ability to perform a visual inspection of an AC system.</p> <p>a. Loose or missing service caps.</p> <p>b. Oily spots – connections – evaporator drain tube.</p> <p>c. Belt tension</p> <p>d. Condensor condition</p> <p>Demonstrate the ability to visually identify the type of AC system and determine the amount of refrigerant charge.</p> <p>a. TXV(H-Block) – Receiver/drier</p> <p>b. Metered orifice - accumulator</p> <p>Demonstrate the ability to identify control switches and safety relief valves, where they are located, pressure/temperature settings, and how to by-pass.</p> <p>a. Pressure cutout switches; binary/trinary</p> <p>b. Clutch cycle switch</p> <p>c. Thermostatic switch</p>

6. Air Conditioning/Heating

Critical Functions	Key Activities	Performance Descriptions
<p>Testing, troubleshooting, Diagnosing, and repairing AC systems (cont.)</p>	<p>d. Interpreting pressure and temperature readings.</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>e. Metering devices and limit switches.</p>	<p>Demonstrate the ability to troubleshoot and diagnose metering devices and limit switch malfunctions.</p>
	<p>f. Leak detection.</p>	<p>Demonstrate the ability to detect refrigerant leaks.</p>
	<p>g. Component replacement/repair.</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>h. Performance testing.</p>	<p>Demonstrate the ability to test the cooling capabilities of an AC system. Emphasis will be placed on demonstrating the knowledge to determine the operational conditions needed to validate a performance test.</p>

6. Air Conditioning/Heating

Critical Functions	Key Activities	Performance Descriptions
6.5 Heating system operation	<ul style="list-style-type: none"> a. Basic system components. b. Water pumps. c. Coolant flow. d. Thermostats. 	<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>
6.6 Servicing heating systems	<ul style="list-style-type: none"> a. Heater core replacement. b. Control valve. c. Thermostats. 	<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>
6.7 Pressurized cabs		<p>Demonstrate knowledge of how to correctly remove, test and install engine thermostats.</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>

Standards Book, August 2008 Edition - Task Force Leaders

The following industry leaders and educators participated in the 2008 review and revision of this standards document:

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The AED Foundation Technical Training Committee 2007-2008

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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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