Apprenticeship Curriculum Standard

Powered Lift Truck Technician

Level 3

Trade Code: 282E

Date: 2010
Please Note: Apprenticeship Training and Curriculum Standards were developed by the Ministry of Training, Colleges and Universities (MTCU). As of April 8th, 2013, the Ontario College of Trades (College) has become responsible for the development and maintenance of these standards. The College is carrying over existing standards without any changes.

However, because the Apprenticeship Training and Curriculum Standards documents were developed under either the Trades Qualification and Apprenticeship Act (TQAA) or the Apprenticeship and Certification Act, 1998 (ACA), the definitions contained in these documents may no longer be accurate and may not be reflective of the Ontario College of Trades and Apprenticeship Act, 2009 (OCTAA) as the new trades legislation in the province. The College will update these definitions in the future.

Meanwhile, please refer to the College’s website (http://www.collegeoftrades.ca) for the most accurate and up-to-date information about the College. For information on OCTAA and its regulations, please visit: http://www.collegeoftrades.ca/about/legislation-and-regulations
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Introduction

The Powered Lift Truck Curriculum Level 3 has been developed in keeping with the prescribed Ministry of Training, Colleges and Universities (MTCU) Training Standards. The curriculum layout used provides an opportunity to cross-reference the in-school learning outcomes and content to the specific workplace Training Standards.

For easy reference, a time allocation has been included for each reportable subject, along with the Theory/Practical breakdown for the delivery of the Learning Content. More detailed time allocations for the instructor have been provided for each topic area to assure consistency for each apprentice intake.

The continual introduction of innovative techniques and more complex equipment is resulting in increasing demands for tradespersons who are not only skilled in the practical aspects of the trade, but who also have a sound theoretical knowledge of the inspecting, diagnosing, repair, and servicing requirements. The curriculum has been developed to provide this theoretical knowledge and to offer some practical applications to complement the on-the-job work experiences of the Powered Lift Truck apprentices.

The objective of the curriculum, therefore, is to provide a basis for:

a. Sound theoretical training that meet the challenges presented by the increasingly more complex equipment designs and testing techniques.
b. A reinforcement of fundamental skills of the trade through the exposure to practical applications.
c. Developing in the apprentices high standards of craftsmanship, problem-solving skills, and personal pride in their trade.
d. Developing desirable work attitudes and a keen sense of responsibility, particularly concerning public and personal safety.

The curriculum has been designed to give the instructor every reasonable opportunity for flexibility and innovation without deviating to any significant degree from the subject requirements, as determined by the Industry Committees and as prescribed in the Regulations for the Trades. Since the scope of the prescribed curriculum is quite extensive, the apprentices must be expected to reinforce the acquired knowledge through regular independent out-of-classroom assignments. The curriculum has been presented in a chronological sequence in keeping with sound teaching methodologies. However, the actual application of the sequence may differ somewhat between colleges because of scheduling, staffing, and facilities utilization.
The curriculum includes specific references to the Ministry of Training, Colleges and Universities Apprenticeship Training Standards. While these references to various performance objectives in the Training Standards have been linked to the respective in-school outcomes, employers should not assume complete coverage to a journeyperson level. The in-school delivery focuses primarily on the knowledge required to master the respective objectives outlined in the Training Standards. Employers, therefore, are expected to complete the training of these respective objectives by applying the prescribed in-school knowledge to the required practical learning experienced in work setting.

To ensure that apprentices will be able to successfully demonstrate the learning outcomes according to performance criteria, specific times have been allocated in the respective areas to allow for some applications enhancement. It is of utmost importance that all application assignments relate to prescribed experiences only. Time constraints will not permit engaging apprentices in tasks of limited learning benefit that are unrelated to the curriculum outcomes. In the Learning Content section, whenever an assigned operation for an applied test or repair procedure indicates that a demonstration should be performed, there is only enough time allocated for the instructor to perform the activity.

Regular evaluations of the apprentices’ learning achievements must be performed in both theory and practical applications throughout the program to ensure consistency with learning outcome expectations. Testing of apprentice knowledge and skills will take place during the allotted delivery hours for each unit. In addition to providing an evaluation of apprentice competency, the review of test question answers is considered to be a valuable learning opportunity.

In all practical activities, the apprentices will observe the Occupational Health and Safety Act and the applicable regulations including use of personal protective equipment. Institutional regulations and policies may also apply.

Participation by Stakeholders
A consortium of six colleges of applied arts and technology, working in collaboration with the Ministry of Training, Colleges and Universities and industry stakeholders, participated in the development of this document. The development and subsequent revisions were based on the training standards that were previously revised by the MTCU in consultation with industry advisory groups. The development was completed using a process and format approved by MTCU.

Participating Colleges
- Cambrian College of Applied Arts and Technology (Project Lead)
- Algonquin College of Applied Arts and Technology
- Centennial College of Applied Arts and Technology (PLT Level 3 lead)
- Fanshawe College of Applied Arts and Technology
- Mohawk College of Applied Arts and Technology
- Sault College of Applied Arts and Technology
Industry Representatives:

- Equipment World Ltd
- Sudbury Truck & Trailer Ltd
- Toromont CAT Ltd
- Nortrax Ltd
- Xstrata Nickel Ltd
- McGavin Farm Equipment Ltd.
- Elmira Farm Service Ltd
- Liftow Inc.
- Vale Inco Ltd
- Volvo Canada Ltd
- Nortrax Ltd
- Atlas Copco Construction & Mining Canada Ltd

The first step in the development process was to assemble a Project Steering Committee (PSC), consisting of both industry representatives and apprenticeship in-school deliverers. The PSC initiated the plan for the project development that followed. The PSC established six working teams, each responsible for the development of in-school apprenticeship curriculum documents for the specific motive power trades listed below:

- Level 1 common to Agricultural Equipment, Heavy Duty Equipment, Powered Lift Truck, and Truck and Coach
- Level 2 common to Agricultural Equipment and Heavy Duty Equipment
- Level 3 specific to Agricultural Equipment
- Level 3 specific to Heavy Duty Equipment
- Level 2 and 3 specific to Powered Lift Truck
- Level 2 and 3 specific to Truck and Coach

The six teams worked with advisory groups during the development of the curriculum. The advisory groups were industry representatives who ensured content validity. During various stages of the process, the PSC and participating industry advisory groups evaluated the draft curriculum documents and provided feedback and recommendations for revisions.
Power Lift Truck Technician

Level 3
### Program Summary of Reportable Subjects - Level 3

<table>
<thead>
<tr>
<th>Number</th>
<th>Reportable Subjects</th>
<th>Hours Total</th>
<th>Hours Theory</th>
<th>Hours Practical</th>
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<tbody>
<tr>
<td>S1277</td>
<td>Trade Practices</td>
<td>24</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>S1278</td>
<td>Electrical Systems</td>
<td>40</td>
<td>24</td>
<td>16</td>
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<tr>
<td>S1279</td>
<td>Computer Control Systems</td>
<td>16</td>
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<td>4</td>
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<td>S1280</td>
<td>Fuel Systems</td>
<td>24</td>
<td>16</td>
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<tr>
<td>S1281</td>
<td>Engine Systems</td>
<td>32</td>
<td>18</td>
<td>14</td>
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<tr>
<td>S1282</td>
<td>Brake Systems</td>
<td>24</td>
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<td>8</td>
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<tr>
<td>S1283</td>
<td>Frame, Drive, and Lift Systems</td>
<td>40</td>
<td>30</td>
<td>10</td>
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<td>S1284</td>
<td>Hydraulic Systems</td>
<td>40</td>
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<td>15</td>
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<td><strong>240</strong></td>
<td><strong>154</strong></td>
<td><strong>86</strong></td>
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</table>
Number: S1277

Reportable Subject: TRADES PRACTICES

Duration: Total 24 hours Theory 13 hours Practical 11 hours

Prerequisites: P.L.T. Level 2

Co-requisites: None

1.1 Heating, Ventilation, and Air Conditioning (HVAC) Systems
   12 Total Hours Theory: 9 hours Practical: 3 hours

1.2 Metal Inert Gas (MIG) Welding
   12 Total Hours Theory: 4 hours Practical: 8 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
   Proctored final exam.
   Periodic quizzes.

Mark Distribution:

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<tr>
<th>Theory Testing</th>
<th>Practical Application Testing</th>
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Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

<table>
<thead>
<tr>
<th>Metal Inert Gas Welder</th>
<th>Chipping hammers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection of filler rods and consumables</td>
<td>Hand grinders</td>
</tr>
<tr>
<td>Air conditioning reclaiming/ charging equipment</td>
<td>Infra-red temperature measurement tool</td>
</tr>
<tr>
<td>Nitrogen pressure testing equipment</td>
<td>Dye type leak detection equipment</td>
</tr>
<tr>
<td>Manifold gauge set</td>
<td>Air conditioner components</td>
</tr>
<tr>
<td>Basic hand tools</td>
<td>Personal Protective Equipment specific to welding</td>
</tr>
</tbody>
</table>
S1277.1 Heating, Ventilation, and Air Conditioning (HVAC) Systems

Duration: Total 12 hours Theory 9 hours Practical 3 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5878.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to test and recommend repairs of heating and refrigeration units following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.1.1 Explain the purpose and fundamentals of HVAC systems.

[2/0] - A/C air-flow characteristics
- internal to external ventilation
- thermodynamic principles

1.1.2 Identify the functions, construction features, composition, types, styles, and application of HVAC systems.

[2/0] - blower motors and wheels
- plenum chambers and cuts
- air doors
- heater cores
- auxiliary heaters (e.g., Espar, Webasto)
- electrical circuits
- A/C circuit components
- A/C controls

1.1.3 Describe the principles of operation of HVAC systems.

[4/0] - ventilation systems
- blower motor and wheels
- plenum air flow
- air doors
1.1.4 Perform the inspection, testing, and diagnostic procedures following manufacturers’ recommendations on HVAC systems.

- **inspect and test heating systems for:**
  - corroded, restricted, and leaking heater cores
  - loose or defective mountings
  - malfunctioning air door operation
  - defective fan blower operation

- **perform a demonstration of the diagnostic procedures for heating system failures**
  - no heat condition
  - slow warm-up time
  - restricted coolant and/or air flow

- **inspect and test air conditioning systems for:**
  - malfunctioning compressor clutch
  - restricted or contaminated receiver dryer
  - leaking, restricted, or damaged condenser
  - leaking restricted, or damaged evaporator
  - malfunctioning A/C circuit controls

- **perform a demonstration of the diagnostic procedures for air conditioning system failures**
  - leaks
  - restricted condenser and/or evaporator
  - poor cooling
  - evaporator freeze-up
  - lower or higher than specified pressure

1.1.5 Recommend reconditioning or repairs following manufacturers’ recommendations on HVAC system components.

- **outline the recommended repairs based on the system test results**

- **outline the replacement procedures for:**
  - heater cores
  - heater hoses
  - ventilation controls
  - auxiliary heaters
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - pressure escape and containment
  - eye and skin protections
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - high pressure fluid injection/penetration to skin
  - supporting, blocking hydraulic components
- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS
- mathematics
  - système international d'unités (s.i.) to Imperial conversion
Power Lift Truck Technician – Level 3

S1277.2  Metal Inert Gas (MIG) Welding

Duration:  Total 12 hours Theory 4 hours Practical 8 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5860.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform a variety of Metal Inert Gas (MIG) welds following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.2.1  Explain the purpose and fundamentals of MIG welding.

[1/0]  - electricity
       - fusion

1.2.2  Identify the functions, construction features, composition, types, styles, and application of MIG welding.

[2/0]  - MIG welding plant
       - MIG shielding gases
       - MIG gun cooling

1.2.3  Describe the principles of operation of MIG welding equipment and MIG welding procedures.

[1/0]  - AC welding transformers
       - DC rectifiers
       - open circuit voltage
       - closed circuit voltage
       - wire speed factors
       - voltage control factors
       - welding wire coding interpretation
       - weld characteristics
       - advantages of MIG welding
       - destructive and non-destructive weld testing
       - analysis of welded coupons
- short circuit method principles
- spray method principles

1.2.4 Perform MIG welding procedures including equipment set-up.

- **MIG short circuit method welding on mild steel**
  - welding wire selection
  - lap welds
  - fillet welds
  - butt welds
  - positional welding techniques
- outline procedure for MIG spray method
- identify types of steel
- analyze failed welds

1.2.5 Recommend reconditioning or repairs following manufacturers’ recommendations of MIG welding.

- identify personal MIG welding safety equipment requirements and high voltage electrical safety hazards
- review requirements for structural and repair welds on powered lift truck chassis
- identify pressure vessels and non-repairable components
- review explosion hazards safety
- protecting electronic and mechanical components from arcing damage
- perform MIG welding equipment cleaning and maintenance
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, face and clothing protection
  - fire prevention
  - ventilation
  - cut and burn treatments
  - flammable container welding precautions
  - electrical shock protection
  - vehicle electronic protection

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
Number: S1278

Reportable Subject: ELECTRICAL SYSTEMS

Duration: Total 40 hours  Theory 24 hours  Practical 16 hours

Prerequisites: P.L.T. Level 2

Co-requisites: None

2.1 Alternating Current Electric Motor Systems
18 Total Hours  Theory: 10 hours  Practical: 8 hours

2.2 Electronic Ignition Systems
12 Total Hours  Theory: 8 hours  Practical: 4 hours

2.3 Charging Circuits
10 Total Hours  Theory: 6 hours  Practical: 4 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

<table>
<thead>
<tr>
<th>Theory Testing</th>
<th>Practical Application Testing</th>
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Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
OEM Service Manuals

Recommended Minimum Equipment:

<table>
<thead>
<tr>
<th>Powered Lift Truck with AC Motors and Control Systems</th>
<th>Powered Lift Truck with Electronic Ignition or Engines with Electronic Ignitions</th>
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</thead>
<tbody>
<tr>
<td>Engines with Charging Systems</td>
<td>OEM Computer Diagnostic Tools and Cable</td>
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<td>AVR Tester</td>
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S1278.1  Alternating Current Electric Motor Systems

Duration:  Total 18 hours Theory 10 hours Practical 8 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT  5873.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend replacement or repairs to alternating current (AC) electric motor systems following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.1.1  Explain the purpose and fundamentals of alternating current (AC) electric motor systems.

[3/0]  -  electrical fundamentals
        -  electronics
           •  Mosfet

2.1.2  Identify the functions, construction features, and composition of alternating current electric motor systems.

[3/0]  -  alternating current motor types
        -  squirrel cage
        -  motor controllers
        -  transistor switching
           •  frequency modulation
           •  pulse width modulation
           •  Mosfet switching
        -  directional switching devices
        -  mechanical
        -  electronic
2.1.3 Describe the principles of operation of alternating current electric motor systems.

- alternating current motor types
- squirrel cage
- motor controllers
- transistor switching
  - frequency modulation
  - pulse width modulation
  - Mosfet switching
- directional switching devices
  - mechanical
  - electronic

2.1.4 Perform inspection and testing procedures following manufacturers’ recommendations on alternating current electric motor systems and components.

- visual inspection for:
  - overheating
  - corrosion
- demonstrate serviceability testing for:
  - continuity
  - current draw
  - voltage drop
  - bench testing
  - insulation stress test
- demonstrate component failure analysis

2.1.5 Recommend reconditioning or repairs following manufacturers’ recommendations of alternating current electric motor systems.

- outline the recommended maintenance procedures
- disassemble and reassemble alternating current electric motors
- outline the procedures to remove and replace alternating current electric motors and components
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - pressure escape and containment
  - eye and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - high-pressure fluid injection/penetration to skin
  - supporting, blocking hydraulic components

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
S1278.2 Electronic Ignition Systems

Duration: Total 12 hours Theory 8 hours Practical 4 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5865.06

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend replacement or repairs to electronic ignition systems following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.2.1 Explain the purpose and fundamentals of electronic ignition systems.

[2/0]
- electronic ignition systems
- electronic engine management
- distributorless ignition
- semi-conductors
- capacitor
- four-stroke cycle and spark timing
- ignition timing factors
  - engine speed
  - load
  - temperature
  - knock (abnormal combustion)

2.2.2 Identify the functions, construction features, composition, types, and application of electronic ignition systems.

[2/0]
- coils
  - primary and secondary windings
  - coil configurations
    - coil on plug
    - waste spark
- distributors
  - reluctor
  - hall effect
  - optical
  - computer controlled
- spark timing advance mechanisms
  - computer controlled
- **secondary voltage output circuit**
  - high-tension spark plug wires
  - spark plugs
- **ignition modules**
  - sensors
  - crankshaft position
  - camshaft position
  - coolant temperature
  - knock sensor
  - manifold absolute pressure

2.2.3 Describe the principles of operation of electronic ignition systems.

[4/0] - **coils**
  - pulse transformer theory
  - capacitive discharge
- **distributors**
  - reluctor
  - hall effect
  - optical
  - computer controlled
- **spark timing advance mechanisms**
  - computer controlled
    - speed
    - load
    - temperature
    - knock retard
- **secondary voltage output circuit**
  - high-tension spark plug wires
  - spark plugs
- **ignition modules**
- **sensors**
  - crankshaft position
  - camshaft position
  - coolant temperature
  - knock sensor
  - manifold absolute pressure
  - mass airflow
2.2.4 Perform inspection, testing, and diagnostic procedures following manufacturers’ recommendations on electronic ignition systems.

- identify and locate electronic ignition system components on vehicles
- test the following components using an ignition analyzer:
  - distributor components
  - ignition modules
  - sensors
  - switches
  - primary wiring
  - ignition timing and spark advance operation
  - ignition coils and high tension wires
- diagnose electronic ignition system component condition using recommended testing sequence and check for:
  - opens, shorts, grounds, and high resistance
  - primary voltage
  - secondary voltage
  - spark plug firing characteristics

2.2.5 Recommend reconditioning or repairs following manufacturers’ recommendations on electronic ignition systems.

- demonstrate the procedure to replace:
  - spark plugs
  - coils and coil packs
  - ignition modules
  - sensors
  - wiring and connections
  - distributor components
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, and face protection
  - battery gas venting
  - explosion precautions

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
S1278.3 Charging Circuits

Duration: Total 10 hours Theory 6 hours Practical 4 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5862.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to test and recommend repairs of charging systems following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.3.1 Explain the purpose and fundamentals of charging circuits.

[2/0] - electronic basics
- diodes and transistors
- electromagnetism
- voltage induction principles
- inductive reactance of stator
- battery conditions as affecting internal resistance
- principles of tracing wiring schematics
  • electrical/electronic symbols
  • temperature effects
- factors affecting voltage and amperage output
  • field strength
  • rotor speed

2.3.2 Identify the functions, construction features, types, and application of charging circuits.

[2/0] - rectifier
- stator
  • delta
  • wye
- rotor
- field winding, poles, slip rings, brush assembly
- diode trio
- case
- magnetic poles
- bearings
- pulleys
- voltage regulators
  - external electronic
  - internal electronic
  - electronic digital
- cooling
  - fins
  - fans

2.3.3 Describe the principles of operation of charging circuits.

[2/0]  
- three-phase
- rectification
  - fullwave
  - halfwave
- induction principles
- alternating current
- voltage regulator
  - internal and external
  - electronic principles
  - load response
- charge indicators

2.3.4 Perform inspection, testing, and diagnostic procedures following manufacturers’ recommendations on heavy-duty charging circuits.

[0/2]  
- charging system visual inspection of:
  - belt tension and alignment
  - connections and wiring
  - battery and alternator specifications and application
- outline recommended charging system testing sequence
- demonstrate charging circuit voltage drop tests
- demonstrate charging system current and voltage output tests
- identify specific charging system faults from test results
- test electronic noise suppression devices
2.3.5 Recommend reconditioning or repairs following manufacturers’ recommendations on heavy-duty charging circuits.

- verify output capacity to satisfy the specific vehicle electrical load specifications
- demonstrate adjusting alternator drive belt tension and alignment
- outline the performance test repairs on vehicle
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - eye, hearing, breathing and face protection
  - battery gas venting
  - explosion precautions
- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS
- mathematics
  - système international d'unités (s.i.) to Imperial conversion
Power Lift Truck Technician – Level 3

Number: S1279

Reportable Subject: COMPUTER CONTROL SYSTEMS

Duration: Total 16 hours Theory 12 hours Practical 4 hours

Prerequisites: P.L.T. Level 2

Co-requisites: None

3.1 Electronic System Management

16 Total Hours Theory: 12 hours Practical: 4 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

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<th>Practical Application Testing</th>
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Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
OEM Service Manuals

Recommended Minimum Equipment:

<table>
<thead>
<tr>
<th>Powered Lift Truck with Electronic Management Systems</th>
<th>OEM Computer Diagnostic Tools and Cables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Multimeter</td>
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</tbody>
</table>
S1279.1  Electronic System Management

Duration:  Total 16 hours Theory 12 hours Practical 4 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT  5865.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to explain diagnostic procedures of electronic management systems and components.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.1.1  Explain the purpose and fundamentals of electronic management systems.

[1/0]  -  computers
       -  digital logic
       -  digital electronics
       -  input and output circuits

3.1.2  Identify the function, construction features, composition, types, styles, and application of electronic management systems.

[2/0]  -  ECMs
       •  chassis
       •  engine
       •  sub-system controllers
       -  switching apparatus
       -  multiplexed ECMs
       -  interface modules

3.1.3  Describe the principles of operation of electronic management systems.

[4/0]  -  microprocessors
       -  cooling and heat sinks
       -  PROM chips and personality modules
3.1.4 Describe the types of programming and communication protocols used in vehicle electronic management systems.

- interface protocols
- vehicle and engine controllers
- customer data programming
- proprietary data programming
- default modes
- tattletale/audit trail logging
- Barcode readers
- self guided systems
  - wire guided system
  - optical guided system

3.1.5 Perform inspection, testing, and diagnostic procedures following manufacturers’ recommendations on electronic management systems.

- demonstrate the following activities:
  - analyze customer data programming
  - analyze proprietary data programming
  - perform sequential troubleshooting using OEM test procedures
  - outline procedure for diagnosing electronic malfunctions

3.1.6 Recommend reconditioning or repairs following manufacturers’ recommendations on electronic management systems.

- outline procedure for replacing and reprogramming ECMs
- perform a demonstration of proprietary data downloading procedures
- perform a demonstration of programming customer engine and chassis data to an ECM
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, hearing, and hand protection
  - electric shock precautions
  - high pressures/residual pressure
  - polarity precautions
  - electrostatic discharge precautions

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
Power Lift Truck Technician – Level 3

Number: S1280

Reportable Subject: FUEL SYSTEMS

Duration: Total 24 hours  Theory 16 hours  Practical 8 hours

Prerequisites: P.L.T. Level 2

Co-requisites: None

4.1 Port-Helix Metering Injection Pumps
   8 Total Hours  Theory: 5 hours  Practical: 3 hours

4.2 High Pressure Common Rail Fuel Systems
   9 Total Hours  Theory: 6 hours  Practical: 3 hours

4.3 Distributor Pump Injection
   7 Total Hours  Theory: 5 hours  Practical: 2 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
                  Proctored final exam.
                  Periodic quizzes.

Mark Distribution:

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<th>Practical Application Testing</th>
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Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
OEM Service Manuals

Recommended Minimum Equipment:

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<thead>
<tr>
<th>Powered Lift Truck or Engine with High Pressure Common Rail System</th>
<th>Powered Lift Truck or Engine with Distributor Pump Injection</th>
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<tbody>
<tr>
<td>Powered Lift Truck or Engine with Port-Helix Metering Injection Pumps</td>
<td>Special Service Tools</td>
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</tbody>
</table>
S1280.1 Port-Helix Metering Injection Pumps

Duration: Total 8 hours Theory 5 hours Practical 3 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5864.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to explain maintenance and repair procedures for port-helix metering pumps following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.1.1 Explain the purpose and fundamentals of port-helix metering injection pumps.

[2/0] - high pressure fuel injection
- hydraulics
- pressure and sectional area
- basic engine theory
- requirements for combustion of liquid fuels
- combustion characteristics
- direct injection
- indirect injection

4.1.2 Identify the function, construction features, and application of port-helix metering injection pumps.

[1/0] - in-line and V configurations
- flange and cradle mounts
- cambox
- camshaft and tappets
- control racks and sleeves
- plunger and barrel assemblies
- charging gallery
- delivery valves
- lubrication
4.1.3 Describe the basic principles of operation of port-helix metering injection pumps.

- cam geometry
- pumping action
- effective stroke control
- helix geometry
- pressure management
- delivery valve operation
- charging, residual, and peak pressure factors
- cambox and pumping element lubrication
- injection and ignition lag

4.1.4 Perform inspection, testing, and service procedures following manufacturers’ recommendations on port-helix metering injection pumps.

- perform a demonstration of the following activities:
  - spill timing a pump to an engine
  - pin and electronically time diesel engines
  - priming strategies for typical pump systems
  - cylinder short-out procedure
  - calibration and phasing on a comparator bench
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, and hand protection
  - high pressure/skin penetration
  - ventilation of work areas
  - explosion hazard of atomized fuel

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
S1280.2 High-Pressure Common Rail Fuel Systems

Duration: Total 9 hours Theory 6 hours Practical 3 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5864.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend maintenance and repair procedures of the pressure-time, common rail fuel systems following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.2.1 Explain the purpose and fundamentals of high-pressure common rail fuel systems.

[2/0] - diesel engine fundamentals
- diesel fuel system fundamentals
- hydraulics
- combustion
- engine governing
- high pressure pump
- accumulator rail
- high pressure regulation
- multi-pulse injection
- electro-hydraulic injectors

4.2.2 Identify the functions, construction features, composition, types, styles, and application of high-pressure common rail fuel systems.

[2/0] - fuel sub-system
- hydraulics
- combustion
- engine governing
- high pressure pump
- accumulator rail
- high pressure regulation
- multi-pulse injection
- electro-hydraulic injectors

4.2.3 Describe the principles of operation of high-pressure common rail fuel systems.

[2/0]  - engine governing
- high pressure pump
- accumulator rail
- high pressure regulation
- multi-pulse injection
- electro-hydraulic injectors
- hydraulics
- fuel sub-system

4.2.4 Perform inspection following manufacturers’ recommendations on high-pressure common rail fuel systems.

[0/3]  - demonstrate the following activities:
  - system pressure testing
  - system leak testing
  - injector performance testing
  - system performance test
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, and hand protection
  - high pressure/skin penetration
  - ventilation
  - explosion hazard of atomized fuel

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
S1280.3  Distributor Injection Pump

Duration: Total 7 hours Theory 5 hours Practical 2 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard: PLTT 5864.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to outline testing and pump replacement procedures of distributor injection pumps following manufacturers’ recommendations

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.3.1 Explain the purpose and fundamentals of hydromechanical governors.

[1/0] - diesel engine fundamentals
      - diesel fuel system fundamentals
      - diesel fuel sub-systems
      - indirect diesel fuel injection

4.3.2 Identify the functions, construction features, types, and application of distributor type injection pumps.

[2/0] - inlet metering pumps
      - sleeve metering pumps
      - opposed plungers
      - hydraulic heads
      - mechanical governors
      - hydraulic governors
      - lubrication
4.3.3 Describe the principles of operation of distributor-type injection pumps.

- inlet metering factors
- opposed plunger pumping
- sleeve metering
- plunger, barrel, and sleeve
- hydraulic governors
- mechanical governors

4.3.4 Perform inspection and testing procedures following manufacturers’ recommendations on distributor-type injection pumps.

- outline timing procedure

4.3.5 Recommend reconditioning or repairs following manufacturers’ recommendations on distributor-type injection pumps.

- outline removal and installation procedure
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, and hand protection
  - high pressure/skin penetration
  - ventilation of work areas
  - explosion hazard of atomized fuel
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
Number: S1281

Reportable Subject: ENGINE SYSTEMS

Duration: Total 32 hours Theory 18 hours Practical 14 hours

Prerequisites: P.L.T. Level 2

Co-requisites: None

5.1 Engine Intake and Exhaust Systems
8 Total Hours Theory: 6 hours Practical: 2 hours

5.2 Turbochargers
7 Total Hours Theory: 5 hours Practical: 2 hours

5.3 Engine Component Failure Analysis
8 Total Hours Theory: 2 hours Practical: 6 hours

5.4 Engine Diagnostics
9 Total Hours Theory: 6 hours Practical: 3 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

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<th>Practical Application Testing</th>
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Instructional and Delivery Strategies:
Lecture and assignment work
Reference Materials:
OEM Service Manuals

Recommended Minimum Equipment:

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<tr>
<th>Powered Lift Truck or Engine with Turbocharger</th>
<th>Turbocharger</th>
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</thead>
<tbody>
<tr>
<td>Special Service Tools</td>
<td>Electronic Service Tools</td>
</tr>
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</table>
S1281.1 Engine Intake and Exhaust Systems

Duration: Total 8 hours Theory 6 hours Practical 2 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5863.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs of intake and exhaust systems according to manufacturers’ specifications and environmental legislation.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.1.1 Explain the purpose and fundamentals of engine intake and exhaust systems.

[1/0] - fundamentals of intake and exhaust systems and pre-heat devices
  • coolant
  • heater grid
  • heat riser
  • vacuum devices

5.1.2 Identify the functions and construction features of intake and exhaust system components.

[2/0] - air filters
 - boost air coolers
 - intake manifolds
 - valve configurations
 - exhaust manifolds
 - intake and exhaust tract geometry
 - exhaust gas recirculation (EGR) valves
 - positive crankcase ventilation (PCV) valves
 - engine silencers
 - catalytic converters
 - exhaust pipes
5.1.3 Describe the principles of operation of intake and exhaust system components.

- positive filtration
- inlet restriction factors
- boost air cooling
- air flow dynamics
- cylinder breathing
- exhaust back pressure
- noxious emissions
- two stage, three way catalysts
- exhaust gas sensors
- engine silencing
  - sound absorption
  - resonance

5.1.4 Perform inspection, testing, and diagnostic procedures following manufacturers’ recommendations on intake and exhaust systems.

- demonstrate testing for inlet restriction
- demonstrate measuring exhaust back pressure
- outline the procedure for performing exhaust gas analysis
- outline the procedure for performing opacity testing of diesel engines

5.1.5 Recommend reconditioning or repairs following manufacturers’ recommendations on intake and exhaust systems.

- outline air cleaner service procedure
- outline procedures for replacing exhaust system components
- perform a demonstration of stud removal techniques
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - pressure escape and containment
  - eye and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - high-pressure fluid injection/penetration to skin
  - supporting, blocking hydraulic components

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
S1281.2 Turbochargers

Duration: Total 7 hours Theory 5 hours Practical 2 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5863.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to test and describe the replacement procedures of turbochargers and components following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.2.1 Explain the purpose and fundamentals of turbochargers.

[0.5/0]
- engine fundamentals
  - volumetric efficiency
  - thermodynamics
  - rejected heat
  - air temperature and ambient pressure

5.2.2 Identify the function, construction features, composition, types, styles, and application of turbochargers.

[2/0]
- compressor housing
  - turbine shaft
  - turbine housing
  - wheels and vanes
  - seals and bearings
  - intercoolers
  - controls (boost control)
  - lubrication
  - oils, passages, lines
  - cooling
5.2.3 Describe the principles of operation of turbochargers.

- rejected heat
- turbine theory
- boost pressures
- waste-gate controls
- thermal efficiency factors
- constant geometry turbochargers
- variable geometry turbochargers

5.2.4 Perform inspection and testing procedures following manufacturers’ recommendations on turbochargers and controls.

- measure boost pressure
- verify operation of waste-gate controls
- test waste-gate operation
- bench test turbocharger for axial and radial run-out
- identify locations for air, oil, coolant, and exhaust leaks
- verify oil pressure and flow
- outline procedure for testing a charge air cooler

5.2.5 Recommend reconditioning or repairs following manufacturers’ recommendations on turbochargers and controls.

- outline the procedure for replacing turbochargers
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - diesel fuel hazards
  - eye and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - high-pressure fluid injection/penetration to skin
  - supporting, blocking hydraulic components

- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- mathematics
  - système international d'unités (s.i.) to Imperial conversion
S1281.3  Engine Component Failure Analysis

Duration:  Total 8 hours Theory 2 hours Practical 6 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5863.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to analyze failures and recommend repair procedures of engine components following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.3.1  Explain the purpose and fundamentals of engine component failure analysis.

[1/0]
- review engine disassembly methods
- identify procedures to determine primary and secondary causes of component failures
- outline the diagnostic procedures for:
  - lubricating systems (including system leaks)
  - cooling systems (including system leaks)
  - power loss
  - oil consumption
  - engine-related noises
  - vibrations

5.3.2  Identify inspection and testing procedures following manufacturers’ recommendations to determine causes of failures of the following systems and components.

[0/3]
- valve timing mechanism
- effect of wear on gears, chains and belts
- valves
- camshafts
- cylinder blocks
- crankshafts
- cylinders
- pistons and rings
- connecting rods and pins
- bearings and seals
5.3.3 Describe failed engine components with typical failure patterns using manufacturers’ failure analysis photography and guides.

[1/3]
- valve timing mechanism
- effect of wear on gears, chains, and belts
- valves
- camshafts
- cylinder blocks
- crankshafts
- cylinders
- pistons and rings
- connecting rods and pins
- bearings and seals
- cooling system
- lubrication system
- engine breathing
- oil analysis
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - diesel fuel hazards
  - eye and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - high-pressure fluid injection/penetration to skin
  - supporting, blocking hydraulic components

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
S1281.4       Engine Diagnostics

Duration:       Total 9 hours Theory 6 hours Practical 3 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT  5863.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to diagnose engine malfunctions using manufacturers’ sequential trouble trees and electronically-guided troubleshooting methods.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.4.1 Explain the purpose and fundamentals of engine diagnostics.
[1/0]  - engine theory
- electricity
- electronics
- computers
- sequential fault flow chart
- electronic schematics
- test instrumentation
- electronic service tools (EST)

5.4.2 Identify the principles of the recommended engine diagnostic procedures and practices.
[3/0]  - troubleshooting hydromechanically governed engines
- troubleshooting electronically managed engines
- oscilloscope analysis
- distinguishing hydromechanical and electronic malfunctions
- sequential troubleshooting procedures
- software driven sequential troubleshooting procedures
- engine dynamometer
- chassis dynamometer
- road test procedures
5.4.3 Perform inspection, testing, and diagnostic procedures following manufacturers’ recommendations for spark ignited and diesel engines.

- troubleshooting hydromechanically governed engines
- troubleshooting electronically managed engines
- perform the following engine condition evaluation procedures
  - oscilloscope analysis
  - exhaust gas analysis
  - distinguishing hydromechanical and electronic malfunctions
  - cylinder leakage testing
  - cylinder balance testing
  - compression testing
  - sequential troubleshooting procedures
  - outline road test procedures

5.4.4 Recommend reconditioning or repairs following manufacturers’ recommendations on spark ignited and diesel engines.

- outline preventative maintenance procedures
- organize a preventative maintenance program designed to prevent repeat failures
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - eye, hearing, breathing, and hand protection
  - rotating components
  - hazards of spring tension
  - wire and grinding wheels
  - cleaning agents

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
6.1 Hydraulic Brake Systems

24 Total Hours Theory: 16 hours Practical: 8 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

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Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
OEM Service Manuals

Recommended Minimum Equipment:

<table>
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<tr>
<th>Powered Lift Truck or other Equipment with Hydraulic Brake Systems</th>
<th>Powered Lift Truck or other Equipment with Air Brake Systems</th>
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<tr>
<td>Precision Measuring Tools</td>
<td>Assortment of brake components</td>
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S1282.1  Hydraulic Brake Systems

Duration:  Total 24 hours Theory 16 hours Practical 8 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT  5869.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs of hydraulic brake system components following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.1.1 Explain the purpose and fundamentals of hydraulic brake systems.

[2/0]  - law of levers, mechanical advantages
       - coefficient of friction
       - hydraulic principles
       - pressure volume relationship
       - actuator/wheel cylinder
       - potential energy
       - linear force
       - leverage
       - brake torque
       - brake friction factors
       - effects of vehicle load and speed

6.1.2 Identify the function, construction features, composition, types, styles, and application of hydraulic brakes.

[3/2]  - foundation brake assembly
       - master cylinder(foot valve)
         • modulation valves
         • standard and reverse modulation
       - power assist systems
         • hydraulic
         • vacuum
       - accumulators
       - hydraulic plumbing
       - wheel cylinders
6.1.3 Describe the principles of operation of hydraulic brakes.

- **hydraulic brake circuit systems**
  - inching
  - transmission interlock

- **foundation brake assembly**

- **wheel cylinders**
  - adjusters
  - adjusting mechanisms

- **park brakes**
  - parking brake adjusting mechanisms

- **master cylinder** (foot valve)
  - modulation valves
  - standard and reverse modulation

- **accumulators**
  - bladder
  - piston
  - diaphragm

- **power assist systems**
  - hydraulic
  - vacuum

- **brake valves**
  - Standard and reverse modulation

- **charge valve and components**
  - charge control valves
  - accumulators
  - shuttle valves
  - directional valves
  - flow valves
  - sequence valves
  - pumps

- **brake module components**
  - pistons
  - seals
  - springs
  - disc/plates
  - multi-disc
  - inboard/outboard
  - spring applied hydraulic release
  - hydraulic applied spring release
  - external disc brakes
  - brake components
  - interpretation of brake schematics
- **hydraulic plumbing**
  - tubing
  - fittings
  - adapters
  - hose
  - legal requirements
- **ABS systems**
  - traction control

6.1.4 Perform inspection, testing, and diagnostic procedures following manufacturers’ recommendations on hydraulic brake systems.

[0/3 ] - identify and inspect hydraulic brake system components
  - check and adjust charge pressures (kick-in/out)
    - check accumulator charge pressure
    - charge accumulator
  - interpret test results and performance problems
    - noises
    - drag or lockup
    - vibrations
    - imbalance
  - interpret potential malfunctions using manufacturers’ diagnostic troubleshooting procedures
  - check and adjust wheel end brake pressure
  - verify brake system performance
  - failure analysis of failed foundation brake components
  - diagnose typical brake failure modes
  - test and adjust park brake assemblies
  - outline procedure for purging a hydraulic brake system

6.1.5 Recommend reconditioning or repairs following manufacturers’ recommendations on heavy-duty hydraulic brakes.

[0/3] - determine serviceability of hydraulic circuit components
  - identify corrective repair actions according to manufacturers’ recommended procedures
  - disassemble and assemble wheel end assembly
    - spring applied, hydraulic release
    - hydraulic applied, spring release
    - external dry disc
  - outline foundation brake overhaul/service procedure
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - eye, hearing, breathing, and hand protection
  - hoist, jack and stand use
  - air pressure protection
  - grease and friction materials
  - electronic system static electricity precautions
  - bending precautions

- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- mathematics
  - système international d'unités (s.i.) to Imperial conversion
Power Lift Truck Technician – Level 3

Number: S1283

Reportable Subject: FRAME, DRIVE, AND LIFT SYSTEMS

Duration: Total 40 hours Theory 30 hours Practical 10 hours

Prerequisites: P.L.T. Level 2

Co-requisites: None

7.1 Lift Systems

24 Total Hours Theory: 16 hours Practical: 8 hours

7.2 Hydrostatic Drive Systems

16 Total Hours Theory: 14 hours Practical: 2 hours

Evaluation Structure: Assignments related to theory and appropriate application skills. Proctored final exam. Periodic quizzes.

Mark Distribution:

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<th>Practical Application Testing</th>
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Instructional and Delivery Strategies: Lecture and assignment work

Reference Materials:
(Operation and Maintenance of Powered Industrial Lift Trucks)

Recommended Minimum Equipment:

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<th>Powered Lift Truck</th>
<th>Special Service Tools</th>
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S1283.1 Lift Systems

Duration: Total 24 hours Theory 16 hours Practical 8 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard: PLTT 5877.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to outline the repair procedures to main mast assemblies, forks, and attachments following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.1.1 Explain the purposes and fundamentals of mast assemblies, forks, and attachments.

[4/0] - hydraulics
    - frame theory
    - weight and mass calculations
    - trigonometry
    - load transfer
    - acceleration and braking forces
    - properties of metals
7.1.2 Identify the functions, construction features, and composition of mast assemblies, forks, and attachments.

- **mast types**
  - slider mast
  - roller masts
  - mast components
    - channels
    - carriage
    - rollers
    - stub shafts
    - wear strips
    - shims
    - chains and anchors
    - sheaves and shafts
    - cross heads
    - bearings and bushings
    - cylinders
  - mono type
  - wide visible type (clear view)

- 2 stage
  - standard
  - full free lift

- 3 stage

- 4 stage

- **forks**
  - identification
    - latches
    - shank
    - heel
    - blade
    - tip
    - hanger
    - hook
    - tube

- **fork types**
  - hook
  - tube
  - EE rated, explosive application
- **fork design configurations**
  - fork tips
  - tapers
    - standard
    - full
    - full taper and polish
    - lumber taper and polish
  - chisel and bevel options
    - top chisel tip
    - bottom chisel tip
    - standard bevel/no bevel
    - standard full taper and polish
  - capacity
    - class
    - dimensions
    - fork calculations
- **attachments**
  - side shifters
  - fork positioner
  - fork extensions
  - clamp rotator
  - clamp side shifter
  - slip sheet
  - carpet boom
  - baseloid

7.1.3 Describe the principles of operation of mast assemblies, forks, and attachments.

[5/0] - **mast types**
  - slider mast
  - roller masts
  - mast components
    - channels
    - carriages
    - rollers
    - stub shafts
    - wear strips
    - shims
    - chains and anchor
    - sheaves and shafts
    - cross heads
    - bearings and bushings
    - cylinders
  - mono type
  - wide visible type (clear view)
  - 2 stage
    - standard
    - full free lift
  - 3 stage
  - 4 stage
- **forks**
  - identification
    - latches
    - shank
    - heel
    - blade
    - tip
    - hanger
    - hook
    - tube
- **fork types**
  - hook
  - tube
  - EE rated, explosive application
- **fork design configurations**
  - fork tips
  - tapers
    - standard
    - full
    - full taper and polish
    - lumber taper and polish
  - chisel and bevel options
    - top chisel tip
    - bottom chisel tip
    - standard bevel/no bevel
    - standard full taper and polish
  - capacity
    - class
    - dimensions
    - fork calculations
- **attachments**
  - side shifters
  - fork positioner
  - fork extensions
  - clamp rotator
  - clamp side shifter
  - slip sheet
  - carpet boom
  - base load
7.1.4 Perform inspection and diagnostic procedures following manufacturers’ recommendations, according to government regulations and legislation on mast assemblies, forks, and attachments.

- **non destructive testing**
  - masts
    - carriages
    - channels
    - rollers
    - stub shafts
    - wear strips
    - shims
    - chains and anchors
    - sheaves and shafts
    - cross heads
    - bearings and bushings
    - cylinders
  - forks
    - hook type
    - tube type
  - attachments

7.1.5 Recommend reconditioning and repairs following manufacturers’ recommendations according to government regulations and legislation on mast assemblies, forks, and attachments.

- **perform a demonstration of the removal, repair, and replacement procedures for:**
  - masts
    - carriages
    - channels
    - rollers
    - stub shafts
    - wear strips
    - shims
    - chains and anchors
    - sheaves and shafts
    - cross heads
    - bearings and bushings
    - cylinders
  - forks
    - hook type
    - tube type
  - attachments
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - pressure escape and containment
  - eye and skin protection
  - control of hazardous materials
  - lifting/hoisting procedures
  - ventilation of work area
  - high pressure fluid injection/skin penetration
  - supporting and blocking of components

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
S1283.2 Hydrostatic Drive Systems

Duration: Total 16 hours Theory 14 hours Practical 2 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5877.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to outline the repair procedures to hydrostatic drive systems following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.2.1 Define the purpose and fundamentals of hydrostatic drives.

7.2.2 Describe the types and construction features of hydrostatic drives.

7.2.1 - application
   - traction drives
   - non-traction drives

- types
  - open loop
  - closed loop
  - open circuit
  - closed circuit

- fundamentals
  - lubricant types
  - hydraulic pressures and output force
  - coolers and circuits

- torque multiplication
- hydrodynamic versus hydrostatic drive systems
- charge pump
- charge pump circuits

7.2.2 - hydrostatic drives
  - variable displacement pumps
  - fixed displacement pumps
  - variable displacement motors
  - fixed displacement motors

- controls
  - flow limiting
  - flow dividing
  - manual displacement control valves
  - electronic displacement control valves
  - hydraulic displacement control valves
- charge pump
- charge pump circuits
- coolers and circuits

7.2.3 Explain the principles of operation of hydrostatic drives.

[4/0] - hydrostatic drives
  - variable displacement pumps
  - variable displacement motors
  - fixed displacement pumps
  - fixed displacement motors
- operation of drive systems in neutral, forward, and reverse
- controls
  - flow limiting
  - flow dividing
  - manual displacement control valves
  - electronic displacement control valves
  - hydraulic displacement control valves
- charge pumps
- charge pump circuits
- coolers and circuits

7.2.4 Perform the inspection, testing, and diagnostic procedures following manufacturers’ recommendations on hydrostatic drives.

[2/1] - test pressures of various hydrostatic drive systems
- examine and measure hydrostatic drive motor and pump components
- verify recommended operating functions of hydrostatic drive controls
- outline methods and procedures to diagnose and determine causes of abnormal noises, directional control problems, and malfunctions in hydrostatic drive systems
- verify recommended operating temperatures of hydrostatic drives
  - cooler restrictions
  - filter restrictions

7.2.5 Recommend reconditioning or repairs following manufacturers’ recommendations on hydrostatic drives.

[2/1] - demonstrate field adjustments for hydrostatic drive systems
- explain the recommended oil levels and grade
- outline recommended removal and replacement procedures for hydrostatic motors, pumps, and coolers
- demonstrate the disassembly and reassembly procedures for hydrostatic drive systems
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- **safety precautions**
  - pressure escape and containment
  - eye and skin protection
  - control of hazardous materials
  - lifting/hoisting procedures
  - ventilation of work area
  - high pressure fluid injection/skin penetration
  - supporting and blocking of components

- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion
Number: S1284
Reportable Subject: HYDRAULIC SYSTEMS
Duration: Total 40 hours  Theory 25 hours  Practical 15 hours
Prerequisites: P.L.T. Level 2
Co-requisites: None

8.1 Hydraulic Principles
  5 Total Hours  Theory: 5 hours  Practical: 0 hours

8.2 Hydraulic Actuators
  10 Total Hours  Theory: 6 hours  Practical: 4 hours

8.3 Hydraulic Accumulators and Accessories
  8 Total Hours  Theory: 5 hours  Practical: 3 hours

8.4 Hydraulic Schematics and Circuit Applications
  6 Total Hours  Theory: 4 hours  Practical: 2 hours

8.5 Hydraulic System Circuits and Diagnosis
  11 Total Hours  Theory: 5 hours  Practical: 6 hours

Evaluation Structure: Assignments related to theory and appropriate application skills.
Proctored final exam.
Periodic quizzes.

Mark Distribution:

<table>
<thead>
<tr>
<th>Theory Testing</th>
<th>Practical Application Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>65%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
OEM Service Manuals

Recommended Minimum Equipment:

<table>
<thead>
<tr>
<th>Hydraulic Test Board</th>
<th>Powered Lift Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure testing equipment: mechanical &amp; electronic gauges</td>
<td>Hydraulic flow meters</td>
</tr>
</tbody>
</table>
S1284.1 Hydraulic Principles

Duration: Total 5 hours Theory 5 hours Practical 0 hours

Prerequisites: P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT 5876.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to interpret hydraulic system schematics following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

8.1.1 Identify the introductory information of hydraulic circuits and schematics.

[0.5/0] - graphic symbols
- hydraulic circuit layouts
- pictorial drawings
- diagrams
- schematics
- Society of Automotive Engineers (SAE)
- International Standards Organization (ISO)
- American National Standards Institute (ANSI)

8.1.2 Interpret hydraulic component diagrams and schematics.

[0.5/0] - component relationships
- graphic symbols

8.1.3 Explain the oil flow circuit path through the various hydraulic system diagrams and schematics.

[2/0] - open centre systems
  • series connections
  • series-parallel connections
- closed centre systems
  • fixed displacement pump
  • variable displacement pump
- interpret graphic symbols as applied to system circuit schematics
8.1.4 Perform calculation of hydraulic circuit applications.

- pressure
- force
- area
- delivery
- cycle times
- power

GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards - WHMIS

- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- mathematics
  - système international d'unités (s.i.) to Imperial conversion
S1284.2  Hydraulic Actuators

Duration:  Total 11 hours Theory 7 hours Practical 4 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:  
PLTT  5876.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repair procedures for hydraulic actuators following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

8.2.1  Explain the purposes and fundamentals of hydraulic actuators.

[2/0]  -  enhancement of fundamentals
  -  displacement
  -  horsepower
  -  flow rate
  -  aeration
  -  pressure and force
  -  cavitation
  -  friction
  -  graphic symbols
  -  contamination and importance of cleanliness
  -  torque
  -  torque rates
  -  rod speed
  -  shaft speed

8.2.2  Identify the construction features of hydraulic actuators.

[2/0]  -  motors
  -  gear
  -  balance and unbalanced vane
  -  compensating valves
  -  variable displacement piston
  -  radial piston
  -  axial piston
- **cylinders**
  - single acting
  - double acting
  - series telescoping
  - regenerating
  - velocity fuses

8.2.3 Describe the principles of operation of hydraulic actuators.

[2/0]  
- **motors**
  - high speed–low torque
  - low speed–high torque
  - gear
  - vane
  - piston
  - balanced and unbalanced

- **cylinders**
  - single acting
  - double acting

8.2.4 Perform inspection, testing, and diagnostic procedures following manufacturers’ recommendations for hydraulic actuators.

[0/3]  
- **inspection and testing of hydraulic motors**
  - outline the recommended diagnostic procedures for determining faults in hydraulic motors and cylinders
  - examine and analyze failed hydraulic motor and cylinder components

8.2.5 Recommend reconditioning or repairs following manufacturers’ recommendations for hydraulic actuators.

[0/1]  
- outline the recommended procedures to remove and replace hydraulic motors and cylinders
  - dismantle and reassemble hydraulic actuators
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards - WHMIS
- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS
- mathematics
  - système international d'unités (s.i.) to Imperial conversion
S1284.3  Hydraulic Accumulators and Accessories

Duration:  Total 8 hours Theory 5 hours Practical 3 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT  5876.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs for hydraulic accumulators and accessories following manufacturers’ recommendation.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

8.3.1 Explain the purpose and fundamentals of hydraulic accumulators and accessories.

   [1/0]  -  accumulator safety precautions
   -  accumulator types
     -  pneumatic (gas charged)
     -  spring loaded
     -  weighted
   -  pressure boosters
   -  switches
   -  gauges
   -  sensors
     -  pressure
     -  flow
     -  temperature
   -  graphic symbols

8.3.2 Identify the construction features of hydraulic accumulators and accessories.

   [1/0]  -  accumulators
     -  pneumatic (gas charged)
     -  spring loaded
     -  weighted
   -  pressure boosters
   -  switches
   -  sensors
     -  pressure
     -  flow
     -  temperature
8.3.3 Describe the principles of operation of hydraulic accumulators and accessories.

- **accumulator**
  - pneumatic (gas charged)
  - spring loaded
  - weighted
- **pressure boosters**
- **switches**
- **sensors**
  - pressure
  - flow
  - temperature

8.3.4 Perform inspection, testing, and diagnostic procedures following manufacturers’ recommendations for hydraulic accumulators and accessories.

- demonstrate the testing procedures for internal and external leakage of accumulators
- examine defective component parts and relate to primary causes for failure or wear
- demonstrate recommended tests for boosters, pressure switches, gauges, and sensors

8.3.5 Recommend reconditioning or repairs following manufacturers’ recommendations of hydraulic accumulators and accessories.

- outline the recommended safety procedures to service accumulators
- identify location of boosters, pressure switches, gauges, and sensors on hydraulic systems
- outline the recommended repair procedures for boosters, pressure switches, gauges, and sensors
- demonstrate recommended safe charging, adjusting, and repair procedures for accumulators
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - eye and hand protection
  - chemical hazards – WHMIS
  - high pressure concerns for skin penetration

- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- mathematics
  - système international d'unités (s.i.) to Imperial conversion
S1284.4  Hydraulic Schematics and Circuit Applications

Duration:  Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT  5876.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to evaluate circuit design and compare using manufacturers’ schematics.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

8.4.1  Explain the purpose and fundamentals of hydraulic circuits.

[1/0]  -  open centre systems
  •  series connections
  •  parallel connections
  •  series-parallel connections
  •  power beyond
  •  flow dividers

-  closed centre systems
  •  fixed displacement pump and accumulators
  •  variable displacement pump
  •  pressure compensated
  •  power beyond
  •  pressure and flow compensated

-  special flow systems
  •  pressure compensated
  •  flow compensated

8.4.2  Identify the construction features of hydraulic system circuits.

[1/0]  -  open centre systems
  •  series connections
  •  parallel connections
  •  series-parallel connections
  •  power beyond
  •  flow dividers

-  closed centre systems
  •  fixed displacement pump and accumulators
  •  variable displacement pump
  •  pressure compensated
  •  power beyond
  •  pressure and flow compensated
- special flow systems
  - pressure and flow compensated

8.4.3 Describe the principles of operation of hydraulic systems for circuits.

[1/0] - open centre systems
  - series connections
  - parallel connections
  - series-parallel connections
  - power beyond
  - flow dividers

- closed centre systems
  - fixed displacement pump and accumulators
  - variable displacement pump
  - pressure compensated
  - power beyond
  - pressure and flow compensated

- special flow systems
  - pressure and flow compensated

8.4.4 Perform system comparison to schematic representation.

[0/2] - identify component locations
- test points
- conductor routing
- sensor locations

8.4.5 Recommend diagnostic procedures pertinent to system assessment following manufacturers’ recommendations.

[1/0] - outline the steps to achieve circuit evaluation
- interpret factors of flow and pressure that affect circuit operation and compare to manufacturers’ specifications
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards-WHMIS

- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- mathematics
  - système international d'unités (s.i.) to Imperial conversion
S1284.5  Hydraulic System Circuits and Diagnosis

Duration:  Total 11 hours  Theory 5 hours  Practical 6 hours

Prerequisites:  P.L.T. Level 2

Cross-Reference to Training Standard:
PLTT  5876.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to diagnose a hydraulic system and recommend repairs following manufacturers’ recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

8.5.1  Explain the fundamentals of diagnosing hydraulic systems.

[1/0]  - examine and interpret manufacturers’ diagnostic troubleshooting charts for hydraulic systems
       - interpret manufacturers’ schematics

8.5.2  Identify types of failures as related to the manufacturers’ recommended performance criteria for hydraulic systems.

[2/0]  - cavitation
       - aeration
       - contamination
       - oil starvation
       - overheating
       - overloading

8.5.3  Describe the procedures to inspect and test the hydraulic system.

[2/0]  - perform the step-by-step procedures of the troubleshooting charts related to hydraulic systems
       - flow tests
       - pressure tests
       - bypass tests
       - cycle times
8.5.4 Verify hydraulic system performance by applying diagnostic procedures following manufacturers’ recommendations and perform assigned operations.

[0/5] - perform the step-by-step procedures of the troubleshooting charts related to hydraulic systems
  - flow tests
  - pressure tests
  - bypass tests
  - cycle times

8.5.5 Recommend reconditioning or repairs following manufacturers’ recommendations on hydraulic system circuits.

[0/1] - demonstrate failure analysis as related to the following components:
  - pumps
  - piston
  - vane
  - gear
  - control valves
  - pressure
  - flow
  - directional
  - actuators
  - linear
  - rotary
  - conductors
  - adapters
GENERAL PRACTICES

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the Learning Content.

- safety precautions
  - eye, hand and skin protection
  - high pressure concerns for skin penetration
  - chemical hazards – WHMIS
  - diesel fuel hazards
  - control of hazardous material
  - ventilation of work areas
  - lifting/hoisting procedures
  - high-pressure fluid injection/penetration to skin
  - supporting, blocking hydraulic components

- communications
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - service information systems
    - electronics format
  - current legislated requirements
  - WHMIS

- mathematics
  - système international d'unités (s.i.) to Imperial conversion
Acronyms:

This listing identifies acronyms found in the following motive power curriculum documents:

- Level 1 – Commercial Vehicles and Equipment (Common Core)
- Level 2 – Commercial Vehicles and Equipment (Common Core)
- Level 3 – Agricultural Equipment Technician
- Level 3 – Heavy Duty Equipment Technician
- Level 2 – Powered Lift Truck Technician
- Level 3 – Powered Lift Truck Technician
- Level 2 – Truck and Coach Technician
- Level 3 – Truck and Coach Technician

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABS</td>
<td>anti-lock braking system</td>
</tr>
<tr>
<td>AC</td>
<td>alternating current</td>
</tr>
<tr>
<td>A/C</td>
<td>air conditioning</td>
</tr>
<tr>
<td>AET</td>
<td>Agricultural Equipment Technician</td>
</tr>
<tr>
<td>AFC</td>
<td>air fuel control</td>
</tr>
<tr>
<td>AGM</td>
<td>absorbed glass mat</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>ATA</td>
<td>American Trucking Association</td>
</tr>
<tr>
<td>ATC</td>
<td>automatic traction control</td>
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<tr>
<td>AVR</td>
<td>amp, volt, ohmmeter</td>
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<tr>
<td>AWG</td>
<td>American Wire Gauge</td>
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<tr>
<td>AWS</td>
<td>American Welding Society</td>
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<tr>
<td>BCM</td>
<td>body control module</td>
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<td>BSP</td>
<td>British Standard Pipe</td>
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<td>BTM</td>
<td>brushless torque motor</td>
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<td>CB</td>
<td>citizen band</td>
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<tr>
<td>CDI</td>
<td>capacitor discharge ignition</td>
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<td>CD-ROM</td>
<td>compact disc read only memory</td>
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<td>CFC</td>
<td>chlorofluorocarbons</td>
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<td>CI</td>
<td>compression ignited</td>
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<tr>
<td>CMVSS</td>
<td>Canadian Motor Vehicle Safety Standard</td>
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<tr>
<td>CNG</td>
<td>compressed natural gas</td>
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<tr>
<td>CPU</td>
<td>central processing unit</td>
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<tr>
<td>CSA</td>
<td>Canadian Standards Association</td>
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<tr>
<td>CVSA</td>
<td>Canadian Vehicle Standards Association</td>
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<tr>
<td>CWS</td>
<td>collision warning systems</td>
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<tr>
<td>DC</td>
<td>direct current</td>
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<tr>
<td>DDC</td>
<td>Detroit Diesel Corporation</td>
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<td>DFF</td>
<td>direct fuel feed</td>
</tr>
<tr>
<td>DIN</td>
<td>Deutsche Institute fur Normung (German Standards Institute)</td>
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<td>Description</td>
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<tr>
<td>DMM</td>
<td>digital multimeter</td>
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<tr>
<td>DOS</td>
<td>Disk Operating System</td>
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<td>DOT</td>
<td>Department of Transportation</td>
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<td>DPF</td>
<td>diesel particulate filter</td>
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<td>E</td>
<td>electronic control module</td>
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<tr>
<td>ECM</td>
<td>electronic control unit</td>
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<td>ECU</td>
<td>erasable programmable read only memory</td>
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<td>electronically erasable programmable read only memory</td>
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<tr>
<td>EG</td>
<td>ethylene glycol</td>
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<tr>
<td>EGR</td>
<td>exhaust gas recirculation</td>
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<tr>
<td>ELC</td>
<td>extended life coolant</td>
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<tr>
<td>EPA</td>
<td>Environmental Protection Act</td>
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<tr>
<td>EST</td>
<td>electronic service tool</td>
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<td>EUI</td>
<td>electronic unit injector</td>
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<tr>
<td>EUP</td>
<td>electronic unit pump</td>
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<tr>
<td>F</td>
<td>Federal Health and Safety Legislation</td>
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<tr>
<td>FHSL</td>
<td>fault mode indicators</td>
</tr>
<tr>
<td>FMVSS</td>
<td>Federal Motor Vehicle Safety Standards</td>
</tr>
<tr>
<td>FOPS</td>
<td>Falling Object Protection System</td>
</tr>
<tr>
<td>FRP</td>
<td>fiberglass reinforced plywood</td>
</tr>
<tr>
<td>G</td>
<td>Gross Combined Weight Rating</td>
</tr>
<tr>
<td>GCI</td>
<td>gasoline fuel injection</td>
</tr>
<tr>
<td>GPS</td>
<td>global positioning satellite</td>
</tr>
<tr>
<td>GVW</td>
<td>Gross Vehicle Weight</td>
</tr>
<tr>
<td>GVWR</td>
<td>Gross Vehicle Weight Rating</td>
</tr>
<tr>
<td>H</td>
<td>hydrocarbon</td>
</tr>
<tr>
<td>HDET</td>
<td>Heavy Duty Equipment Technician</td>
</tr>
<tr>
<td>HEUI</td>
<td>hydraulically actuated electronic unit injector</td>
</tr>
<tr>
<td>HCFC</td>
<td>hydrochlorofluorocarbons</td>
</tr>
<tr>
<td>HFC</td>
<td>hydrofluorocarbons</td>
</tr>
<tr>
<td>HPI-TP</td>
<td>high pressure injector-time pressure (Cummins)</td>
</tr>
<tr>
<td>HVAC</td>
<td>heating, ventilation and air conditioning</td>
</tr>
<tr>
<td>I</td>
<td>inside diameter</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organization</td>
</tr>
<tr>
<td>J</td>
<td>Joint Industry Conference</td>
</tr>
<tr>
<td>JIS</td>
<td>Japanese Industrial Standard</td>
</tr>
<tr>
<td>JIT</td>
<td>just in time</td>
</tr>
<tr>
<td>KPI</td>
<td>king pin inclination</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------</td>
</tr>
<tr>
<td>LED</td>
<td>light emitting diode</td>
</tr>
<tr>
<td>LPG</td>
<td>liquid petroleum gas</td>
</tr>
<tr>
<td>LVD</td>
<td>low voltage disconnect</td>
</tr>
<tr>
<td>MAP</td>
<td>manifold absolute pressure</td>
</tr>
<tr>
<td>MIDs</td>
<td>message identifiers</td>
</tr>
<tr>
<td>MIG</td>
<td>metal inert gas</td>
</tr>
<tr>
<td>MSDS</td>
<td>material safety data sheet</td>
</tr>
<tr>
<td>MUI</td>
<td>mechanical unit injector</td>
</tr>
<tr>
<td>MVSA</td>
<td>Motor Vehicle Safety Act (Canadian)</td>
</tr>
<tr>
<td>N/A</td>
<td>not applicable</td>
</tr>
<tr>
<td>NOP</td>
<td>nozzle opening pressure</td>
</tr>
<tr>
<td>NPN</td>
<td>negative positive negative semi-conductor</td>
</tr>
<tr>
<td>NPT</td>
<td>National Pipe Thread</td>
</tr>
<tr>
<td>NV-RAM</td>
<td>non-volatile random access memory</td>
</tr>
<tr>
<td>OD</td>
<td>outside diameter</td>
</tr>
<tr>
<td>ODP</td>
<td>ozone depletion prevention</td>
</tr>
<tr>
<td>OEM</td>
<td>original equipment manufacturer</td>
</tr>
<tr>
<td>OHSA</td>
<td>Occupational Health and Safety Act</td>
</tr>
<tr>
<td>OOS</td>
<td>out of service criteria</td>
</tr>
<tr>
<td>OPS</td>
<td>operator protection system</td>
</tr>
<tr>
<td>ORB</td>
<td>o-ring boss</td>
</tr>
<tr>
<td>ORFS</td>
<td>o-ring face seal</td>
</tr>
<tr>
<td>PC</td>
<td>personal computer</td>
</tr>
<tr>
<td>PCV</td>
<td>positive crankcase ventilation</td>
</tr>
<tr>
<td>PFI</td>
<td>port fuel injection</td>
</tr>
<tr>
<td>PG</td>
<td>propylene glycol</td>
</tr>
<tr>
<td>PHSL</td>
<td>Provincial Health and Safety Legislation</td>
</tr>
<tr>
<td>PIDs</td>
<td>parameter identifiers</td>
</tr>
<tr>
<td>PLTT</td>
<td>Powered Lift Truck Technician</td>
</tr>
<tr>
<td>PNP</td>
<td>positive negative positive semi-conductor</td>
</tr>
<tr>
<td>PROM</td>
<td>programmable read only memory</td>
</tr>
<tr>
<td>PT</td>
<td>pressure time</td>
</tr>
<tr>
<td>PTA</td>
<td>pressure time (injector) A series</td>
</tr>
<tr>
<td>PTG-AFC</td>
<td>pressure time governor/air fuel control</td>
</tr>
<tr>
<td>PTD</td>
<td>pressure time (injector) B series</td>
</tr>
<tr>
<td>PTG</td>
<td>pressure time governor (control pump)</td>
</tr>
<tr>
<td>PTO</td>
<td>power take-off</td>
</tr>
<tr>
<td>PWM</td>
<td>pulse width modulation</td>
</tr>
</tbody>
</table>
R
RAM random access memory
RBM resist bend moment
ROM read only memory
ROPS roll over protection system
R.P. recommended practices
RPM revolutions per minute

S
SAE Society of Automotive Engineers
SALT sealed and lubricated tracks
SCA supplemental coolant additives
SI spark ignited
s.i. Système International d'Unités
SIDs sub-system identifiers
SMAW shielded metal arc welding
SRS supplemental restraint systems
STC step timing control

T
TBI throttle body injection
TCT Truck and Coach Technician
TDS total dissolved solids
TP time/pressure injector
TPS throttle position sensor
TQM total quality management
TMC Technical and Maintenance Council

V
VCO valve closes orifice
VIN vehicle identification number

W
WHMIS Workplace Hazardous Materials Information System
WIF water in fuel sensors
Glossary:

This glossary provides definitions of terms found in the following motive power curriculum documents:

Level 1 – Commercial Vehicles and Equipment (Common Core)
Level 2 – Commercial Vehicles and Equipment (Common Core)
Level 3 – Agricultural Equipment Technician
Level 3 – Heavy Duty Equipment Technician
Level 2 – Powered Lift Truck Technician
Level 3 – Powered Lift Truck Technician
Level 2 – Truck and Coach Technician
Level 3 – Truck and Coach Technician

A
ABS Anti-lock braking system. Electronically controlled brakes that monitor vehicle wheel speeds and manage application forces to prevent wheel lock-up.
AC See alternating current.
A/C Air conditioning.
accumulator A cylinder or device used to store pressure, can contain a diaphragm and pneumatic pressure. Used in hydraulic systems.

Ackermann Angle Angle between the planes of the steered wheels of a vehicle with zero steering angle; a measure of toe-in or toe-out.

acronym A word formed by the initial letters of other words.
active codes An electronically monitored system circuit, condition, or component that is malfunctioning and logs an ECM code, which may be displayed or read using an EST.
actuator Any output device controlled by a computer. Also used in hydraulics as an output device such as a linear or rotary device (cylinder or motor).

aeration The mixing of gas with a liquid, usually air with oil, fuel, or coolant.
AFC Air/fuel control.
AFC (Cummins) A circuit that senses turbo boost sensing and is part of the fuel management components on a Cummins PTC-AFC pump.
AFR See air/fuel ratio.
air/fuel ratio The mass ratio of an air-to-fuel mixture; also AFR.
air-to-air aftercooler Heat exchanger that cools the intake air after the turbocharger before going to the intake manifold, by using ambient air.
alcohol Any of a group of distillate hydrocarbon liquids containing at least one hydroxyl group; sometimes referred to as oxygenates.
aldehydes A class of chemical compounds having the general formula RCHO, where R is an alkyl (aliphatic) or aryl (aromatic) radical (SAE J1213 NOV82).
alloy The mixing of a molten base metal with metallic or non-metallic elements to alter the metallurgical characteristics.

alternating current Electric current that reverses cyclically due to reversal of
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>altitude-pressure compensator</td>
<td>Any sensor or device that automatically compensates for changes in altitude.</td>
</tr>
<tr>
<td>Amboid gear</td>
<td>A bevel gear crown and pinion assembly where the axes are at right angles but the pinion is on a higher plane than the crown.</td>
</tr>
<tr>
<td>ANSI</td>
<td>The American National Standards Institute.</td>
</tr>
<tr>
<td>American Society for Testing Materials (ASTM)</td>
<td>Agency that sets industry standards and regulations, including those for fuel.</td>
</tr>
<tr>
<td>ammeter</td>
<td>Instrument for measuring current flow.</td>
</tr>
<tr>
<td>ampere (A)</td>
<td>The unit of measurement for the flow of electric current. An ampere is defined as the amount of current that one volt can send through one ohm of resistance.</td>
</tr>
<tr>
<td>analog</td>
<td>The use of physical variables, such as voltage or length, to represent values.</td>
</tr>
<tr>
<td>anaerobic sealant aneroid</td>
<td>Paste-like sealants that cure (harden) without exposure to air.</td>
</tr>
<tr>
<td>aneroid</td>
<td>A device used to sense light pressure conditions. The term is used to describe manifold boost sensors that limit fueling until there is sufficient boost air to combust it and usually consists of a diaphragm, spring, and fuel-limiting mechanism.</td>
</tr>
<tr>
<td>antifreeze</td>
<td>A liquid solution added to water to blend the engine coolant solution that raises the boiling point and lowers the freezing point. Ethylene glycol (EG), propylene glycol (PG), and extended life coolants (ELC) are currently used.</td>
</tr>
<tr>
<td>antifriction bearing</td>
<td>A bearing that uses balls or rollers between a journal and a bearing surface to decrease friction.</td>
</tr>
<tr>
<td>API</td>
<td>The American Petroleum Institute.</td>
</tr>
<tr>
<td>application software</td>
<td>Programs that direct computer processing operations.</td>
</tr>
<tr>
<td>Apprentice program</td>
<td>Any educational program designed to teach a trade through a combination of on-the-job training and classroom study.</td>
</tr>
<tr>
<td>Apprentice technician</td>
<td>A beginner who is learning under the direction of one or more experienced certified technicians.</td>
</tr>
<tr>
<td>Aqueous Solution</td>
<td>a solution in water, eg. a homogeneous mixture of two or more substances; frequently (but not necessarily) a liquid solution; &quot;he used a solution of peroxide and water&quot;</td>
</tr>
<tr>
<td>Aqueous Urea Injection</td>
<td>Is a system that is designed for reducing NOx (Nitrous Oxide) emissions formed in the presence of high combustion temperatures in internal combustion diesel engines. By injecting urea in the exhaust stream, it causes the NOx to break down into nitrogen and oxygen.</td>
</tr>
<tr>
<td>arcing</td>
<td>Bearing or gear failure caused by electric arcing.</td>
</tr>
<tr>
<td>articulating piston</td>
<td>A two-piece piston with separate crown and skirt assemblies, linked by the piston wrist pin and afforded a degree of independent movement. The wrist pin is usually full floating or bolted directly to the connecting rod, in which case it is known as a crosshead piston.</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing Materials. Standards rating organization that classifies materials generally and all fuels.</td>
</tr>
<tr>
<td>ATA</td>
<td>American Trucking Association. Organization with a broad</td>
</tr>
</tbody>
</table>
spectrum of representation responsible for setting standards in the U.S. trucking industry.

**ATA data link**
An SAE/ATA standard J1584/J1708/J1939, 6-pin Deutsche connector currently used by all truck and truck engine OEMs to access the on-board ECMs.

**ATAAC**
Air-to-air charge air cooling.

**ATDC**
After top dead centre.

**atom**
The smallest part of a chemical element that can take part in a chemical reaction; composed of electrons, protons, and neutrons.

**atomization**
The process of breaking liquid fuel into small droplets by pumping it at a high pressure through a minute flow area.

**atomized droplets**
The liquid droplets emitted from an injector nozzle.

**audit trail**
A means of electronically tracking electronically monitored problems in an engine management system. May be discreet, that is, not read by some diagnostic ESTs and programs; also known as tattletale.

**B**

**backfire**
Ignition/combustion of the fuel in an oxy-acetylene torch in the torch tip causing a popping and squealing noise.

**backlash**
The clearance or “play” between two parts, such as the teeth of two gears.

**battery**
A device containing one or more cells that produces electricity through electrochemical action.

**battery capacity**
The amount of current a battery is capable of delivering.

**battery charging**
The process of restoring a battery’s charge by passing current through it in a reverse direction (positive to negative).

**battery plate**
Battery components made of lead peroxide in sponge form and porous lead.

**battery rating**
Standardized measurement of a battery's ability to deliver an acceptable level of energy under specified conditions. Standards established by the battery council international (BCI).

**baud**
Times per second that a data communications signal changes and permits one bit of data to be transmitted.

**baud rate**
The speed of a data transmission.

**Bernoulli’s Principle**
The statement that an increase in the speed of a fluid produces a decrease in pressure and a decrease in the speed produces an increase in pressure.

**beta ratio**
The beta ratio or rating is used for fine filters and is determined under laboratory testing. Although not a true measure of how well a filter will do in an operating system, the beta rating is a good indicator of the filter performance. The beta ratio of an operating filter during steady state flow test is simply the count upstream divided by the count downstream of fine test dust, based on any selected particle size.

**binary system**
A two-digit arithmetic, numeric system commonly used in computer electronics.

**blower**
A low-pressure air pump used on diesel engines to increase the amount and pressure of the air coming into the engine.
Sometimes referred to as a supercharger.

This sensor measures intake manifold air pressure and sends a signal to the ECM.

A measure of positive air pressure provided by a supercharger or turbocharger.

The diameter of an engine cylinder. Sometimes used to refer to the cylinder itself.

Thin film lubrication characteristics of an oil.

The absolute pressure of a fixed mass of gas varies inversely as the volume, provided the temperature remains constant.

Power developed by an engine measured at the flywheel measured by a dynamometer or brake. Factored by torque or RPM.

Measurement of the amount of heat required to raise the temperature of one pound of water by 1 degree F, at sea level.

A boring bit used for final, accurate bore sizing.

Brushless torque motor. Caterpillar rotary proportional solenoid used for PEEC timing and rack position control.

A filter assembly plumbed in parallel with the lubrication circuit, usually capable of high filtering efficiencies.

A diverter valve fitted to full flow filter (series) mounting pads, designed to reroute lubricant around a plugged filter element to prevent a major engine failure.

The pressure which causes rupture. Also, the inside out differential pressure that causes out-ward structural failures.

High speed RAM located between the CPU and main memory used to increase processing efficiency.

The heating value of a fuel measured in BTU, calories, or joules.

The specific values required when setting performance to specification.

Comparative measuring instrument used for measuring outside diameter and inside diameter.

Trunk-type pistons that are machined slightly eccentrically. Because of the greater mass of material required at the wrist pin boss, this area will expand proportionally more when heated. Cam ground pistons are designed to assume a true circular shape at operating temperatures.

Measure of how much electrical charge can be stored for a given voltage potential; measured in farads.

An electrical device that can store an electrical charge or block AC and pass DC. Also known as condenser.

An element found in various forms including diamonds, charcoal, and coal. It is the primary constituent element in hydrocarbon fuels. Atomic #6.

One of the products of combustion. Also a dry chemical mixture that is an excellent fire retardant. Compressed into solid form this material is known as dry ice, and remains at a
temperature of 109 degrees F.
carbon monoxide (CO) A deadly colorless, odorless gas that is formed when fuel is not burned completely.
carcinogen Any substance, such as asbestos, and carbon tetrachloride, that can cause cancer.
cardan joint A universal joint commonly used as a driveshift coupler permitting articulation. Two yokes are united by a rigid cross whose races run in a yoke supported needle bearings or races.
case-harden A process of heating a piece of steel to harden its surface while the inside remains relatively soft.
catalyst A substance that stimulates, accelerates, or enables a chemical reaction without itself undergoing any change.
catalytic converter An exhaust system device that enables oxidation and reduction reactions; in lean burn truck diesel engines, only oxidation catalytic converters are used at this moment in time.
cavitation Describes metal erosion caused by the formation and subsequent collapse of vapor pockets (bubbles) produced by physical pulsing into a liquid such as that of a wet liner against the wall of coolant that surrounds it. Bubble collapse causes high unit pressures and can quickly erode wet liners when the protective properties of the coolant diminish. Also known in hydraulics as a gaseous condition within a liquid stream causing the rapid implosion of a gaseous bubble.
CCW Counter-clockwise or left hand rotation.
CD Compact disk. Optically encoded, digital data storage.
CD-ROM An optically encoded data disk that is read by a laser in the same way an audio CD is read and is designed for read-only data.
centrifugal filter A filter that uses a centrifuge consisting of a rotating cylinder charged with pressurized fluid and canted jets to drive it; centrifugal filters often have high efficiencies and are often of the bypass type.
centrifugal force The force acting outward on a rotating body.
centrifuge A device that uses centrifugal propulsion or a centrifugal force principle of operation.
centripetal force Tendency to move toward a center; such as water draining from a bathtub.
cetane A colourless liquid (C_{16}H_{34}). Used as a basis to test the performance characteristics of diesel fuel.
cetane improver A diesel fuel additive designed to increase the cetane number rating or ignition quality. Cyclohexanol nitrate is a commonly used cetane improver.
cetane number (CN) The standard rating of a diesel fuel's ignition quality. It is a comparative rating method that measures the ignition quality of a diesel fuel verses that of a mixture of cretonne (good ignition characteristics). A mixture of 45% cretonne and 55% would have a CN of 45. Diesel fuels refined for use in North America are classified by the ASTM as #1D and #2D and must have a minimum CN of 40.
CFM Cubic Feet per Minute. Used as a measurement for the
amount of air entering an engine’s intake.

Charles’ s Law
See Gay-Lussac's Law.

CI
Compression ignition; an engine in which the fuel/air mixture is ignited by the heat of compression.

clearance
A given space between two parts such as a piston and cylinder.

clearance volume
Volume in an engine cylinder when the piston is at TDC.

clockwise rotation
Rotation is the same as the direction as the movement of the hands of a clock.

coefficient of friction
A rating of a material's ability to generate friction. Describes the “aggressiveness” of materials in contact with each other. Affected by temperature and the presence of lubricants.

Cold crank rating (CCR)
Standard battery rating system that identifies the maximum current drain a fully charged battery can deliver at 0 degrees F or -17 degrees C - measured in cold cranking amps (CCA).

Combustion
The act of burning, oxidation.

Combustion chamber
In most current S.I. and C.I. engines, the engine cylinder and the geometry of the head and piston crown form the combustion chamber. In I.D.I. diesel engines, the combustion chamber is a separate cell connected to, but not integral with, the cylinder. Also, the area above the piston with the piston at TDC. Measured in cubic centimeters.

Combustion cycle
The thermodynamic process of a heat engine cycle through induction, compression, oxidation, and exhaust.

Compound
(i) A substance consisting of two or more elements held together by chemical force and not necessarily retaining any of the characteristics of the composite elements; i.e., Water: \( \text{H}_2\text{O} \):

(ii) Auxiliary gearbox that "compounds" the main transmission by increasing the available ratios and ranges.

Compression
The process by which a confined fluid is reduced in volume and increased in density with the application of pressure.

Compression ratio
The ratio of the piston swept volume to the total cylinder volume with the piston at BDC - a volumetric ratio and not a pressure ratio.

Communication Protocol
SAE has specific protocols for mobile equipment communication, such as J1939, J1587/1708

Concentric
Circles having a common centre.

Conductance
The ability of a material to carry an electrical current.

Conductors
Materials that readily permit the flow of electrons from atom to atom; usually metallic elements that have less than 4 electrons in their outer shells.

Conduction
Heat transmission through solid matter, also the transfer of heat from one object to another by being in direct contact.

Connecting rod
The rigid mechanical link between the piston wrist pin and the crankshaft throw.

Constant horsepower
Sometimes used to describe a high torque rise engine.

Co-requisite
A unit of learning that can be taken concurrently with another subject, but in order to be successful, both subjects must be completed successfully.
Conventional theory (Of current flow) asserts that current flows from a positive source to a negative source. Despite the fact that it is fundamentally incorrect, it is nevertheless widely accepted and used.

Convection A transfer of heat from one object to another through a liquid. Also heat transfer occasioned by the upward flow of hot air and the downward flow of cool air.

Counterbore Cylindrical enlargement of the cylinder bore at the block deck to seat a liner flange.

Crankshaft A shaft with offset throws designed to convert the reciprocating movements of the pistons into torque.

Crank throw The offset part of the crankshaft where the connecting rods fasten.

Creep Describes the independent movement of two components clamped by fasteners when they have different coefficients of thermal expansion or have different mass, which means their expansion and contraction rates do not concur.

Cross flow Describes a four-stroke cycle engine breathing configuration where intake and exhaust manifolds are located on opposite sides of the cylinder head so gas flow is across the piston crown.

Crosshead Part of the valve train in an engine that actuates two valves per cylinder. Permits two valves in the same cylinder to be opened simultaneously by a single rocker arm.

Crosshead piston An articulating piston with separate crown and skirt assemblies in which the connecting rod is bolted directly to the wrist pin.

Crude oil The organic fossil fuel pumped from the ground from which diesel fuel, gasoline, and many other petroleum products are refined; raw petroleum.

Current The flow of free electrons through a conductor.

Curriculum hour Is described as the breakdown of time for theory and practical in-school delivery. It is timed at 50 minutes per curriculum hour listed in the document.

Cycle time A reoccurring period in which a series of actions take place in a definite order. Also used in hydraulics as the time it takes for an actuator or function to complete full extend to full retract: thus a cycle time.

Cylinder block The main frame of any engine to which all the other components are attached.

Cylinder head A detachable portion of an engine that covers the upper end of the cylinder bores and forms part of the combustion chamber. Also includes the valves in the case of overhead valve engines.

Cylinder sleeve A liner or sleeve interposed between the piston and the cylinder wall or water jacket to provide an easily replaceable surface for the cylinders.

Damper A unit or device used to reduce or eliminate vibration, oscillation, of a moving part, fluid, etc.
Data
Raw (unprocessed) information.

Database
A data storage location or program.

Data link
The connection point or path for data transmission in networked devices.

Data link connector
Plastic plug-in terminal with two or more electrical connections used to interface with engine or vehicle’s computers.

DC
Direct current.

DCA
Diesel coolant additives. A proprietary supplemental coolant additive.

DI
Direct injection. Fuel is injected directly into the engine cylinder. This is the common means of injecting, current C.I. engines and used in some gasoline-fueled engines.

Dial indicator
Tool used to precisely measure linear travel.

Diesel cycle
A four-stroke cycle similar to the Otto cycle (intake, compression, expansion, and exhaust strokes) but where ignition of the fuel charge is occasioned by the heat of compression. A true diesel cycle engine is known as a constant pressure engine, meaning that fuel is metered into the cylinder at a rate that will produce constant pressure for a number of crank angle degrees.

Digital signal
An electronic signal that uses on and off pulses.

Diode
A semiconductor device that allows current flow in one direction but resists it in the other, which acts like an electrical check valve.

Displacement
The total volume displaced by the cylinders when moving from BDC to TDC.

Direct current (DC)
Electric current that flows steadily in one direction only.

Droop
An engine governor term denoting a transient speed variation that occurs when engine loading suddenly changes.

Droop curve
A required hydro-mechanical governor characteristic in which fueling drops off in an even curve as engine speed increases from the rated power value to high idle.

Dry air filter
A filter element that requires no oil or other liquid medium to trap dirt particles. Most motive power air filters are of the dry type.

Dry liners
Liners that are fitted either with fractional looseness or fractional interference that dissipate cylinder heat to the cylinder block bore and have no direct contact with the water jacket.

Electromagnetism
Describes any magnetic field created by current flow through a conductor.

Electron
A negatively charged component of an atom.

Electrolyte
A solution capable of conducting electrical current.

Electron theory
The theory that asserts that current flow through a circuit is by electron movement from a negatively charged point to a positively charged one. See conventional theory.

Electronic engine management
Computerized engine control.

Electronic control unit
Refers to the computer and integral switching apparatus in an
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ECU)</td>
<td>electronically controlled system. Some engine OEMs use this term rather than the more commonly used ECM.</td>
</tr>
<tr>
<td>Electronically controlled unit injector</td>
<td>Mechanically actuated, electronically controlled unit injector that combines pumping, electronic fuel metering, and injecting elements in a single unit.</td>
</tr>
<tr>
<td>Emissions</td>
<td>Any release of harmful materials into the environment. Gases produced from exhaust, crankcase, and fuel tanks and their contribution to smog.</td>
</tr>
<tr>
<td>End play</td>
<td>Amount of lengthwise movement between two parts due to clearance.</td>
</tr>
<tr>
<td>Energy</td>
<td>Any capacity for doing work.</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>A liquid chemical used in engine coolant. See antifreeze.</td>
</tr>
<tr>
<td>Exhaust scrubber</td>
<td>An exhaust emission device used to clean particulate matter from engine exhaust. Used predominately in off road equipment for use in underground mining and enclosed buildings.</td>
</tr>
<tr>
<td>Expansion ratio</td>
<td>Ratio of cylinder volume at the moment the exhaust port or valves open to clearance volume; usually less than compression ratio.</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Material failure or deterioration due to repetitive stress loading or usage.</td>
</tr>
<tr>
<td>Ferrous material</td>
<td>Metal containing metal or steel.</td>
</tr>
<tr>
<td>Fiber optics</td>
<td>The transmission of laser light waves through thin stands of fiber. Used to digitally pulse data more cheaply and at much higher speeds than copper wire.</td>
</tr>
<tr>
<td>Fire point</td>
<td>The temperature at which a flammable material or liquid vaporizes at a rate sufficient to burn continuously.</td>
</tr>
<tr>
<td>Flammable</td>
<td>Any substance that can be combusted.</td>
</tr>
<tr>
<td>Flashback</td>
<td>A highly dangerous condition that can occur in operating oxy-acetylene equipment in which the flame may travel behind the mixing chamber in the torch and explode the acetylene tank using the system oxygen. Most current oxy-acetylene torches are equipped with flashback arresters.</td>
</tr>
<tr>
<td>Fluid power</td>
<td>The term used to describe both hydraulics and pneumatics.</td>
</tr>
<tr>
<td>Flywheel</td>
<td>A large heavy wheel that forms the base for the starter ring gear and in which energy is absorbed and stored by means of momentum. Also provides a mounting surface for the torque converter or clutch assembly.</td>
</tr>
<tr>
<td>Force</td>
<td>The action of one body attempting to change the state of motion of another. The application of force does not necessarily result in any work accomplished.</td>
</tr>
<tr>
<td>Friction</td>
<td>The resistance an object or fluid encounters in moving over or through another.</td>
</tr>
<tr>
<td>Four-stroke cycle engine</td>
<td>An engine design where a power pulse occurs every other revolution of the crankshaft. These strokes are (1) intake stroke (2) compression (3) power or expansion stroke; and (4) exhaust stroke.</td>
</tr>
</tbody>
</table>
| Full-floating                            | Used to describe components that permit more than the usual amount of movement—for instance a full-floating piston pin is
Retained in the pin boss, but permits independent movement of both the piston and the rod eye.

**Full floating axle**

A drive axle design where the axle shafts provide wheel torque only and bear no part of the vehicle load.

**G**

**Gay-Lussac's Law**
The law that at constant pressure the volume of a fixed mass or quantity of gas varies directly with the absolute temperature; a close approximation. Also known as Charles’s Law.

**General Learning Outcomes**

Learning outcomes represent culminating demonstrations of learning and achievement. Outcomes are not simply a listing of discrete skills, nor broad statements of knowledge and comprehension. Outcomes describe performances that demonstrate that significant learning has been achieved and applied.

**General Practices**

This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the learning content.

**Governor**

A component that manages engine fueling on the basis of fuel demand (accelerator) and engine RPM; may be hydro-mechanical or electronic.

**Grade markings**

Lines placed on the heads of some bolts to indicate tensile strength.

**Gross Horsepower**
The brake horsepower of an engine with optimum settings and without allowing for power absorbed by the engine-driven accessories.

**Gross Torque**
The maximum torque produced when measured at the engine's crankshaft. Does not allow for torque consumed by the engine-driven accessories.

**H**

**Hall Effect**
A method of accurately sensing rotational speed and digitally signaling it. A rotating metallic shutter alternately blocks and opens a magnetic field from a semiconductor sensor.

**Hazardous Waste**
Any chemical or material that has one or more characteristics that make it hazardous to health, life, and/or the environment.

**Heat**
A form of energy associated with the motion of atoms or molecules and capable of being transmitted by conduction, convection, and radiation.

**Helix**
A spiral groove or scroll. The helical cut recesses in some injection pumping plungers that are used to meter fuel delivery. Plural: helices.

**Hg manometer**
A mercury (Hg) filled manometer.

**High Idle Speed**
The highest no load speed of an engine.

**Hooke’s Law**
The law that the stress of a solid is directly proportional to the strain applied to it.

**Horsepower (hp)**
Measurement of an engine's ability to perform work. One horsepower is defined as the ability to move 33,000 pounds one foot in one minute.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H₂O Manometer</strong></td>
<td>A water-filled manometer.</td>
</tr>
<tr>
<td><strong>Hunting</strong></td>
<td>Rhythmic fluctuation of engine RPM usually caused by unbalanced cylinder fueling.</td>
</tr>
<tr>
<td><strong>Hydraulics</strong></td>
<td>The science and practice of confining and pressurizing liquids in circuits to provide motive power.</td>
</tr>
<tr>
<td><strong>Hydraulic electronic unit injector (HEUI)</strong></td>
<td>Unit injector featuring a hydraulically-actuated injection pumping, with an electronically controlled injector. Combines fuel metering and injecting elements into a single unit.</td>
</tr>
<tr>
<td><strong>Hydrocarbon</strong></td>
<td>Describes substances primarily composed of elemental carbon and hydrogen. Fossil fuels and alcohols are both hydrocarbon fuels.</td>
</tr>
<tr>
<td><strong>Hydrometer</strong></td>
<td>An instrument designed to measure the specific gravity of liquids, usually battery electrolyte and coolant mixtures. Not recommended for measuring either in truck engine applications where a refractometer is the appropriate instrument due to greater accuracy.</td>
</tr>
<tr>
<td><strong>Hypoid gear</strong></td>
<td>A bevel gear crown and pinion assembly where the axes are at right angles but the pinion is on a lower plane than the crown.</td>
</tr>
<tr>
<td><strong>Hysteresis</strong></td>
<td>(i) In hydro-mechanical governor terminology, a response lag.</td>
</tr>
<tr>
<td></td>
<td>(ii) Molecular friction caused by the lag between the formation of magnetic flux behind the magneto motive force that creates it.</td>
</tr>
<tr>
<td><strong>Impedance</strong></td>
<td>The combination of resistance and reactance in an AC circuit.</td>
</tr>
<tr>
<td><strong>Indirect injection (IDI)</strong></td>
<td>Describes any of a number of methods of injecting fuel to an engine outside of the cylinder. This may be to an intake tract in the intake manifold or to a cell adjacent to the cylinder such as a pre-combustion chamber.</td>
</tr>
<tr>
<td><strong>Indicated horsepower</strong></td>
<td>Gross power produced in the engine cylinders often arrived at by calculation and always greater than brake power because it does not factor in pumping and friction losses.</td>
</tr>
<tr>
<td><strong>Industry Committee</strong></td>
<td>A committee of industry members who are representative of the province and help to guide the MTCU about apprenticeship issues.</td>
</tr>
<tr>
<td><strong>Inertia</strong></td>
<td>In physics, it describes the tendency of a body at rest or in motion to continue that state unless it is changed by an external force.</td>
</tr>
<tr>
<td><strong>Inline block</strong></td>
<td>An engine that has all of its cylinders aligned in a straight row.</td>
</tr>
<tr>
<td><strong>Insulator</strong></td>
<td>Materials that either prevent or inhibit the flow of electrons: usually nonmetallic substances that contain more than four electrons in their outer shell.</td>
</tr>
<tr>
<td><strong>Integral</strong></td>
<td>Whole or combined with another component to act as a single unit.</td>
</tr>
</tbody>
</table>
| **Isochronous governor**         | A zero droop governor or one that accommodates no change.
in RPM on the engine it manages as engine load varies. In electronically managed truck engines, the term is sometimes used to describe engine operation in PTO mode.

J
Jounce Literally "bump"-used to describe the most compressed condition of a suspension spring.
Journal The part of an axle or shaft that actually contacts the bearing.
Jumper pipe A term used to describe the pipes that connect the charge and return galleries with DDC MUIs or with each other in multi-cylinder heads.

K
Kinetic energy Any energy associated with motion.
Kingpin inclination Inclination angle of the steering axis to a vertical plane.
Kirchhoff's 1st Law States that the current flowing into a point or component in an electrical circuit must equal the current flowing out of it.
Kirchhoff's 2nd Law States that the voltage will drop in exact proportion to the resistance in a circuit component and that the sum of the voltage drops must equal the voltage applied to the circuit; also known as Kirchhoff's Law of voltage drop.

L
Lambda sensor An exhaust gas sensor used on electronically managed, SI gasoline-fueled engines to signal the ECM the oxygen content in the exhaust gas.
Laminar flow A condition where the fluid particles move in continuous parallel paths; streamline flow.
Lead acid battery Standard vehicle battery consisting of lead acid cells in series. Twelve volt batteries have become standard and they can be used in multiples in parallel or series for heavy duty applications.
L-head engine An in-line engine configuration where the intake and exhaust valve ports are located adjacent to the cylinder in the block. Seldom used in current engines.
Learning outcome Learning outcomes are discrete statements that describe the elements leading to attainment of the general learning outcome.
Learning content The learning activities required for the learner to achieve the Learning Outcomes. A comprehensive list of activities to guide the trainer.
Liner protrusion The amount the liner protrudes above the deck of the block, thus allowing retention when the head is properly torqued.
Logic (i) The science of reasoning.
(ii) Arithmetic and data comparison protocols of a microprocessor.

M
Magnetism The phenomenon that includes the physical attraction for iron observed in lodestone and associated with electric current flow. It is characterized by fields of force, which can exert a
mechanical and electrical influence on anything within the boundaries of that field.

**Manometer**
A tubular, U-shaped column mounted on a calibration scale. The tube is water or mercury-filled to balance at 0 on the scale and the instrument is used to measure light pressure or vacuum conditions in fluid circuits.

**Mechanical efficiency**
A measure of how effectively indicated power is converted into brake power; factors in pumping and friction losses.

**Micrometer**
A precision instrument for measuring either internal, external, or depth dimensions to within thousands or ten thousands of an inch or millimeter.

**Micron**
One millionth of a meter or .000039 inch. The term used to rate the size of filters for liquids, such as engine oil or hydraulic fluids.

**Muffler**
An engine silencer that uses sound absorption and resonance principles to alter the frequency of engine noise.

**Mechanical Unit Injector (MUI)**
Cam-actuated, governor-controlled unit injectors used by DDC and Caterpillar.

**Multimeter**
A test instrument capable of reading volts, amps, and ohms.

**Multi-orifii nozzle**
A typical hydraulic injector nozzle whose function it is to switch and atomize the fuel injected to an engine cylinder. Consists of a nozzle body machined with the orifii, a nozzle valve, and a spring. Used in most DI diesel engines using port helix injection pumps, MUIs, EUIs, and HEUIs.

**Multiplexing**
A method of using one communications path to carry two or more signals simultaneously.

**N**

**Nitrogen dioxide**
One of the oxides of nitrogen produced in vehicle engines and a significant contributor in the formation of photochemical smog.

**Non-ferrous metal**
Metals and alloys that contain little or no iron.

**Non-volatile RAM**
NVRAM-read-write RAM device capable of data retention in cells in a vehicle module after the ignition circuit is opened; also known as KAM

**Normal rated power**
The highest power specified for continuous operation of an engine.

**O**

**O. Reg.631/94 section 3**
Is an Ontario regulation for regulations as they apply to overhead cranes

**OEM**
Original equipment manufacturer.

**Ohm**
A unit for quantifying electrical resistance in a circuit.

**Ohm's Law**
The formula used to calculate electrical circuit performance. It asserts that it requires 1 v of potential to pump 1 A of current through a circuit resistance of 1 ohm.

**Ohmmeter**
An instrument for measuring resistance in an electric component or circuit.

**Opacity meter**
A light extinction means of testing exhaust gas particulate and liquid emission that rates density of exhaust smoke based on
the percentage of emitted light that does not reach the sensor, so the higher the percentage reading, the more dense the exhaust smoke.

Orifice  A hole or aperture.
Orifi  Plural of orifice.
Oscilloscope  An instrument designed to graphically display electrical waveforms on a CRT or other display medium.
Otto cycle  The four stroke, spark ignited cycle, patented by Nicolas Otto in 1876 and consisting of induction, compression, power and exhaust strokes.
Overhead camshaft  An engine which locates the valve actuating camshaft(s) in the cylinder head to either directly or indirectly actuate the valves and in some diesel applications, the unit injectors.
Oxy-acetylene  A commonly used cutting, heating, and welding process that uses pure compressed oxygen in conjunction with acetylene fuel.
Oxidation  The act of oxidizing a material; can mean combusting or burning a substance.
Oxides of nitrogen (NOx)  An undesirable compound of nitrogen and oxygen in exhaust gases. Usually produced when combustion chamber temperatures are excessively high.

P
Parallel port valve configuration  Engine cylinder valve arrangement that locates multiple valves parallel to crank centreline permitting equal gas flow through each (assuming identical lift).
Particulate trap  A canister in series with the exhaust piping containing a filtering medium to entrap diesel HC exhaust particulates and in some instances oxidize them.
Pascal's Law  A principle of fluids that states that when pressure is applied to a confined fluid, it is transferred undiminished throughout the fluid.
PC networks  Any of a variety of small personal computers designed for full function in isolation from other units but which may be used to network with other systems.
Piezoelectric Principle  Certain crystals become electrically charged when exposed to pressure, the voltage produced increasing proportionally with pressure rise. Quartz and Rochelle salt crystals have these properties. Combustion pressure sensors may both use the Piezoelectric Principle.
Pintle nozzle  A type of hydraulic injector nozzle used in some IDI automobile, small bore diesel engines until recently.
Plenum chamber  A chamber or cavity in which a fluid is held at a pressure above atmospheric or above system mean pressure.
Pneumatics  Branch of fluid power physics dealing with pressure and gas dynamics.
Poppet nozzle  Forward opening injector nozzle valve used on older Caterpillar IDI systems.
Port-helix metering  Consists of a pumping plunger and barrel assembly designed to regulate fuel delivery.
Potentiometer  A three-terminal variable resistor or voltage divider used to
vary the voltage potential of a circuit. Commonly used as a throttle position sensor.

**Power**
The rate of accomplishing work; it is necessarily factored by time.

**Practical**
The hands-on element of learning in the curriculum document. Apprentice activities develop skills to achieve completion of psychomotor learning outcomes.

**Preloading**
Process of adjusting a bearing so that it has a mild pressure placed upon it, beyond zero endplay.

**Prerequisite**
Learning that must be achieved prior to taking a given subject.

**Pressure**
Force exerted per unit of area.

**Pulse width modulation**
The shaping of pulses and waveforms for purposes of digital signaling. Acronym PWM is often used.

**Pyrometer**
A thermocouple type, high temperature sensing device used to signal exhaust temperature. Consists of two dissimilar wires (pure iron and constantan) joined at the hot end with a millivoltmeter at the read end. Increase in temperature will cause a small current to flow, which is read at the voltmeter as a temperature value.

**Q**
**Quenching**
Process of dipping a heated object into water, oil, or other substance to quickly reduce its temperature.

**Quiescent Combustion**
Non-turbulent flame propagation characteristic of slow running diesel engines that are direct injected.

**R**
**Radial**
A line at right angles to a shaft, cylinder, etc., Centerline.

**RAM**
Random access memory. Electronically retained "main memory."

**Rated power**
The highest power specified for continuous operation.

**Rated speed**
The RPM at which an engine produces peak power.

**Reluctor**
Term describing a number of devices that use magnetism and motion to produce an AC voltage-a pick-up coil.

**Rebound**
Reactive response of a spring, the opposite of jounce.

**Reportable Subject**
(i) A clustering or grouping of related or like learning outcomes.
(ii) A standalone learning unit with a distinct start and end.
(iii) A course or module.

**Reserve Capacity**
The amount of time a battery can produce an acceptable current when not charged by the alternator.

**Rheostat**
A two terminal, variable resistor.

**S**
**SAE**
Society of Automotive Engineers.

**SAE horsepower**
A structured formula used to calculate brake horsepower data that can be used for comparison purposes.

**Scoring**
Scratch/gouge damage to a surface finish.

**Semiconductor**
A substance, such as silicon, that acts as a conductor or insulator, depending on its operating condition and
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<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Semi-floating axle</td>
<td>A drive axle design in which the axle shaft imparts drive to the wheel and supports the vehicle weight.</td>
</tr>
<tr>
<td>Sensor</td>
<td>A term that covers a wide range of command and monitoring input (ECM) signal devices.</td>
</tr>
<tr>
<td>Shunt winding</td>
<td>A wire coil that forms an alternate path through which electrical current can flow.</td>
</tr>
<tr>
<td>s.i.</td>
<td>Système international d'unités. A measure in metric units.</td>
</tr>
<tr>
<td>Silicon</td>
<td>A non metallic element found naturally in silica, silicone dioxide in the form of quartz.</td>
</tr>
<tr>
<td>Silicon-controlled rectifier</td>
<td>Function similarly to a bipolar transistor with a fourth semiconductor layer; used to switch DC.</td>
</tr>
<tr>
<td>Spark ignition (SI)</td>
<td>Any gasoline-fueled, spark-ignited engine usually using an Otto cycle principle.</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>A relative weight of a given volume of a specific material as compared to an equal volume of water.</td>
</tr>
<tr>
<td>Spiral gear</td>
<td>A winding helical protrusion or thread machined to a shaft, as in a worm gear.</td>
</tr>
<tr>
<td>Static electricity</td>
<td>Accumulated electrical charge not flowing in a circuit.</td>
</tr>
<tr>
<td>Stoichiometric Ratio</td>
<td>The exact ratio of reactants participating in a reaction required to complete the reaction. Most often used in the context of explaining the mass of air required to completely combust a fuel.</td>
</tr>
<tr>
<td>Supercharger</td>
<td>Technically any device capable of providing manifold boost, but in practice used to refer to gear-driven blowers such as the Roots blower.</td>
</tr>
<tr>
<td>Sulfur</td>
<td>An element present in most crude petroleums, but refined out of most current highway fuels. During combustion, it is oxidized to sulfur dioxide, and classified as a noxious emission.</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>The compound that is formed when sulfur is oxidized that is the primary contributor to sulfurous type smog. Vehicles contribute little to sulfurous smog problems due to the use of low sulfur fuels.</td>
</tr>
<tr>
<td>Supplemental Restraint System (SRS)</td>
<td>An emergency inflatable air bag system designed to enhance crash safety.</td>
</tr>
<tr>
<td>Swept Volume</td>
<td>The volume displaced in a cylinder as a piston moves from BDC to TDC.</td>
</tr>
<tr>
<td>Synthetic Oils</td>
<td>Petroleum based oils that have been chemically compounded by polymerization and other processes.</td>
</tr>
<tr>
<td>TDC</td>
<td>Top dead centre of an engine.</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>Widely used term denoting the required unit stress to cause material separation. In ferrous alloys, tensile strength usually exceeds yield strength by about 10%. Measured in force per unit area, psi.</td>
</tr>
<tr>
<td>Theory</td>
<td>The theoretical hours listed in the curriculum document that represent learning in the cognitive domain, the thinking portion of the training.</td>
</tr>
<tr>
<td>Thermal Efficiency</td>
<td>Ratio of brake power to that of the calorific value (heat energy</td>
</tr>
</tbody>
</table>
potential) of a material failure caused by engine performance.

Thermistor
A commonly used temperature sensor that is supplied with a reference voltage and by using a temperature sensitive variable resistor, signals back to the ECM portion of it.

Thrust faces
A term used to describe loading of surface area generally but most often of pistons. When the piston is subject to cylinder gas pressure there is a tendency for it to cock (pivot off a vertical centerline) and load the contact faces off its axis on the pin.

Torque
Twisting effort or force. Torque does not necessarily result in accomplishing work.

Torque rise
The increase in torque potential designed to occur in a diesel engine as it is lugged down from the rated power RPM to the peak torque RPM, during which the power curve remains relatively flat. High torque rise engines are sometimes described as constant horsepower engines.

Training Standards
Training standards are created by the MTCU with the Industry Committee and are intended to be used by the apprentice, instructors, and companies as a "blueprint" for on-the-job training, or as a prerequisite for government certification.

Transducer
A device that converts energy from one power form to another for instance, a physical pressure value to an electrical pressure value.

Trunk piston
A single piece piston usually constructed of aluminum alloy.

Turbocharger
A turbine device that utilizes exhaust pressure to increase the air pressure going into the cylinders. Used particularly in reference to movement of air in the cylinder and combustion chamber.

Turbulence
A violent irregular movement or agitation of a fluid or gas. Violent swirling motion. Fuel injection provided some turbulence. Additional turbulence is provided by the design features of the combustion space.

Turbulent Flow
A condition where the fluid particles move in random paths rather than in continuous parallel paths.

Two-stroke cycle
An engine that requires one complete revolution of the crankshaft to fire each piston once. An engine requiring only one complete revolution of the crankshaft to complete the cycle of events.

U
Unit injector
A diesel fuel injector which receives fuel at charging pressure and performs the functions of metering, creating injection pressure values and atomizing fuel-usually directly to the engine cylinder. Mechanically or electronically controlled, mechanically or hydraulically actuated.

Universal joint
A flexible joint that permits changes in driving angles between a driving and driven shaft.

Urea
the chief solid component of mammalian urine; synthesized from ammonia and carbon dioxide and used as fertilizer and in animal feed and in plastics
Valve timing  Crank angle locations in the cycle when the valves are open and closed.
Valve train  The sum of the components responsible for actuating a valve, extending from the cam profile to the valve itself.
V-engine  Engine configuration in which the cylinders are arranged so that their axes form a V. Described by the angle, most commonly, 45, 60, and 90 degrees.
Volatility  The ability of a liquid to evaporate. Gasoline has greater volatility than diesel fuel.
Volute  A snail-shaped diminishing sectional area such as used in turbocharger geometry.
Viscosity  Denotes the fluidity of a liquid.
Viscosity Index  A measure of a liquid's fluidity at a specific temperature—diminishes as temperature drops and vice versa.
Viscous damper  An engine vibration damper consisting of disc shaped housing containing a fluid medium (silicon gel) and a solid inertia ring; uses fluid friction to dampen torsional oscillation.
Voltmeter  Instrument for testing charge differential or voltage in a circuit.
Volumetric efficiency  Engine breathing efficiency. Extent to which end gases are purged from an engine cylinder, usually expressed as a percentage of new charge to cylinder volume. A ratio of mass not volume. Seldom 100% in naturally aspirated engines, can be greater than 100% in boosted engines.
Wastegate  A valve that vents excess exhaust gas to limit the amount of boost delivered by a turbocharger.
Watt's Law  Formula for computing unknown power, voltage, or current in a circuit by using two known factors to find the unknown value.
Wet liners  Cylinder block liners that have direct contact with the water jacket and therefore must support cylinder combustion pressures and seal the coolant to which they are exposed.
Wheatstone bridge  A galvanometer that bridges an electrical circuit to give a resistance reading.
Yield strength  The stress loading required to permanently deform a material—automotive construction materials, especially steels, are classified by yield strength rating.
Zenor diode  Specialty diode designed to conduct with a reverse bias current after a specific voltage value is reached.