



**ONTARIO COLLEGE OF TRADES**  

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**ORDRE DES MÉTIERS DE L'ONTARIO**

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 8<sup>th</sup>, 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**

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

<b>Number</b>	<b>Reportable Subjects</b>	<b>Hours Total</b>	<b>Hours Theory</b>	<b>Hours Practical</b>
S1277	Trade Practices	24	13	11
S1278	Electrical Systems	40	24	16
S1279	Computer Control Systems	16	12	4
S1280	Fuel Systems	24	16	8
S1281	Engine Systems	32	18	14
S1282	Brake Systems	24	16	8
S1283	Frame, Drive, and Lift Systems	40	30	10
S1284	Hydraulic Systems	40	25	15
	<b>Total</b>	<b>240</b>	<b>154</b>	<b>86</b>

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:

Theory Testing	Practical Application Testing
65%	35%

Instructional and Delivery Strategies:

Lecture and assignment work

Reference Materials:

O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Metal Inert Gas Welder	Chipping hammers
Selection of filler rods and consumables	Hand grinders
Air conditioning reclaiming/ charging equipment	Infra-red temperature measurement tool
Nitrogen pressure testing equipment	Dye type leak detection equipment
Manifold gauge set	Air conditioner components
Basic hand tools	Personal Protective Equipment specific to welding

**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**

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**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.

- [1/2]
- **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.

- [0/1]
- **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

**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.

- [0/4]
- **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.

- [0/4]
- **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 16hours

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:

Theory Testing	Practical Application Testing
65%	5%

Instructional and Delivery Strategies:  
Lecture and assignment work

Reference Materials:  
OEM Service Manuals

Recommended Minimum Equipment:

Powered Lift Truck with AC Motors and Control Systems	Powered Lift Truck with Electronic Ignition or Engines with Electronic Ignitions
Engines with Charging Systems	OEM Computer Diagnostic Tools and Cable
AVR Tester	

**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:

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**PLTT 5873.0**

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**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.

- [4/0]
- **alternating current motor types**
  - **squirrel cage**
  - **motor controllers**
  - **transistor switching**
    - frequency modulation
    - pulse width modulation
    - Mosfet switching
  - **directional switching devices**
    - mechanical
    - electronic

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

- [0/4]
- **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.

- [0/4]
- **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:

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**PLTT 5865.06**

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**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  
                            o coil on plug  
                            o 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**
    - reductor
    - 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.

- [0/3]
- **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.

- [0/1]
- **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.

- [0/2]
- **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

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:

Theory Testing	Practical Application Testing
60%	40%

Instructional and Delivery Strategies:  
 Lecture and assignment work

Reference Materials:  
 OEM Service Manuals

Recommended Minimum Equipment:

Powered Lift Truck with Electronic Management Systems	OEM Computer Diagnostic Tools and Cables
Digital Multimeter	

**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**

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**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.

- [4/0]
- **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.

- [0/2]
- **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.

- [1/2]
- **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

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:

Theory Testing	Practical Application Testing
75%	25%

Instructional and Delivery Strategies:  
 Lecture and assignment work

Reference Materials:  
 OEM Service Manuals

Recommended Minimum Equipment:

Powered Lift Truck or Engine with High Pressure Common Rail System	Powered Lift Truck or Engine with Distributor Pump Injection
Powered Lift Truck or Engine with Port-Helix Metering Injection Pumps	Special Service Tools

**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.

- [2/0]
- **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.

- [0/3]
- **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:

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**PLTT 5864.0**

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**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.

- [2/0]
- **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.

- [0/1]
- **outline timing procedure**

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

- [0/1]
- **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:

Theory Testing	Practical Application Testing
65%	35%

Instructional and Delivery Strategies:  
Lecture and assignment work

Reference Materials:  
OEM Service Manuals

Recommended Minimum Equipment:

Powered Lift Truck or Engine with Turbocharger	Turbocharger
Special Service Tools	Electronic Service Tools

**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.

- [3/0]
- **positive filtration**
  - **inlet restriction factors**
  - **boost air cooling**
  - **air flow dynamics**
  - **cylinder breathing**
  - **exhaust back pressure**
  - **noxious emissions**
  - **two stage, three way catalyts**
  - **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.

- [0/1]
- **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.

- [0/1]
- **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.

- [2/0]
- **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.

- [0/2]
- **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.

- [0.5/0  
]
- **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**

- **cooling system**
- **lubrication system**
- **engine breathing**
- **oil analysis**

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**

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**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.

- [1/3]
- **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.

- [1/0]
- **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

Number: **S1282**

Reportable Subject: **BRAKE SYSTEMS**

Duration: Total 24 hours      Theory 16 hours      Practical 8 hours

Prerequisites: P.L.T. Level 2

Co-requisites: None

### 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:

Theory Testing	Practical Application Testing
65 %	35 %

Instructional and Delivery Strategies:  
Lecture and assignment work

Reference Materials:  
OEM Service Manuals

Recommended Minimum Equipment:

Powered Lift Truck or other Equipment with Hydraulic Brake Systems	Powered Lift Truck or other Equipment with Air Brake Systems
Precision Measuring Tools	Assortment of brake components

**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:

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**PLTT 5869.0**

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**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**

- **brake plumbing**
- **hydraulic brake circuit schematics interpretation**

6.1.3 Describe the principles of operation of hydraulic brakes.

- [11/0]
- **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

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:

Theory Testing	Practical Application Testing
65%	35%

Instructional and Delivery Strategies:  
 Lecture and assignment work

Reference Materials:  
 OEM Service Manuals, -(Reference ISBN 0-7778-8974-9, July 1999)  
 (Operation and Maintenance of Powered Industrial Lift Trucks)

Recommended Minimum Equipment:

Powered Lift Truck	Special Service Tools
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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:

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**PLTT 5877.0**

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**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.

- [5/0] - **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.

- [0/4] - **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.

- [2/4] - **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**

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**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.

- [4/0]
- **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 Describe the types and construction features of hydrostatic drives.

- [2/0]
- **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

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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:

Theory Testing	Practical Application Testing
65%	35%

Instructional and Delivery Strategies:  
 Lecture and assignment work

Reference Materials:  
 OEM Service Manuals

Recommended Minimum Equipment:

Hydraulic Test Board	Powered Lift Truck
Pressure testing equipment: mechanical & electronic gauges	Hydraulic flow meters

**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:

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**PLTT 5876.0**

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**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.

- [2/0]
- **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:

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**PLTT 5876.0**

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**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**

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**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.

- [3/0]
- **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.

- [0/2]
- **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.

- [0/1]
- **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:

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**PLTT 5876.0**

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**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 11hours Theory 5 hours Practical 6 hours

Prerequisites:            P.L.T. Level 2

Cross-Reference to Training Standard:

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**PLTT 5876.0**

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**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

### A

ABS anti-lock braking system  
 AC alternating current  
 A/C air conditioning  
 AET Agricultural Equipment Technician  
 AFC air fuel control  
 AGM absorbed glass mat  
 API American Petroleum Institute  
 ANSI American National Standards Institute  
 ATA American Trucking Association  
 ATC automatic traction control  
 AVR amp, volt, ohmmeter  
 AWG American Wire Gauge  
 AWS American Welding Society

### B

BCM body control module  
 BSP British Standard Pipe  
 BTM brushless torque motor

### C

CB citizen band  
 CDI capacitor discharge ignition  
 CD-ROM compact disc read only memory  
 CFC chlorofluorocarbons  
 CI compression ignited  
 CMVSS Canadian Motor Vehicle Safety Standard  
 CNG compressed natural gas  
 CPU central processing unit  
 CSA Canadian Standards Association  
 CVSA Canadian Vehicle Standards Association  
 CWS collision warning systems

### D

DC direct current  
 DDC Detroit Diesel Corporation  
 DFF direct fuel feed  
 DIN Deutsche Institute fur Normung (German Standards Institute)

DMM digital multimeter  
 DOS Disk Operating System  
 DOT Department of Transportation  
 DPF diesel particulate filter

**E**

ECM electronic control module  
 ECU electronic control unit  
 EPROM erasable programmable read only memory  
 EEPROM electronically erasable programmable read only memory  
 EG ethylene glycol  
 EGR exhaust gas recirculation  
 ELC extended life coolant  
 EPA Environmental Protection Act  
 EST electronic service tool  
 EUI electronic unit injector  
 EUP electronic unit pump

**F**

FHSL Federal Health and Safety Legislation  
 FIMs fault mode indicators  
 FMVSS Federal Motor Vehicle Safety Standards  
 FOPS Falling Object Protection System  
 FRP fiberglass reinforced plywood

**G**

GCWR Gross Combined Weight Rating  
 GFI gasoline fuel injection  
 GPS global positioning satellite  
 GVW Gross Vehicle Weight  
 GVWR Gross Vehicle Weight Rating

**H**

HC hydrocarbon  
 HDET Heavy Duty Equipment Technician  
 HEUI hydraulically actuated electronic unit injector  
 HCFC hydrochlorofluorocarbons  
 HFC hydrofluorocarbons  
 HPI-TP high pressure injector-time pressure (Cummins)  
 HVAC heating, ventilation and air conditioning

**I**

ID inside diameter  
 ISO International Standards Organization

**J**

JIC Joint Industry Conference  
 JIS Japanese Industrial Standard  
 JIT just in time

**K**

KPI king pin inclination

**L**

LED light emitting diode  
 LPG liquid petroleum gas  
 LVD low voltage disconnect

**M**

MAP manifold absolute pressure  
 MIDs message identifiers  
 MIG metal inert gas  
 MSDS material safety data sheet  
 MUI mechanical unit injector  
 MVSA Motor Vehicle Safety Act (Canadian)

**N**

N/A not applicable  
 NOP nozzle opening pressure  
 NPN negative positive negative semi-conductor  
 NPT National Pipe Thread  
 NV-RAM non-volatile random access memory

**O**

OD outside diameter  
 ODP ozone depletion prevention  
 OEM original equipment manufacturer  
 OHSA Occupational Health and Safety Act  
 OOS out of service criteria  
 OPS operator protection system  
 ORB o-ring boss  
 ORFS o-ring face seal

**P**

PC personal computer  
 PCV positive crankcase ventilation  
 PFI port fuel injection  
 PG propylene glycol  
 PHSL Provincial Health and Safety Legislation  
 PIDs parameter identifiers  
 PLTT Powered Lift Truck Technician  
 PNP positive negative positive semi-conductor  
 PROM programmable read only memory  
 PT pressure time  
 PTA pressure time (injector) A series  
 PTG-AFC pressure time governor/air fuel control  
 PTD pressure time (injector) B series  
 PTG pressure time governor (control pump)  
 PTO power take-off  
 PWM pulse width modulation

**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 <i>alternating current</i> .
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 <i>air/fuel ratio</i> .
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

	polarity at the voltage source; AC.
altitude-pressure compensator	Any sensor or device that automatically compensates for changes in altitude.
Amboid gear	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.
ANSI	The American National Standards Institute.
American Society for Testing Materials (ASTM)	Agency that sets industry standards and regulations, including those for fuel.
ammeter	Instrument for measuring current flow.
ampere (A)	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.
analog	The use of physical variables, such as voltage or length, to represent values.
anaerobic sealant	Paste-like sealants that cure (harden) without exposure to air.
aneroid	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.
antifreeze	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.
antifriction bearing	A bearing that uses balls or rollers between a journal and a bearing surface to decrease friction.
API	The American Petroleum Institute.
application software	Programs that direct computer processing operations.
Apprentice program	Any educational program designed to teach a trade through a combination of on-the-job training and classroom study.
Apprentice technician	A beginner who is learning under the direction of one or more experienced certified technicians.
Aqueous Solution	a solution in water, eg. a homogeneous mixture of two or more substances; frequently (but not necessarily) a liquid solution; "he used a solution of peroxide and water"
Aqueous Urea Injection	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.
arcing	Bearing or gear failure caused by electric arcing.
articulating piston	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 <i>crosshead piston</i> .
ASTM	American Society for Testing Materials. Standards rating organization that classifies materials generally and all fuels.
ATA	American Trucking Association. Organization with a broad

	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 <i>tattletale</i> .
<b>B</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 <i>supercharger</i> .
boost pressure sensor	This sensor measures intake manifold air pressure and sends a signal to the ECM.
boost pressure	A measure of positive air pressure provided by a supercharger or turbocharger.
bore	The diameter of an engine cylinder. Sometimes used to refer to the cylinder itself.
boundary lubrication	Thin film lubrication characteristics of an oil.
Boyle's Law	The absolute pressure of a fixed mass of gas varies inversely as the volume, provided the temperature remains constant.
brake power	Power developed by an engine measured at the flywheel measured by a dynamometer or <i>brake</i> . Factored by <i>torque</i> or RPM.
British thermal unit (BTU)	Measurement of the amount of heat required to raise the temperature of one pound of water by 1 degree F, at sea level.
broach	A boring bit used for final, accurate bore sizing.
BTM	Brushless torque motor. Caterpillar rotary proportional solenoid used for PEEC timing and rack position control.
bypass filter	A filter assembly plumbed in parallel with the lubrication circuit, usually capable of high filtering efficiencies.
bypass valve	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.
burst pressure	The pressure which causes rupture. Also, the inside out differential pressure that causes out-ward structural failures.
<b>C</b>	
cache	High speed RAM located between the CPU and main memory used to increase processing efficiency.
calorific value	The heating value of a fuel measured in BTU, calories, or joules.
calibration parameters	The specific values required when setting performance to specification.
calipers	Comparative measuring instrument used for measuring outside diameter and inside diameter.
cam ground	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.
capacitance	Measure of how much electrical charge can be stored for a given voltage potential; measured in farads.
capacitor	An electrical device that can store an electrical charge or block AC and pass DC. Also known as <i>condenser</i> .
carbon (C)	An element found in various forms including diamonds, charcoal, and coal. It is the primary constituent element in hydrocarbon fuels. Atomic #6.
carbon dioxide (CO <sub>2</sub> )	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 driveshaft 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 <i>bypass</i> 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 <sub>16</sub> H <sub>34</sub> ). Used as a basis to test the performance characteristics of diesel fuel.
cetane improver	A diesel fuel additive designed to increase the <i>cetane number</i> 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, <i>oxidation</i> .
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: H <sub>2</sub> 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 <i>torque rise</i> 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.
<b>D</b>	
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 <i>constant pressure</i> 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.
<b>E</b>	
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 <i>conventional theory</i> .
Electronic engine management	Computerized engine control.
Electronic control unit	Refers to the computer and integral switching apparatus in an

(ECU)	electronically controlled system. Some engine OEMs use this term rather than the more commonly used ECM.
Electronically controlled unit injector	Mechanically actuated, electronically controlled unit injector that combines pumping, electronic fuel metering, and injecting elements in a single unit.
Emissions	Any release of harmful materials into the environment. Gases produced from exhaust, crankcase, and fuel tanks and their contribution to smog.
End play	Amount of lengthwise movement between two parts due to clearance.
Energy	Any capacity for doing work.
Ethylene glycol	A liquid chemical used in engine coolant. See <i>antifreeze</i> .
Exhaust scrubber	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.
Expansion ratio	Ratio of cylinder volume at the moment the exhaust port or valves open to clearance volume; usually less than compression ratio.
<b>F</b>	
Fatigue	Material failure or deterioration due to repetitive stress loading or usage.
Ferrous material	Metal containing metal or steel.
Fiber optics	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.
Fire point	The temperature at which a flammable material or liquid vaporizes at a rate sufficient to burn continuously.
Flammable	Any substance that can be combusted.
Flashback	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.
Fluid power	The term used to describe both <i>hydraulics</i> and <i>pneumatics</i> .
Flywheel	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.
Force	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.
Friction	The resistance an object or fluid encounters in moving over or through another.
Four-stroke cycle engine	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.
Full-floating	Used to describe components that permit more than the usual amount of movement-for instance a <i>full-floating piston pin</i> 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.
<b>G</b>	
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.
<b>H</b>	
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: <i>helices</i> .
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.

H <sub>2</sub> O Manometer	A water-filled manometer.
Hunting	Rhythmic fluctuation of engine RPM usually caused by unbalanced cylinder fueling.
Hydraulics	The science and practice of confining and pressurizing liquids in circuits to provide motive power.
Hydrodynamic suspension	The principle used to float a rotating shaft on a bed of constantly changing, pressurized lubricant.
Hydraulic electronic unit injector (HEUI)	Unit injector featuring a hydraulically-actuated injection pumping, with an electronically controlled injector. Combines fuel metering and injecting elements into a single unit.
Hydrocarbon	Describes substances primarily composed of elemental carbon and hydrogen. Fossil fuels and alcohols are both hydrocarbon fuels.
Hydrodynamic engine management	All engines managed without computers.
Hydrometer	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.
Hypoid gear	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.
Hysteresis	<ul style="list-style-type: none"> <li>(i) In hydro-mechanical governor terminology, a response lag.</li> <li>(ii) Molecular friction caused by the lag between the formation of magnetic flux behind the magneto motive force that creates it.</li> </ul>
I	
Impedance	The combination of resistance and reactance in an AC circuit.
Indirect injection (IDI)	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.
Indicated horsepower	Gross power produced in the engine cylinders often arrived at by calculation and always greater than <i>brake power</i> because it does not factor in pumping and friction losses.
Industry Committee	A committee of industry members who are representative of the province and help to guide the MTCU about apprenticeship issues.
Inertia	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.
Inline block	An engine that has all of its cylinders aligned in a straight row.
Insulator	Materials that either prevent or inhibit the flow of electrons: usually nonmetallic substances that contain more than four electrons in their outer shell.
Integral	Whole or combined with another component to act as a single unit.
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 1<sup>st</sup> 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 2<sup>nd</sup> 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 <i>indicated power</i> is converted into <i>brake power</i> ; 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 <i>engine silencer</i> that uses sound absorption and resonation 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.
<b>N</b>	
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.
<b>O</b>	
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.
Orifiii	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.
<b>P</b>	
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 <i>Piezoelectric Principle</i> .
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

	application.
Semi-floating axle	A drive axle design in which the axle shaft imparts drive to the wheel and supports the vehicle weight.
Sensor	A term that covers a wide range of command and monitoring input (ECM) signal devices.
Shunt winding	A wire coil that forms an alternate path through which electrical current can flow.
s.i.	système international d'unités. A measure in metric units.
Silicon	A non metallic element found naturally in silica, silicone dioxide in the form of quartz.
Silicon-controlled rectifier	Function similarly to a bipolar transistor with a fourth semiconductor layer; used to switch DC.
Spark ignition (SI)	Any gasoline-fueled, spark-ignited engine usually using an Otto cycle principle.
Specific gravity	A relative weight of a given volume of a specific material as compared to an equal volume of water.
Spiral gear	A winding helical protrusion or thread machined to a shaft, as in a worm gear.
Static electricity	Accumulated electrical charge not flowing in a circuit.
Stoichiometric Ratio	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.
Supercharger	Technically any device capable of providing manifold boost, but in practice used to refer to gear-driven blowers such as the Rootes blower.
Sulfur	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.
Sulfur dioxide	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.
Supplemental Restraint System (SRS)	An emergency inflatable air bag system designed to enhance crash safety.
Swept Volume	The volume displaced in a cylinder as a piston moves from BDC to TDC.
Synthetic Oils	Petroleum based oils that have been chemically compounded by polymerization and other processes.
<b>T</b>	
TDC	Top dead centre of an engine.
Tensile strength	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.
Theory	The theoretical hours listed in the curriculum document that represent learning in the cognitive domain, the thinking portion of the training.
Thermal Efficiency	Ratio of brake power to that of the calorific value (heat energy

Thermistor	potential) of a material failure caused by engine performance. 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.
<b>U</b>	
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

**V**

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.

**W**

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.

**Y**

Yield strength	The stress loading required to permanently deform a material-automotive construction materials, especially steels, are classified by yield strength rating.
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**Z**

Zenor diode	Specialty diode designed to conduct with a reverse bias current after a specific voltage value is reached.
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