ONTARIO COLLEGE OF TRADES

ORDRE DES MÉTIERS DE L'ONTARIO

Apprenticeship Curriculum Standard

Commercial Vehicle And Equipment

Level 1

For the following Motive Power trades:
Agricultural Equipment Technician – 425A
Heavy Duty Equipment Technician – 421A
Powered Lift Truck Technician – 282E
Truck and Coach Technician – 310T

Date: 2010

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

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

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

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Introduction

The Commercial Vehicles and Equipment curriculum (CVAE) Level 1 has been developed in keeping with the prescribed Ministry of Training, Colleges and Universities (MTCU) Training Standards, which are common in the four trades of Agricultural Equipment Technician, Heavy Duty Equipment Technician, Powered Lift Truck Technician, and Truck and Coach Technician. 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 practic aspects of the trade, but who also have a sound theoretical knowledge of the inspectina diagnosing, repair, and servicing requirements. The curriculum has been developed tc provide this theoretical knowledge and to offer some practical applications to complem the on-the-job work experiences of the Agricultural Equipment, Heavy Duty Equipment, Powered Lift Truck, and Truck and Coach 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 the 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
- Fanshawe College of Applied Arts and Technology
- Mohawk College of Applied Arts and Technology
- Sault College of Applied Arts and Technology (CVAE Level 1 Lead)

Industry Representatives

Equipment World ltd	McGavin Farm Equipment Ltd.
Sudbury Truck & Trailer Ltd	Liftow Inc.
Toromont CAT Ltd	Volvo Canada Ltd
Nortrax Ltd	Vale Inco Ltd
Xstrata Nickel Ltd	Atlas Copco Construction & Mining Canada Ltd
Elmira Farm Service 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 is common to Agricultural Equipment, Heavy Duty Equipment, Powered Lift Truck, and Truck and Coach
- Level 2 is common to Agricultural Equipment and Heavy Duty Equipment
- Level 3 is specific to Agricultural Equipment
- Level 3 is specific to Heavy Duty Equipment
- Level 2 and 3 is specific to Powered Lift Truck
- Level 2 and 3 is 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.

Commercial Vehicle and Equipment

Level 1

Program Summary of Reportable Subjects - Level 1

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S1241	Trade Practice	40	24	16
S1242	Fluid Power Systems	24	19	5
S1243	Engine Systems	40	22	18
S1244	Electrical Systems	48	33	15
S1245	Fuel Systems	24	18	6
S1246	Drive Train Systems	32	24	8
S1247	Wheel End Assemblies & Brake Systems	32	16	16
	Total	240	156	84

Number: **S1241**

Reportable Subject: **TRADE PRACTICES**

Duration: Total 40 hours Theory 24 hours Practical 16 hours

Prerequisites: None

Co-requisites: None

1.1 Occupational Health and Safety

10 Total Hours Theory: 8 hours Practical: 2 hours

1.2 Precision Measuring Tools

6 Total Hours Theory: 3 hours Practical: 3 hours

1.3 Fastening Devices and Torquing Procedures

8 Total Hours Theory: 4 hours Practical: 4 hours

1.4 Bearings, Seals, and Sealants

8 Total Hours Theory: 5 hours Practical: 3 hours

1.5 Oxy-Fuel Processes

8 Total Hours Theory: 4 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:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Precision measuring tools	Tap and die and thread reclaiming tools
Engine components	Assortment of anti friction bearings
Powertrain components	Bearing installation tools
Camshafts	Bearing heater
Torque wrenches	Basic hand tools
Fasteners, sealing and locking compounds	Oxygen and acetylene torch assemblies

S1241.1 Occupational Health and Safety

Duration: Total 10 hours Theory 8 hours Practical 2 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5920.0, 5920.01, 5920.02, 5920.03, 5920.04, 5920.05, 5902.06, 5920.07
HDET	5890.0, 5890.01, 5890.02, 5890.03, 5890.04, 5890.05, 5890.06, 5890.07
PLTT	5860.0, 5860.01, 5860.02, 5860.03, 5860.04, 5860.05, 5860.06, 5860.07
TCT	5135.0, 5135.01, 5135.02, 5135.03, 5135.04, 5135.05, 5135.06, 5135.07

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the legal responsibilities of employees and employers relating to safe working practices, protection of the environment, and demonstrate the operation of lifting, rigging, blocking and safety equipment according to government safety and environmental legislation.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.1.1 Explain the fundamentals of safe practices in the workplace.

[1/0]
- **protective clothing and equipment**
  - CSA approved eye, foot, hearing and hand protection
  - Breathing and ventilation
- **housekeeping and cleanliness**
- **dangers of wearing jewellery and loose clothing**
- **fire protection**
  - extinguisher applications
  - prevention
- **lifting techniques**
  - posture
  - procedures
- **environmental protection**
  - disposal of antifreeze, fuels, oils, cleaning solvents, tires, and batteries.
  - air quality and ventilation
  - discharge of vapours

1.1.2 Identify the legal responsibilities of employees and employers relating to government legislation for relevant workplace activities.

[1/0]
- **Occupational Health and Safety Act**
- **Workplace Hazardous Material Information System (WHMIS)**
- **Apprenticeship and Certification Act**
- **Environment Protection Act**
- **environment responsibilities**
- **storage of hazardous material**
  - volatile liquids
  - cleaning agents
  - acids
- **disposal of:**
  - antifreeze coolant
  - oils
  - tires
  - cleaning solvent

1.1.3 Demonstrate inspection, testing, and operating procedures for lifting rigging and blocking equipment following manufacturers' recommended procedures and government regulations.

[1/2]
- **lifting devices**
  - hoists
  - legal lifting requirement for overhead crane operation***
  - refer to O. Reg. 631/94 section 3 of Trades Qualification and Apprenticeship Act
  - jacks
  - chain lifts
- **blocking devices**
  - stands
  - safety locks and lockouts
- **rigging devices**
  - rope
  - chains
  - belts
  - brackets and hooks
  - fastening procedures

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 and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedure
  - potential lifting hazards
  - fire hazard prevention
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1241.2 Precision Measuring Tools

Duration: Total 6 hours Theory 3 hours Practical 3 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5922.0, 5923.0, 5924.0, 5925.0, 5926.0, 5927.0, 5928.0, 5929.0, 5930.0, 5931.0, 5932.0, 5933.0, 5935.0, 5936.0, 5937.0, 5938.0, 5939.0, 5940.0
HDET	5891.0, 5892.0, 5893.0, 5894.0, 5895.0, 5896.0, 5897.0, 5898.0, 5899.0, 5900.0, 5901.0, 5903.0, 5904.0, 5905.0,
PLTT	5862.0, 5863.0, 5864.0, 5865.0, 5866.0, 5867.0, 5868.0, 5869.0, 5870.0, 5871.0, 5873.0, 5874.0, 5875.0, 5876.0, 5877.0, 5879.0, 5880.0, 5881.0
TCT	5136.0, 5137.0, 5138.0, 5139.0, 5140.0, 5141.0, 5142.0, 5143.0, 5144.0, 5145.0, 5146.0, 5147.0, 5148.0, 5149.0, 5151.0, 5152.0

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to use precision measuring tools following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.2.1 Explain the fundamentals of precision and non-precision measuring tools.

[1/0]
- **système international d'unités (s.i.) and Imperial**
- **measurements and conversions**
- **accuracy and reliability vs. the cost of measuring tools**

1.2.2 Identify the construction features, composition, types, styles, and application of precision measuring tools.

[1/0]
- **micrometers**
  - inside, outside, depth
- **small hole gauges**
- **callipers**
  - precision vernier, non-precision
- **telescoping gauges**
- **straight edge**
- **thickness gauge (feeler gauges)**
- **dial indicators**
- **torque wrenches**
  - click type
  - dial type
  - flexing beam type
  - electronic type
  - adapters and extensions

1.2.3 Describe the principles of operation of precision measuring tools.

[1/0]
- **micrometer**
  - inside, outside, depth
- **small hole gauges**
- **callipers**
  - precision vernier, non-precision
- **telescoping gauges**
- **straight edge**
- **thickness gauge (feeler gauges)**
- **dial indicators**
- **torque wrenches**
  - click type
  - dial type
  - flexing beam type
  - electronic type
  - adapters and extensions

1.2.4 Perform manufacturer maintenance and calibration procedures for precision and non-precision measuring tools, and measure components.

[0/3]
- **describe basic tool maintenance procedures**
  - storage
  - lubrication
  - methods of restoring critical surfaces
  - adjustments, calibration
- **precision measuring activities on various components**
  - crankshaft
  - camshaft

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 and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting, hoisting procedures
  - fire hazard prevention
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1241.3 Fastening Devices and Torquing Procedures

Duration: Total 8 hours Theory 4 hours Practical 4 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5921.0, 5922.0, 5923.0, 5924.0, 5925.0, 5926.0, 5927.0, 5928.0, 5929.0, 5930.0, 5931.0, 5932.0, 5933.0, 5934.0, 5935.0, 5936.0, 5937.0, 5938.0, 5939.0, 5940.0
HDET	5891.0, 5892.0, 5893.0, 5894.0, 5895.0, 5896.0, 5897.0, 5898.0, 5899.0, 5900.0, 5901.0, 5902.0, 5903.0, 5904.0, 5905.0, 5906.0, 5907.0
PLTT	5862.0, 5863.0, 5864.0, 5865.0, 5866.0, 5867.0, 5868.0, 5869.0, 5870.0, 5871.0, 5872.0, 5873.0, 5874.0, 5875.0, 5876.0, 5877.0, 5878.0, 5879.0, 5880.0, 5881.0
TCT	5136.0, 5137.0, 5138.0, 5139.0, 5140.0, 5141.0, 5142.0, 5143.0, 5144.0, 5145.0, 5146.0, 5147.0, 5148.0, 5149.0, 5150.0, 5151.0, 5152.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform fastening device installation and removal procedures following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.3.1 Explain the fundamentals of fastening devices and torquing procedures.

[1/0]
- **thread terminology, fastener grades/application**
- **Society of Automotive Engineers (SAE) standards, système international d'unités (s.i.)**
- **yield strength, tensile strength, shear strength, and fatigue**
- **grade, pitch, threads per inch**
- **diameter, length, and head size**
- **thread locking compounds**
- **anti-seize compounds**
- **sealant applications**
- **factors that affect torque/tension**
  - lubrication
  - temperature
  - length and diameter
  - grade of fastener
  - condition of threads
  - composition of material

1.3.2 Identify the construction, composition, types, styles, and application of fastening devices.

[2/0]
- **bolts**
- **nuts**
- **screws**
- **studs**
- **locking devices**
- **pins**
- **rivets**
- **keys**
- **washers**
- **retaining rings**
- **thread repair devices**
- **thread sealants**
- **thread locking compounds**
- **grade application criteria**

1.3.3 Describe the principles of operation of fastening devices.

[1/0]
- **torque-to-yield fasteners**
- **torque effects of wet, dry, and clean threads**
- **locking devices**
- **thread repair principles**
- **temperature**
- **compatibility**
- **clamping force**
- **effect of fastener grade on strength, flexibility, and torque**

1.3.4 Perform installation and removal procedures following manufacturers' recommendations for fastening devices.

[0/4]
- **test fastener strength and torque requirements for wet and dry applications**
- **demonstrate thread repair procedures for:**
  - freeing seized threads, removal of broken fasteners
  - installation of thread repair and locking devices
- **metal working practices for:**
  - drilling
  - tapping
  - hacksawing
  - filing
- **sealant selection, removal, and installation practices**
- **thread locking and anti-seize application**
- **torquing of fasteners to manufacturers' recommendations**

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 and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - fire hazard prevention
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1241.4 Bearings, Seals, and Sealants

Duration: Total 8 hours Theory 5 hours Practical 3 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5922.0, 5923.0, 5929.0, 5930.0, 5933.0, 5936.0, 5937.0, 5938.0, 5939.0, 5940.0
HDET	5891.0, 5895.0, 5896.0, 5897.0, 5898.0, 5899.0, 5904.0
PLTT	5863.0, 5866.0, 5867.0, 5868.0, 5869.0, 5871.0, 5876.0
TCT	5139.0, 5142.0, 5143.0, 5146.0, 5147.0, 5150.0, 5152.0

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform the maintenance and repair procedures for bearings, seals, and sealants following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.4.1 Explain the purpose and fundamentals of bearings, seals, and sealants.

[1/0]
- **friction**
- **temperature**
- **lubrication**
- **bearing loads**
  - axial loads
  - radial loads
- **preload**
- **endplay**
- **pressure**
  - seals
  - dynamic
  - static
- **sealants**
  - anaerobic
  - non-anaerobic
- **gaskets**
- **cleaning and surface preparation products**

1.4.2 Identify the construction features, composition, types, styles, and application of bearings, seals, and sealants.

[2/0]
- **friction bearings**
- **anti-friction bearings**
  - ball
  - roller
  - needle
  - code identification
- **seals**
  - dynamic
  - static
- **sealants**
  - anaerobic
  - non-anaerobic
- **gaskets**
- **cleaning and surface preparation products**

1.4.3 Describe the principles of operation of bearings, seals, and sealants.

[2/0]
- **friction bearings**
- **hydrodynamic suspension**
- **anti-friction bearings**
  - ball
  - roller
  - needle
- **temperature**
- **lubrication**
- **bearing adjustments**
  - preload
  - end play
- **pressure**
- **seals**
  - dynamic
  - static
- **sealant**
  - anaerobic
  - non-anaerobic
- **gaskets**
  - yield
  - creep
- **speciality sealant**
- **cleaning and surface preparation products**

1.4.4 Demonstrate inspection and testing procedures following manufacturers' recommendations for bearings, seals, and sealants.

[0/1]
- **bearing inspection and testing for:**
  - scoring
  - spalling
  - over-heating
  - noise
  - vibration
  - electrical damage (arcing)
  - clearance
- **seal inspection and testing for:**
  - migration
  - leakage of seals or gaskets
  - shaft and housing bore condition
  - fluid compatibility

1.4.4 Recommend reconditioning or repairs following manufacturers' recommendations for bearings, seals, and sealants.

[0/2]
- **removal and installation procedures for:**
  - bearings
  - seals
  - sealants
    - o correct selection of sealant for application
  - gaskets

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 and skin protection
  - control of hazardous material/solvents
  - ventilation of work areas
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislation
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1241.5 Oxy-Fuel Processes

Duration: Total 8 hours Theory 4 hours Practical 4 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5924.03, 5928.03, 5933.06, 5936.03, 5937.03, 5938.03, 5939.03
HDET	5893.03, 5900.03, 5903.03, 5904.06
PLTT	5869.03, 5869.06, 09, 5871.03, 5877.03, 5879.03
TCT	5141.03, 5142.03,06,09, 5143.03, 5145.03, 5146.03

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to operate heating and cutting equipment following manufacturers' recommendations, government regulations, and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.5.1 Explain the purpose and fundamentals of heating and cutting practices.

[1/0]
- **oxy-fuel gases**
- **eye, face, hand, foot, and clothing protection**
- **set-up, ignition, and shutdown sequence**
- **cylinder handling/storage**
- **fire prevention**
  - combustible material (e.g. butane lighter risks)
- **flashback**
- **backfire**
- **removing damaged or broken fasteners**
- **using heat to free seized fasteners**

1.5.2 Identify the construction features, types, and application of oxyacetylene heating and cutting equipment.

[1/0]
- **cylinders**
  - identification features
- **pressure regulator**
- **manual valves**
- **manifold systems**
- **gauges and hoses**
- **cutting attachments**
- **tips**
  - cutting
  - heating
- **torch body**
- **heating tips**
- **flashback arresters**

1.5.3 Describe the principles of operation of oxyacetylene heating and cutting equipment.

[1/0]
- **cylinders**
- **pressure regulator**
- **manual valves**
- **manifold systems**
- **gauges and hoses**
- **cutting attachments**
- **torch body**
- **tips**
  - cutting
  - heating
- **flashback arresters**

1.5.4 Outline the manufacturers' system maintenance procedures for oxyacetylene heating and cutting equipment.

[1/0]
- **cylinders**
- **approved storage and securement**
- **gauges and hoses**
- **manual valves**
- **pressure regulators**
- **cutting attachments**
- **tips**
  - cutting
  - heating
- **torch body**
- **manifold**

1.5.5 Perform basic heating and cutting procedures following manufacturers' recommendations.

[0/4]
- **equipment set-up, ignition, and shutdown sequence**
  - oxygen and acetylene pressure settings
  - ignition procedures
  - select heating and cutting tips
  - observe tip angle, travel speed, and gap
  - demonstrate awareness of potential damage from heating or cutting to surrounding materials
  - identify potential risks for altering metallurgical properties
  - perform appropriate pressure settings, ignition, and flame adjustments for specific heating and cutting tasks
  - remove damaged fasteners
  - heating and removing procedures of seized fasteners

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**
  - oxygen and acetylene dangers
  - eye, skin, hand, foot, hearing and clothing protection
  - control of hazardous material/solvents
  - ventilation of work areas
  - personal protective equipment
  - cut and burn treatment
  - fire extinguisher availability
  - set-up and shutdown sequence
  - cylinder handling
  - vehicle electronic systems protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number: **S1242**

Reportable Subject: **FLUID POWER SYSTEMS**

Duration: Total 24 hours Theory 19 hours Practical 5 hours

Prerequisites: None

Co-requisites: None

2.1 Fluid Power Fundamentals

4 Total Hours Theory: 4 hours Practical: 0 hours

2.2 Fluid Power Component and Graphic Symbols

4 Total Hours Theory: 4 hours Practical: 0 hours

2.3 Fluid Power Principles of Operation

7 Total Hours Theory: 4 hours Practical: 3 hours

2.4 Fluid Power Hydraulic Fluids and Filters

2 Total Hours Theory: 2 hours Practical: 0 hours

2.5 Fluid Power Conductors and Connectors

4 Total Hours Theory: 3 hours Practical: 1 hour

2.6 Fluid Power Maintenance Schedule

3 Total Hours Theory: 2 hours Practical: 1 hour

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

Mark Distribution:

Theory Testing	Practical Application Testing
80%	20%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Reference Documentation

Recommended Minimum Equipment:

Hydraulic simulator or equipment with a hydraulic system.	Pressure testing equipment
Air brake simulator or equipment with air brakes	Hydraulic and air brake components

S1242.1 Fluid Power Fundamentals

Durations: Total 4 hours Theory 4 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5922, 5930, 5932, 5936, 5937, 5938, 5939
HDET	5895, 5896, 5898, 5899, 5900, 5905
PLTT	5876, 5866, 5868, 5869, 5871, 5877
TCT	5152, 5142, 5146, 5147, 5150

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to perform basic calculations of pressure, force, and area using Imperial and système international d'unités (s.i.) measurement.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.1.1 Explain the fundamentals of hydraulic and pneumatic systems.

[2/0] - **basic laws and their applications**
- Pascal's Law
- Boyle's Law
- Charles's Law
- Gay-Lussac's Law
- Bernoulli's Principle

2.1.2 Describe hydraulic and pneumatic terms and applications.

[1/0] - **basic terms**
- hydrostatics
- hydrodynamics
- positive and negative pressures

- **basic applications of hydraulics and pneumatics**
- fluid power leverage

2.1.3 Perform calculations for:

[1/0] - **pressure, force, and area**
- Imperial
- système international d'unités (s.i.)

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, hearing and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - fire hazard prevention
  - high pressure fluid injection/penetration to skin
  - supporting, blocking hydraulic components
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1242.2 Fluid Power Component and Graphic Symbols

Duration: Total 4 hours Theory 4 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5922, 5929, 5930, 5931, 5936, 5937, 5938, 5939
HDET	5895, 5898, 5899, 5900, 5901, 5905
PLTT	5876, 5868, 5869, 5870, 5877, 5880
TCT	5152, 5146, 5147, 5148, 5149, 5150

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to interpret basic hydraulic and pneumatic systems following manufacturers' recommendations and schematics.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.2.1 Identify the components and graphic symbols.

[1/0] - **basic components**
- reservoir (filters and lines)
- pumps and compressors
- valves (pressure, volume and directional control)
- actuators (rotary and linear)

2.2.2 Describe the features, composition, types, and application of schematics for pneumatic and hydraulic systems.

[2/0] - **pneumatic schematics and graphic symbols**
- **hydraulic schematics and graphic symbols**
  - explain and interpret manufacturer’s schematic legends

2.2.3 Perform basic circuit drawing using graphic symbols.

[1/0] - **hydraulic circuits**
- **pneumatic circuits**

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, hearing and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - fire hazard prevention
  - high pressure fluid injection/penetration to skin
  - supporting and blocking hydraulic components
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1242.3 Fluid Power Principles of Operation

Duration: Total 7 hours Theory 4 hours Practical 3 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5922, 5929, 5930, 5931, 5936, 5937, 5938, 5939
HDET	5895, 5898, 5899, 5900, 5901, 5905
PLTT	5876, 5868, 5869, 5870, 5877, 5880
TCT	5152, 5146, 5147, 5148, 5149, 5150

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to explain the operation of basic hydraulic and pneumatic components following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.3.1 Explain the fundamental of pneumatic and hydraulic components.

[1/0]
- **pumps and compressors**
  - gear
  - vane
  - piston
- **valves**
  - pressure relief valve
  - directional control valve
  - volume control valve
- **actuators**
  - linear
  - rotary
- **reservoirs and receivers**
  - vented and pressurized

2.3.2 Identify the construction features, types, and styles of pneumatic and hydraulic components.

[1/0]
- **pumps and compressors**
  - gear
  - vane
  - piston
- **valves**
  - pressure relief valve
  - directional control valve
  - volume control valve
- **actuators**
  - linear

  - rotary
- **reservoirs and receivers**
  - vented and pressurized

2.3.3 Describe the principles of operation of pneumatic and hydraulic components.

[2/0]
- **pumps and compressors**
  - gear
  - vane
  - piston
- **valves**
  - pressure relief valve
  - directional control valve
  - volume control valve
- **actuators**
  - linear
  - rotary
- **reservoirs and receivers**
  - vented and pressurized

2.3.4 Identify and locate hydraulic and pneumatic components on basic systems.

[0/3]
- **pneumatic components using schematics**
- **hydraulic components using schematics**

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, hearing and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - fire hazard prevention
  - high pressure fluid injection/penetration to skin
  - supporting and blocking hydraulic components
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1242.4 Fluid Power Hydraulic Fluid and Filters

Duration: Total 2 hours Theory 2 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5922, 5927, 5929, 5930
HDET	5895, 5896, 5898, 5899
PLTT	5876, 5866, 5868, 5869, 5877
TCT	5152, 5142, 5147, 5150

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to describe the different types of hydraulic fluid and their application following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.4.1 Explain the purpose and fundamentals of hydraulic fluids.

[0.5/0]
- **power transfer medium**
- **lubrication**
- **cooling**

2.4.2 Identify the composition and properties of hydraulic fluids.

[1.5/0]
- **viscosity**
- **fire supporting**
  - volatility
  - flammability
- f**ire retarding**
- **synthetic**

2.4.2 Describe the function and construction features of hydraulic fluid filters.

[1/0]
- **basic filtration**
- **media types**
  - surface types
  - depth types
- **beta ratio**
- **micron rating**
- **delta pressure**
- **full-flow**
- **by-pass**

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, hearing and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - high pressure concerns for skin penetration
  - supporting and blocking hydraulic components
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1242.5 Fluid Power Conductors and Connectors

Duration: Total 4 hours Theory 3 hours Practical 1 hour

Prerequisites: None

Cross-Reference to Training Standard:

AET	5922, 5927, 5929, 5930, 5931, 5936, 5937, 5938
HDET	5895, 5896, 5898, 5899, 5901, 5905
PLTT	5876, 5866, 5868, 5869, 5870, 5877
TCT	5152, 5142, 5146, 5147, 5149

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to describe the inspection and testing procedures for hydraulic and pneumatic conductors and fittings following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.5.1 Explain the purpose of pneumatic and hydraulic conductors and connectors.

[1/0]
- **lines**
- **pipes and tubing**
- **fittings**

2.5.2 Identify the construction features, types, and application of conductors and connectors.

[2/0]
- **pneumatic lines and hoses**
- **hydraulic lines and hoses**
- **pneumatic fittings**
- **hydraulic fittings**
  - standard, British and metric fitting

2.5.3 Demonstrate the fabrication, inspection, and testing procedures following manufacturers' recommendations for pneumatic and hydraulic conductors and connectors.

[0/1]
- **hydraulic hose fabrication**
- **identify hazards related to line replacement**
  - identify the risks of fluid injection into the skin
- **outline the inspection procedure for hydraulic conductors and connectors**
  - always use a mechanical device to move hydraulic lines when looking for leaks

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, hearing and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - fire hazard prevention
  - high pressure fluid injection/penetration to skin
  - supporting, blocking hydraulic components
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiches
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1242.6 Fluid Power Maintenance Schedule

Duration: Total 3 hours Theory 2 hours Practical 1 hour

Prerequisites: None

Cross-Reference to Training Standard:

AET	5922, 5927, 5929, 5930, 5931, 5936, 5937, 5938
HDET	5895, 5896, 5898, 5899, 5901, 5905
PLTT	5876, 5866, 5868, 5869, 5870, 5877
TCT	5152, 5142, 5146, 5147, 5149

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to describe a regularly scheduled maintenance service following manufacturers' recommendations for hydraulic and pneumatic systems.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.6.1 Explain the fundamentals of regular hydraulic and pneumatic system maintenance service.

[2/0]
- **maintenance schedules**
- **oil sampling**
- **fluid servicing**
- **filter servicing**
- **reservoir servicing**
- **inspection**
- **troubleshooting common defects**

2.6.2 Demonstrate maintenance procedures following manufacturers’ recommendations for pneumatic and hydraulic systems.

[0/1]
- **procedure to service filters**
- **oil sampling procedures**
- **identify oil contamination**
- **hydraulic and pneumatic line inspection**
- **water separator inspection**
- **perform a maintenance schedule check-off report**

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, hearing and skin protection
  - control of hazardous materials
  - ventilation of work areas
  - lifting/hoisting procedures
  - fire hazard prevention
  - high pressure fluid injection/penetration to skin
  - supporting and blocking hydraulic components
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management systems
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number: **S1243**

Reportable Subject: **ENGINE SYSTEMS**

Duration: Total 40 hours Theory 22 hours Practical 18 hours

Prerequisites: None

Co-requisites: None

3.1 Engine Operation Fundamentals

10 Total Hours Theory: 10 hours Practical: 0 hours

3.2 Engine Component Fundamentals

9 Total Hours Theory: 5 hours Practical: 4 hours

3.3 Engine System Identification, Maintenance and Service Procedures

21 Total Hours Theory: 7 hours Practical: 14 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:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Inline engine components for identification of parts	Engine with an in block camshaft (disassembled)
V-block engine for identification of parts	equipment simulator or operational equipment
Engine with an overhead cam (disassembled)	engine oil sampling collection equipment
basic hand tools	

S1243.1 Engine Operation Fundamentals

Duration: Total 10 hours Theory 10 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5923, 5924
HDET	5891, 5893
PLTT	5863
TCT	5139, 5141

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice will be able to explain the terminology used on engine blocks, cylinder heads, valve train and power train components.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.1.1 Explain the fundamentals of engine assemblies.

[2/0]
- **Otto cycle**
- **Diesel cycle**
- **spark ignition**
- **compression ignition**
- **two-stroke cycle**
- **four-stroke cycle**

3.1.2 Describe engine terminology.

[4/0]
- **inertia heat**
- **heat**
- **energy**
- **pressure**
- **force**
- **torque**
- **bore**
- **stroke**
- **swept volume**
- **displacement**
- **clearance volume**
- **compression ratio**
- **volumetric efficiency**
- **mechanical efficiency**
- **thermal efficiency**
- **power**
- **indicated horsepower**
- **brake horsepower**

- **Society of Automotive Engineers (SAE) horsepower**

3.1.3 Identify the principles of operation of engine assemblies.

[4/0]
- **Otto cycle**
- **Diesel cycle**
- **two-stroke cycle**
- **four-stoke cycle**
- **spark ignition**
- **compression ignition**
- **combustion dynamics**
- **process of combustion**
- **combustion chamber design**
- **expansion coefficients**
- **air/fuel ratios**
- **perform basic engine calculations**
  - swept volume
  - compression ratio
  - compression pressure
  - indicated horsepower
  - brake horsepower
  - Society of Automotive Engineers (SAE) horsepower
  - mechanical efficiency
  - volumetric efficiency
  - thermal efficiency

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 Instructional Activities.

- **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 system
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1243.2 Engine Component Fundamentals

Duration: Total 9 hours Theory 5 hours Practical 4 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5923.0, 5923.01, 5923.11, 5923.12, 5923.13, 5924
HDET	5891.0, 5891.01, 5891.11, 5891.12, 5891.13, 5893
PLTT	5863.0, 5863.01, 5863.11, 5863.12, 5863.13
TCT	5139.0, 5139.01, 5139.11, 5139.12. 5139.13, 5141

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice will be able to explain and identify the operating principles of engine blocks, cylinder heads, valve trains and power train components.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.2.1 Explain the purpose and fundamentals of engine block, cylinder head, valve train, and power train components.

[1/0]
- **engine blocks**
  - design features
  - configuration
- **gear train assemblies**
- **cylinder heads**
- **valve train assembly**
  - in block cam
  - overhead cam

3.2.2 Identify and describe the functions, types, styles, and applications of engine blocks, cylinder heads, valve trains and power train components.

[4/4]
- **cylinder blocks**
  - design feature
    - top deck surface
    - main bearing bores
  - configuration
    - V-block
    - inline
    - sleeves / liners
    - wet
    - dry
    - integral
    - air cooled
    - liquid cooled
- **counter bore**

- **flywheel vibration dampers**
- **crankshaft**
- **connecting rods**
  piston pins
- **pistons**
- **piston rings**
- **camshaft and timing gears**
- **cylinder head types**
  - overhead cam
  - L-head
- **cylinder head and valve train assembly**
  - valves, seats, guides, seals, springs and retainers
  - rocker assemblies, valve bridges, pushrods, lifters, camshafts
  - drive mechanisms
- **injector sleeves and fuel manifolds**

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 Instructional Activities.

- **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
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1243.3 Engine System Identification, Maintenance and Service Procedures

Duration: Total 21 hours Theory 7 hours Practical 14 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5923.0, 5923.01, 5923.11, 5923.12, 5923.13, 5924
HDET	5891.0, 5891.01, 5891.11, 5891.12, 5891.13, 5893
PLTT	5863.0, 5863.01, 5863.11, 5863.12, 5863.13
TCT	5139.0, 5139.01, 5139.11, 5139.12, 5139.13, 5141

GENERAL OUTCOME

Upon successful completion the apprentice is able to perform engine system maintenance, inspection and service procedures, following manufacturer's recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.1.1 Explain the terms and maintenance procedures used to service engine systems.

[5/0]
- **lubrication system**
- **lubricating oil ratings**
  - Society of Automotive Engineers (SAE)
  - American Petroleum Institute (API)
  - OEM vs. generic aftermarket specifications
- **lubricating circuits**
  - bypass valve
  - relief valve
- **filter types**
  - bypass
  - full flow
  - centrifugal
- **cooling system**
  - coolant handling and waste disposal
- **fan drives**
- **shroud and fan enclosure**
  - fan clutches
- **coolant pumps**
- **coolant types**
  - OEM vs. generic aftermarket specifications
- **radiator coolant level switches**
- **hoses, clamps, and belts**
- **intake systems**
  - pre-cleaners
  - dry-type air cleaners
  - wet-type air cleaners
  - air to air after coolers

  - air to coolant after coolers
  - air intake heaters
  - air intake restriction indicators
- **exhaust systems**
  - turbo chargers
  - mufflers
  - pipes
- **accessory drive systems**
  - belts
  - pulleys
  - gear drives
- **fuel delivery systems**
  - filters
  - water separators
  - water in fuel (WIF)
  - priming procedure

3.3.2 Perform inspections, maintenance and basic service procedures following manufacturers' recommendations for engine lubrication, cooling, intake, exhaust, and fuel systems.

[2/14]
- **servicing oil and oil filters**
  - handling and disposal procedures
  - pressure test
  - inspection of lubrication system
    - o determining oil condition
    - o sampling procedure
    - o identify contaminants
  - bypass filter service procedure
- **demonstrate the inspection and maintenance procedures for:**
  - radiator condition and pressure testing
  - radiator and heater hose condition
  - radiator cap condition and pressure testing
  - testing pH level of coolant
  - testing coolant strengths and condition
  - testing supplemental coolant additives level
  - testing coolant total dissolved solids level
- **intake systems**
  - visual inspection
  - leak testing
  - air inlet restriction testing
  - filter servicing
- **exhaust systems**
  - visual inspection
  - noise and leak inspection
- **diesel particulate filter (DPF)**
- **aqueous urea injection system**
- **fuel system**
  - fuel handling and waste disposal
  - filter replacement
  - servicing water separators
  - fuel priming

  - fuel tank water draining
- **OEM maintenance tracking software**

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 Instructional Activities.

- **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
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number:	**S1244**		
Reportable Subject:	**ELECTRICAL SYSTEMS**		
Duration:	Total 48 hours	Theory 33 hours	Practical 15 hours
Prerequisites:	None		
Co-requisites:	None		

4.1 Introduction to Electricity

3 Total Hours Theory: 3 hours Practical: 0 hours

4.2 Electrical Laws

2 Total Hours Theory: 2 hours Practical: 0 hours

4.3 Electrical Test Equipment and Electronic Service Tools

5 Total Hours Theory: 5 hours Practical: 0 hours

4.4 Electrical Circuits and Calculations

8 Total Hours Theory: 4 hours Practical: 4 hours

4.5 Electrical Circuits and Protective Devices

7 Total Hours Theory: 4 hours Practical: 3 hours

4.6 Electrical Circuit Repair

8 Total Hours Theory: 4 hours Practical: 4 hours

4.7 Electromagnetic Devices

7 Total Hours Theory: 7 hours Practical: 0 hours

4.8 Battery Fundamentals

8 Total Hours Theory: 4 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
70%	30%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Electrical circuit board or equipment with electrical systems	Battery or equipment and battery test equipment
Sealed Wire Terminal and Connector Body Repair Kit	Basic Hand tools
Terminal Extraction and Installation Tools	Terminal Crimping Tools
High Impedance Multi Meters	

S1244.1 Introduction to Electricity

Duration: Total 3 hours Theory 3 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard

AET	5921, 5925, 5926, 5934, 5935
HDET	5892, 5894, 5902, 5903
PLTT	5862, 5864, 5865, 5872, 5873, 5878, 5879
TCT	5136, 5137, 5140, 5145, 5151

GENERAL OUTCOME

Upon successful completion the apprentice is able to describe the principles of electricity following accepted scientific theories.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.1.1 Explain the purpose, fundamentals, and principles of electricity.

[3/0]
- **atomic structure**
- **conductors and insulators**
- **electron and conventional theories**
- **sources of electricity**
  - heat
  - pressure
  - friction
  - chemical
  - light
  - magnetism

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 and skin protection
  - accidental grounding rings, jewellery, and tools
  - first aid procedures
  - hand, and foot protection

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

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

S1244.2 Electrical Laws

Duration: Total 2 hours Theory 2 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5921, 5925, 5926, 5934, 5935
HDET	5892, 5894, 5902, 5903
PLTT	5862, 5864, 5865, 5872, 5873, 5878, 5879
TCT	5136, 5137, 5140, 5145, 5151

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the laws governing electricity.

LEARNING OUTCOME AND CONTENT

Upon successful completion, the apprentice is able to:

4.2.1 Explain the fundamentals of electrical laws.

[2/0]

- **Ohm's Law**
  - state law
  - mathematical relationship between current, voltage, and resistance
- **Watt's Law**
  - state law
  - mathematical relationship between current, voltage, and wattage
- **Kirchhoff's Laws**
  - state laws
    - current law
    - voltage law
  - mathematical relationship of individual voltage drops to circuit voltage

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 and skin protection
  - accidental grounding rings, jewellery and tools
  - first aid procedures
  - hand, and foot protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1244.3 Electrical Test Equipment and Electronic Service Tools

Duration: Total 5 hours Theory 5 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5921, 5925, 5926, 5934, 5935
HDET	5892, 5894, 5902, 5903
PLTT	5862, 5864, 5865, 5872, 5873, 5878, 5879
TCT	5136, 5137, 5140, 5145, 5151

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to use basic electrical test equipment following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.3.1 Explain the purpose and fundamentals of electrical test equipment.

[1/0] - **analog and digital instruments**
- voltmeter
- ammeter
- ohmmeter
- electronic service tools (EST)
- test lamp

4.3.2 Identify the function, types, and application of electrical test equipment.

[4/0] - **analog and digital instruments**
- voltmeter
- ammeter
- ohmmeter
- electronic service tools (EST)
  - message identifiers (MIDs)
  - parameters identifiers (PIDs)
  - subsystem identifiers (SIDs)
  - fault mode indicators (FIMs)
  - communication protocol J1939 and J1587/1708
- test lamp

- **select scale appropriate to test being performed**

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 and skin protection
  - accidental grounding rings, jewellery and tools
  - first aid procedures
  - hand, and foot protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1244.4 Electrical Circuits and Calculations

Duration: Total 8 hours Theory 4 hours Practical 4 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5921, 5925, 5926, 5934, 5935
HDET	5892, 5894, 5902, 5903
PLTT	5862, 5864, 5865, 5872, 5873, 5878, 5879
TCT	5136, 5137, 5140, 5145, 5151

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to trace, test, and repair electrical circuits following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.4.1 Explain the fundamentals of electrical circuits.

[1/0]
- **define the following terms:**
  - voltage
  - amperage
  - resistance
  - wattage
  - grounds
  - power source
- **circuit related electrical fundamentals**

4.4.2 Identify the construction features, composition, types, and application of electrical circuits.

[3/0]
- **electrical schematics and symbols**
- **electrical circuit formulae**
- **series, parallel, and series-parallel circuits**
- **circuit characteristics**

4.4.3 Perform circuit calculations to verify Ohm's and Kirchoff's Laws.

[0/2]
- **apply Ohm's law to the following:**
  - series, parallel, and series-parallel circuits
  - circuit calculations

4.4.4 Perform tests of electrical circuits following manufacturers' recommendations using selected meters to measure voltage, amperage, and resistance.

[0/2]
- **circuit board test exercises**
- **simulated electrical circuit tests**
- **identify vehicle electrical circuits**
- **demonstrate the comparison between measured and calculated circuit performance**

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 and skin protection
  - accidental grounding rings, jewellery and tools
  - first aid procedures
  - hand, and foot protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1244.5 Electrical Circuits and Protective Devices

Duration: Total 7 hours Theory 4 hours Practical 3 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5921, 5925, 5926, 5934, 5935
HDET	5892, 5894, 5902, 5903
PLTT	5862, 5864, 5865, 5872, 5873, 5878, 5879
TCT	5136, 5137, 5140, 5145, 5151

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to locate and test circuits and components following manufacturers' schematics and specifications.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.5.1 Explain the purpose and function of vehicle electrical circuit schematics and protection devices.

[1/0]
- **schematics**
- **symbol**
- **fuses/breakers/fusible links**
- **virtual fuses/breakers (current protected drivers)**
- **circuit identification**

4.5.2 Identify the construction features, type, style, and application of wiring diagrams.

[3/0]
- **wiring schematics**
  - line type
  - valley forge type
  - illustrated
  - Deutsche International (DIN)
- **electrical symbols**
- **protection devices**
  - circuit breakers
  - fuses
  - virtual fuses/breakers (current protected drivers)
  - fusible links
- **wiring and connectors**
  - wire size configuration – American Wire Gauge (AWG)/système international d'unités (s.i.)
  - identification
  - composition
  - terminal configuration (multi-pin, layout)

4.5.3 Perform component location and condition assessment exercise following manufacturers' recommendations.

[0/3]
- **pin-out test**
- **component function test (switches, ect.)**
- **identify component location using equipment schematics**

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 and skin protection
  - accidental grounding rings, jewellery and tools
  - first aid procedures
  - hand, and foot protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1244.6 Electrical Circuit Repair

Duration: Total 8 hours Theory 4 hours Practical 4 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5921, 5925, 5926, 5934, 5935
HDET	5892, 5894, 5902, 5903
PLTT	5862, 5864, 5865, 5872, 5873, 5878, 5879
TCT	5136, 5137, 5140, 5145, 5151

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to diagnose and repair electrical circuits following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.6.1 Explain electrical circuit failures.

[1/0]
- **opens**
- **shorts**
- **unintentional grounds**
- **high resistance conditions**

4.6.2 Identify the characteristics of electrical circuit failures.

[1/0]
- **opens**
- **shorts**
- **unintentional grounds**
- **high resistance conditions**

4.6.3 Describe the construction, types, styles, and application of electrical circuit connectors.

[2/0]
- **proprietary connectors (Weatherpack-Deutsch)**
- **soldered and solderless joints**
- **heat shrink tubing**
- **connectors**
- **corrosive protection materials**

4.6.4 Perform reconditioning or repair procedures following manufacturers' recommendations for electrical circuits.

[0/4]
- **repair of electrical circuit connectors for:**
  - proprietary connectors/tools (e.g. Weatherpack-Deutsch)
  - soldered and solderless joints
  - heat shrink tubing
- **identification corrosive protection materials**

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 protection
  - accidental grounding rings, jewellery and tools
  - first aid procedures
  - hand, hearing and foot protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1244.7 Electromagnetic Devices

Duration: Total 7 hours Theory 7 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5921, 5925, 5926, 5934, 5935
HDET	5892, 5894, 5902, 5903
PLTT	5862, 5864, 5865, 5872, 5873, 5878, 5879
TCT	5136, 5137, 5140, 5145, 5151

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to describe the operation of electromagnetic devices following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.71 Explain the fundamentals of electromagnetic devices.

[2/0]
- **magnetism**
- **electromagnetism**
- **current flow and magnetic principles for relays, solenoids, and motors**
- **right and left hand rules**
- **counter electromotive force effects**

4.7.2 Identify the construction, types, and application of electromagnetic devices.

[3/0]
- **electric motors**
- **solenoids**
- **relays**
- **generators**
- **coils**
- **stepper motors**

4.6.3 Describe the principles of operation of electromagnetic devices.

[2/0]
- **motors**
  - torque and power
- **solenoids**
- **relays**
- **coils**
- **generators**
- **stepper motors**

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 and skin protection
  - accidental grounding rings, jewellery and tools
  - first aid procedures
  - hand, and foot protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1244.8 Battery Fundamentals

Duration: Total 8 hours Theory 4 hours Practical 4 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5921
HDET	5894
PLTT	5862, 5872
TCT	5136, 5137

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to service, test and evaluate batteries following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.8.1 Explain the purpose and fundamentals of batteries.

[1/0]
- **electrical storage device**
- **reserve capacity**
- **cold cranking rating**
- **temperature effects**
- **internal resistance**
- **electrolyte characteristics**

4.8.2 Identify the types, styles, and application of batteries.

[1/0]
- **flooded cell (e.g. lead acid)**
- **low maintenance**
- **gel cell batteries**
- **absorbed glass mat (AGM)**

4.8.3 Describe the principles of operation during charge and discharge of batteries.

[2/0]
- **chemical action**
- **temperature/internal resistance effects**
- **charge/discharge cycle (constant voltage/current)**

4.8.4 Perform inspection and testing procedures following manufacturers' recommendations for batteries.

[0/2]
- **inspection and testing procedures for:**
  - visual inspection
  - state of charge
  - surface discharge

- load test
- high rate discharge test
- refractometer test
- impedance test
- safe handling

4.8.5 Recommend reconditioning or repairs following manufacturers' recommendations to batteries.

[0/2] - **perform battery maintenance procedures for:**

- storage
- activation
- cleaning
- charging
- removal and replacement procedures
- safe handling

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 and skin protection
  - accidental grounding rings, jewellery and tools
  - first aid procedures
  - hand, and foot protection
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number: **S1245**

Reportable Subject: **FUEL SYSTEMS**

Duration: Total 24 hours Theory 18 hours Practical 6 hours

Prerequisites: None

Co-requisites: None

5.1 Fundamentals of Diesel Fuel Systems

6 Total Hours Theory: 6 hours Practical: 0 hours

5.2 Diesel Fuel Injection Principles

6 Total Hours Theory: 4 hours Practical: 2 hours

5.3 Diesel Fuel Injection Sub-Systems

6 Total Hours Theory: 4 hours Practical: 2 hours

5.4 Diesel Hydraulic Injectors

6 Total Hours Theory: 4 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:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Operational Diesel engine	Fuel system components
Basic Hand Tools	Primary Circuit Test Equipment
Injector Removal and Installation Kit	Hydraulic / Unitized Diesel fuel injectors and test equipment

S1245.1 Fundamentals of Fuel Systems

Duration: Total 6 hours Theory 6 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5925
HDET	5892
PLTT	5864, 5865
TCT	5138, 5140

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to describe the fundamentals of diesel fuel following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.1.1 Explain the purpose and fundamentals of fuels.

[2/0]
- **engine theory**
- **thermodynamics**
- **heat energy/calorific value**
- **combustion ratios**
- **fuel chemistry**

5.1.2 Identify the functions, composition, and properties of fuels.

[3/0]
- **diesel fuel**
  - volatility
  - cetane number
  - viscosity
  - additives
  - sulphur content
- **gasoline**
  - octane ratings
  - additives
- **compressed natural gas**
- **propane**
- **alternative fuels**
  - bio-diesel

5.1.3 Describe the combustion principles of fuels.

[1/0]
- **oxidation reactions**
- **products of combustion**
- **air/fuel ratios**

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
  - explosive hazard of atomized fuel
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1245.2 Fuel Injection Principles

Duration: Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5923, 5925, 5926
HDET	5891, 5892
PLTT	5863, 5864, 5865
TCT	5138, 5139, 5140

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to inspect engine fuel systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.2.1 Explain the purpose and fundamentals of fuel systems.

[1/0]
- **hydraulics**
- **engine operating principles**
- **the Diesel and Otto cycle**
- **cylinder combustion dynamics**

5.2.2 Identify the functions, composition features, types, and application of fuel system components.

[1/0]
- **fuel system circuit layout**
- **fuel sub-systems**
- **pressure injection apparatus**
- **combustion chamber types**
  - indirect injection
  - direct injection
- **hydromechanical engine management**
- **electronic engine management**
- **identifying fuel systems by type**

5.2.3 Describe the combustion principles of fuels.

[2/0]
- **types of low and high pressure pumps**
- **indirect injection**
- **direct injection**
- **ignition timing, cylinder pressure, and crank throw mechanics**

5.2.4 Perform inspection and testing procedures following manufacturers' recommendations for fuel systems.

[0/1]
- **identify fuel circuit components on different engines**
- **demonstrate the external differences between mechanical and electronic engine fuel systems**

5.2.5 Recommend reconditioning or repairs following manufacturers' recommendations for fuel systems.

[0/1]
- **identify different OEM engines and fuel systems**
- **use OEM service information 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**
  - eye, hearing, breathing, and hand protection
  - high pressure/skin penetration
  - ventilation
  - explosive hazard of atomized fuel
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d’unités (s.i.) to Imperial conversion

S1245.3 Diesel Fuel Injection Sub-Systems

Duration: Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5923, 5925, 5926
HDET	5891, 5892
PLTT	5863, 5864, 5865
TCT	5138, 5139, 5140

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to recommend repairs to diesel fuel sub-systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.3.1 Explain the purpose and fundamentals of diesel fuel sub-systems.

[1/0]
- **hydraulics**
- **diesel fuel injection**
- **the Diesel cycle**

5.3.2 Identify the construction, composition, types, and application of diesel fuel sub-systems.

[2/0]
- **diesel fuel classification**
- **fuel tanks**
- **venting apparatus**
- **pick-up tubes and sending units**
- **primary fuel circuit and primary fuel filters**
- **anti-siphon valves**
- **water separators**
- **transfer pumps**
- **secondary (charge) fuel circuit and secondary fuel filters**
- **fuel manifolds**
- **fuel return circuit**
- **leak-off pipes**
- **fuel hose types and grades**
- **crossover plumbing**
- **bleeding devices**
- **fuel heaters**
  - water in fuel sensors (WIF)
  - charge pressure sensors
  - fuel temperature sensors
- **fuel coolers**

5.3.3 Describe the principles of operation of diesel fuel sub-systems.

[1/0]
- **heat exchangers**
- **primary and secondary filters**
- **vane, plunger and gear type pumps**
- **pressure relief valves**
- **vent valves**
- **rollover check valves**
- **coolant and electrical fuel heaters**
- **priming fuel sub-systems**

5.3.4 Perform the inspection and testing procedures following manufacturers' recommendations for diesel engine fuel sub-systems.

[0/1]
- **inspection and testing procedures for:**
  - identifying deteriorated fuel
  - testing primary circuit restriction to specification
  - testing secondary (charge) circuit pressure to specification
  - testing a fuel sending unit

5.3.5 Recommend reconditioning or repairs following manufacturers' recommendations for diesel engine fuel sub-systems.

[0/1]
- **service procedures**:
  - fuel filter replacement
  - prime a fuel sub-system

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
  - explosive hazard of atomized fuel
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1245.4 Diesel Hydraulic Injectors

Duration: Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5923, 5925, 5926
HDET	5891, 5892
PLTT	5863, 5864, 5865
TCT	5138, 5139, 5140

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to recommend repairs to injectors following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.4.1 Explain the purpose and fundamentals of diesel engine injectors.

[1/0]
- **high pressure fuel injection**
- **hydraulics**
- **pressure and sectional area**
- **requirements for combustion of liquid fuels**
- **combustion characteristics**
- **indirect injection**
- **direct injection**

5.4.2 Identify the functions, construction features, composition, types, and application of diesel engine injectors.

[1/0]
- **electro hydraulic nozzles**
  - electronic unit injectors (EUI)
  - common rail
- **hydraulic nozzles**
  - poppet nozzles
  - pintle nozzles
  - multi-orifii nozzles
  - mechanical unit injectors (MUI)
  - electronic unit injectors (EUI)
  - hydraulic electronic unit injectors (HEUI)
- **high pressure pipes**
- **leak-off lines**
- **fuel manifolds**

5.4.3 Describe the principles of operation of diesel engine injectors.

[2/0]
- **electro hydraulic nozzles**
  - soft opening control
  - solenoid actuators
  - piezo actuators
- **pintle nozzles**
- **multi-orifii nozzles**
- **hydraulic nozzles**
  - mechanical unit injectors (MUI)
  - electronic unit injector (EUI)
  - hydraulic electronic unit injectors (HEUI)
  - nozzle flow area and pressure
  - atomization requirements of engine by type
  - nozzle differential ratio
  - variable control orifice nozzle principle
  - pressure wave reflection

5.4.4 Demonstrate the inspection and testing procedures following manufacturers' recommendations for diesel injectors.

[0/2]
- **nozzle body service**
- **nozzle opening pressure (NOP) testing**
- **nozzle opening pressure (NOP) adjustment**
- **testing for forward leakage, back leakage, and spray pattern geometry**
- **identifying the effects of nozzle malfunction on engine 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 hand protection
  - high pressure/skin penetration
  - ventilation
  - explosive hazard of atomized fuel
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number: **S1246**

Reportable Subject: **DRIVE TRAIN SYSTEMS**

Duration: Total 32 hours Theory 24 hours Practical 8 hours

Prerequisites: None

Co-requisites: None

6.1 Push-Type Clutch and Flywheel Assemblies

6 Total Hours Theory: 4 hours Practical: 2 hours

6.2 Gearing Fundamentals

6 Total Hours Theory: 6 hours Practical: 0 hours

6.3 Single Countershaft Manual Transmissions

8 Total Hours Theory: 6 hours Practical: 2 hours

6.4 Drive Shafts, Power Take-Off Shafts, and Universal Joints

6 Total Hours Theory: 4 hours Practical: 2 hours

6.5 Single Reduction Drive Axle Assemblies

6 Total Hours Theory: 4 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:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Simulator or equipment with push type clutches and flywheels	Single countershaft transmission (Medium or Heavy Duty Type)
Equipment with a drive shaft, power take-off shafts and universal joints	Basic Hand Tools
Precision Measuring Tools	Equipment with a single reduction drive assembly or a single reduction drive axle

S1246.1 Push-Type Clutch and Flywheel Assemblies

Duration: Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5923, 5927
HDET	5891, 5896
PLTT	5863, 5866
TCT	5139, 5142

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to recommend repairs to push-type clutch and flywheel assemblies following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.1.1 Explain the purpose and fundamentals of push-type clutches and flywheel assemblies.

[1/0]
- **clamping forces**
- **mechanical advantage (lever and hydraulic)**
- **static and sliding friction**
- **coefficient of friction and heat**
- **centrifugal force**

6.1.2 Identify the composition, construction, types, and application of push-type clutches and flywheel assemblies.

[1/0]
- **push type (clutch assemblies)**
- **disengagement and engagement**
- **flywheel**
- **pressure plate**
- **clutch friction disc assembly**
- **hubs**
- **input shaft**
- **release bearing**
- **mechanical release mechanisms**
- **hydraulic release mechanisms**
- **bell/clutch housings**

6.1.3 Describe the principles of operation of push-type clutches and flywheel assemblies.

[1/0]
- **single disc clutches**
- **double disc clutches**
- **centrifugal clutches**
- **clutch control systems**

- **friction media**
- **flywheel**
- **pressure plate(s)**
- **heat dissipation**
- **coefficient of friction**
- **wave springs**
- **friction discs**
- **hubs**
- **clutch housing**
- **clutch assembly alignment**
- **power flow**
- **pilot bushing/bearing**

6.1.4 Demonstrate the inspection, testing, and diagnostic procedures following manufacturers' recommendations for push-type clutches and flywheel assemblies.

[0/1]
- **visual inspection**
  - test clutch and control operation
    - check mechanical linkage
    - check hydraulic actuation system
  - diagnosing clutch condition
  - outlining lubrication practices

6.1.5 Recommend reconditioning or repairs following manufacturers' recommended procedures for push-type clutches and flywheel assemblies.

[1/1]
- **familiarization with manufacturers' service literature**
- **perform clutch adjustment**
- **outline clutch assembly overhaul procedures**
  - check clutch and housing alignment and concentricity
- **outline machining practices and flywheels dimensions**

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, breathing, and hearing protection
  - use of hoists and stands
  - safe vehicle operation
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1246.2 Gearing Fundamentals

Duration: Total 6 hours Theory 6 hours Practical 0 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5927, 5928
HDET	5896, 5897
PLTT	5866, 5867
TCT	5142, 5143

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to explain the fundamentals of gearing used in drive train systems.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.2.1 Explain the purpose and fundamentals of gears and related support assemblies.

[2/0]
- **mechanical advantage**
- **laws of levers**
- **torque**
- **input/output ratio speed**
- **gear ratio**
- **shafts, splines, and gears**
- **lubrication**

6.2.2 Identify the construction features, composition, types, and application of gears and related support assemblies.

[2/0]
- **clutching mechanisms**
- **case**
- **gears**
- **shafts**
- **bearings and bushings**
- **spacers and thrust washers**
- **seals and gaskets**
- **shifting mechanisms**

6.2.3 Describe the principles of operation of gears and related support assemblies.

[2/0]
- **clutching mechanisms**
- **gears**
  - matching
  - timing
- **shafts**
- **power flow**
- **lubrication circuits**
- **thrust control**
- **bearings and bushings**
- **sealing**
- **shifting mechanisms**

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, breathing, and hearing protection
  - use of hoists and stands
  - safe vehicle operation
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1246.3 Single Countershaft Manual Transmissions

Duration: Total 8 hours Theory 6 hours Practical 2 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5927
HDET	5896
PLTT	5866
TCT	5142

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to recommend repairs to single countershaft manual transmissions following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.3.1 Explain the purpose and fundamentals of single countershaft manual transmissions.

[1/0]
- **mechanical advantage**
- **laws of levers**
- **torque**
- **input/output ratio speed**
- **gear ratio**
- **shafts, splines, and gears**
- **lubrication**

6.3.2 Identify the construction, composition, types, and application of single countershaft manual transmissions.

[1/0]
- **clutching mechanisms**
  - synchronizers
- **case**
- **gears**
- **shafts**
- **bearings and bushings**
- **spacers and thrust washers**
- **seals and gaskets**
- **shifting mechanisms**

6.3.3 Describe the principles of operation of gears and related support assemblies.

[3/0]
- **clutching mechanisms**
  - synchronizers
- **gears**
  - matching
  - timing
- **shafts**
- **power flow**
- **lubrication circuits**
- **thrust control**
- **bearings and bushings**
- **sealing**
- **shifting mechanisms**

6.3.4 Perform the inspection, testing, and diagnostic procedures following manufacturers' recommendations on single countershaft manual transmissions.

[0/2]
- **demonstrate:**
  - visual inspection
  - performance testing
  - thrust measurement
  - checking fluid level and condition
  - verify power flow
- **failure analysis for:**
  - shock failures
  - fatigue failures
  - torsional failures
  - surface failures

6.3.5 Recommend reconditioning or repairs following manufacturers' procedures on single countershaft manual transmissions.

[1/0]
- **outline procedure for checking lubricant levels**
- **recommended lubricant change intervals and procedures**
- **identify lubricant types and application**
- **outline procedure for transmission removal, disassembly, reassembly and replacement**

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, breathing, and hearing protection
  - dismantling
  - use of drifts
  - control of snap ring or circlip removal
  - hoist and stand use
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1246.4 Drive Shafts, Power Take-Off Shafts, and Universal Joints

Duration: Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5927, 5928
HDET	5896, 5897
PLTT	5866, 5867
TCT	5142, 5143

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to recommend repair to drive shafts, power take-off shafts, safety shields and universal joints following manufacturers' procedures.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.4.1 Explain the fundamentals of drive shafts, power take-off shafts, safety shields and universal joints.

[1/0]
- **angularity**
- **articulation**
- **telescoping**
- **theory of non-uniform velocity**
- **parallel drive line arrangements**
- **broken-back drive line arrangements**
- **parallelogram**
- **working angle calculations**
- **equal angle hitch geometry (e.g. agricultural drawn equipment)**
- **shielding requirements**
  - PTO (power take off) adapters

6.4.2 Identify the construction features, composition, types, and application of drive shafts, power take-off shafts, safety shields and universal joints.

[1/0]
- **drive shaft classification**
- **drive shaft load ratings**
- **drive shaft speed ratings**
- **hanger bearings**
- **slip splines**
- **carden joints**
  - trunnion
  - bearings
- **flanges and yokes**
- **shielding requirements**
  - PTO (power take off) adapters

6.4.3 Describe the principles of operation of drive shafts, power take-off shafts, safety shields and universal joints.

[2/0] - **shafts and cardan joints**
- angularity
- velocity
- phasing
- balancing
- run-out
- torsional loading
- vibration

6.4.4 Perform the inspection, testing, and diagnostic procedures following manufacturers' recommendations of drive shafts, power take-off shafts, safety shields and universal joints.

[0/1] - **demonstration of:**
- inspection techniques (wear/damage)
- noise analysis
- evaluating drive line vibration
- determining universal joint working angles

- **failure analysis for:**
- torsional vibration
- excessive angularity
- operational overloading
- seized slip-joint
- shock failures
- fatigue failures

6.4.5 Recommend reconditioning or repairs following manufacturers' procedures of drive shafts, power take-off shafts, safety shields and universal joints.

[0/1] **demonstrate:**
- **lubricating a universal joint and slip-spline assembly**
- **replacing a cardan joint**
- **replacing a centre hanger bearing assembly**
- **measuring slip-spline wear**
- **correcting component working angles**

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, breathing, and hearing protection
  - hoist and stands
  - solvents
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1246.5 Single Reduction Drive Axle Assemblies

Duration: Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5928.0, 5928.01, 5928.02, 5928.03, 5928.04
HDET	5897.0, 5897.01, 5897.02, 5897.03, 5897.04, 5897.05, 5897.06, 5897.07
PLTT	5866.0, 5867.01, 5867.02, 5867.03, 5867.04
TCT	5143.0, 5143.01, 5143.02, 5143.03, 5143.04

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to recommend repairs to single reduction drive axle assemblies following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.5.1 Explain the purpose and fundamentals of single reduction drive axle assemblies.

[1/0]
- **mechanical advantage**
- **laws of levers**
- **torque**
- **input/output ratio speed**
- **gear ratios**
- **loading characteristics**
- **differential action**
- **thrust loads**
- **power flow**
- **bearing preloads**
- **lubrication**
- **engagement mechanisms**

6.5.2 Identify the construction features, composition, types, and application of single reduction drive axle assemblies.

[1/0]
- **drive axle assembly**
- **housings**
- **carriers**
  - removable
  - integral
- **drive gear sets (crown and pinion)**
  - spiral bevel
  - hypoid
  - amboid
- **differential gearing**
- **axle shafts**

- semi-floating
- full floating

6.5.3 Describe the principles of operation of single reduction drive axle assemblies.

[2/0]
- **drive axle assembly**
- **carriers**
  - removable
  - integral
- **drive gear sets (crown and pinion)**
  - spiral
  - hypoid
  - amboid
- **differential gearing**
- **axle shafts**
  - semi-floating
  - full floating
- **lubrication**
- **lubricants**
  - noise and temperature analysis

6.5.4 Perform inspection, testing, and diagnostic procedures following manufacturers' recommendations of single reduction drive axle assemblies.

[0/1]
- **demonstrate:**
  - lubricant level and condition checks
  - backlash measurement
  - pattern check

6.5.5 Recommend reconditioning or repairs following manufacturers' procedures of single reduction drive axle assemblies.

[0/1]
- **demonstrate:**
  - lubricant change procedures
  - identifying lubricant type and application
  - carrier removal, disassembly, reassembly, and replacement procedure
- **procedure for adjusting:**
  - pinion bearing preload
  - pinion depth
  - carrier bearing preload
  - drive gear set backlash
- **procedure for checking:**
  - drive gear set contact pattern
  - drive gear set backlash
  - thrust block adjustment

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, breathing, and hearing protection
  - dismantling
  - use of drifts
  - control of snap ring or circlip removal
  - hoist and stand use
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

Number: **S1247**

Reportable Subject: **WHEEL END ASSEMBLIES AND BRAKE SYSTEMS**

Duration: Total 32 hours Theory 16 hours Practical 16 hours

Prerequisites: None

Co-requisites: None

7.1 Wheel End Assemblies

7 Total Hours Theory: 3 hours Practical: 4 hours

7.2 Hydraulic Brake Systems

12 Total Hours Theory: 6 hours Practical: 6 hours

7.3 Air Brake Systems

13 Total Hours Theory: 7 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
50%	50%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Medium and Heavy Duty Brake wheel end assemblies	Wheel End Assembly Tools
Equipment Simulator or equipment with hydraulic brake system components	Precision Measuring Tools
Engine with an overhead cam (disassembled)	Equipment Simulator or equipment with an air brake system
Basic hand tools	

S1247.1 Wheel End Assemblies

Duration: Total 7 hours Theory 3 hours Practical 4 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5928, 5930
HDET	5897, 5899
PLTT	5869, 5867
TCT	5143, 5150

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to perform adjustments and repairs to wheel end assemblies following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.1.1 Explain the fundamentals of wheel end assemblies.

[0.5/0]
- **sliding and rolling friction**
- **load carrying bearing**
- **lubrication**
- **tire and rim safety**
- **safe wheel removal and installation procedures**
  - hub-piloted
  - stud-piloted
  - cast spoke
  - multi piece

7.1.2 Identify the construction, composition, types, styles and application of wheel end assemblies.

[0.5/0]
- **bearing and retaining locks**
- **tapered roller**
  - cups
  - cones
- **ball bearing**
  - race
  - cage assembly
- **preset hubs**
- **tire and rim safety**
- **safe wheel removal and installation procedures**
  - hub-piloted
  - stud-piloted
  - cast spoke
  - multi piece rims

7.1.3 Describe the principle(s) of operation of wheel end assemblies.

[1/0]
- **lubrication**
- **oil**
- **grease**
- **synthetic**
- **API specifications**
- **reduced maintenance**
- **endplay**
- **preload**
- **preset hubs**

7.1.4 Perform inspection and installation procedures of wheel end assemblies.

[1/0]
- **visual inspection**
  - bearing match
  - bearing endplay
  - bearing fit
  - hub condition
  - spindle condition

7.1.5 Recommend reconditioning or repairs following manufacturers' procedures on wheel end assemblies.

[0/3]
- **remove and Install a wheel end assembly following recommended procedures using the following:**
  - Technical and Maintenance Council (TMC) procedure
  - Original Equipment Manufacturers (OEM) procedure
- **inspect and service seals as required following manufactures recommended service procedures**
  - bearing cleaning precautions
  - preset hubs

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, breathing, and hearing protection
  - hoist, jack, and stand use
  - spring chamber handling
  - air pressure protection
  - brake dust
  - grease on friction materials
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1247.2 Hydraulic Brake Systems

Duration: Total 12 hours Theory 6 hours Practical 6 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5930, 5928
HDET	5899, 5897
PLTT	5869, 5867
TCT	5150, 5143

GENERAL LEARNING OUTCOME

Upon successful completion, the apprentice is able to recommend repairs to hydraulic brake systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.2.1 Explain the purpose and fundamentals of braking system assemblies.

[1/0]
- **Pascal's law**
- **laws of levers, mechanical advantages**
- **friction**
- **co-efficient of friction**
- **brake fluids**
- **servo-action**
- **self-energizing**
- **velocity and acceleration**
- **torque multiplication**
- **displacement**
- **identify appropriate legislation governing brake systems (e.g. CMVSS-105**)

7.2.2 Identify the construction features, composition, types, and styles of brake system components.

[2/0]
- **brake lines and hoses**
- **master cylinders**
- **wheel cylinders**
- **calipers**
- **brake shoes and disc pads**
- **drums and rotors**
- **control and metering devices**
- **self-adjusting devices**
- **hand and parking brake cables**
- **brake fluids**

7.2.3 Describe the principles of operation of brake system components.

[3/0]
- **master cylinders**
- **wheel cylinders**
- **calipers**
- **shoes and pads**
- **control and metering devices**
- **self-adjusters**
- **drums and rotors**
- **hand and parking brake cables**

7.2.4 Perform reconditioning or repairs following manufacturers' procedures for hydraulic system components.

[0/6]
- **fabricate brake lines**
  - bend
  - flare
    - o double and bubble
- **service**
  - master and wheel cylinder and bleeding of air from the system
  - calipers, mounting hardware, boots, and piston seals
  - shoes and pads, mounting hardware, and backing plates
  - adjusting devices
  - hand and parking brake assembly

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, breathing, and hearing protection
  - hoist, jack, and stand use
  - spring chamber handling
  - air pressure protection
  - brake dust
  - grease on friction materials
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic format
  - current legislated requirements
  - WHMIS
- **mathematics**
  - système international d'unités (s.i.) to Imperial conversion

S1247.3 Air Brake Systems

Duration: Total 13 hours Theory 7 hours Practical 6 hours

Prerequisites: None

Cross-Reference to Training Standard:

AET	5930, 5931, 5928
HDET	5899, 5901, 5897
PLTT	5869, 5870, 5867
TCT	5151, 5149, 5143

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform repairs to air brake systems following manufacturers' recommendations and statutory criteria.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.3.1 Explain the purpose and fundamentals of basic air brake systems.

[1/0]
- **laws of levers**
- **mechanical advantages**
- **co-efficient of friction**
- **pressure volume relationship**
- **spring brake chamber calculations**
  - potential energy
  - linear force
  - leverage
  - brake torque
  - brake friction factors
- **effects of vehicle load and speed**
- **Canadian Motor Vehicle Safety Standards (CMVSS) 121**
- **Commercial Vehicle Safety Alliance (Out-of-service OOS citations)**

7.3.2 Identify the functions, construction features, composition, types, and application of basic air brake systems.

[2/0]
- **air supply system**
- **primary service circuit**
- **secondary service circuit**
- **park/emergency circuit**
- **foundation assemblies**
  - S-cam
  - wedge
  - disc
- **slack adjusters**
- **actuator chambers**

- **hoses, lines, and fittings**

7.3.3 Describe the principle(s) of operation of wheel end assemblies.

[4/0]
- **air supply system**
- **primary service circuit**
- **secondary service circuit**
- **park/emergency circuit**
- **foundation assemblies**
  - S-cam
  - wedge
  - disc
- **slack adjusters**
- **actuator chambers**
- **hoses, lines, and fittings**

7.3.4 Perform inspection and testing procedures following manufacturers' recommendations on air brake systems.

[0/3]
- **foundation brake checks for:**
  - stroke length
  - automatic slack adjusters
- **outline procedure for air compressor, air dryer, air receiver and testing**
- **check governor operation**
- **interpret pneumatic schematics**
- **interpret statutory inspection safety criteria**

7.3.5 Recommend reconditioning or repair following manufacturers' recommendations to air brake systems.

[0/3]
- **demonstrate how to disarm spring brake chambers following recommended safe practices**
- **service foundation components**:
  - relining
  - machining practices
  - perform complete wheel-end service
  - disc brake components
- **demonstrate servicing pneumatic circuit components**
- **perform air brake adjustment according to recommended procedures**
- **interpretation of statutory 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, hand, breathing, and hearing protection
  - hoist, jack, and stand use
  - spring chamber handling
  - air pressure protection
  - brake dust
  - grease on friction materials
- **communications**
  - information accessing
  - practical reporting
  - technical service bulletins
  - data management
    - service records
    - microfiche
    - service information systems
    - electronic 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
FMIs	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 *alternating current.*
A/C	Air conditioning.
accumulator	A cylinder or device used to store pressure, can contain a diaphragm and pneumatic pressure. Used in hydraulic systems.
Ackermann Angle	Angle between the planes of the steered wheels of a vehicle with zero steering angle; a measure of toe-in or toe-out.
acronym	A word formed by the initial letters of other words.
active codes	An electronically monitored system circuit, condition, or component that is malfunctioning and logs an ECM code, which may be displayed or read using an EST.
Actuator	Any output device controlled by a computer. Also used in hydraulics as an output device such as a linear or rotary device (cylinder or motor).
aeration	The mixing of gas with a liquid, usually air with oil, fuel, or coolant.
AFC	Air/fuel control.
AFC (Cummins)	A circuit that senses turbo boost sensing and is part of the fuel management components on a Cummins PTC-AFC pump.
AFR	See *air/fuel ratio.*
air/fuel ratio	The mass ratio of an air-to-fuel mixture; also AFR.
air-to-air aftercooler	Heat exchanger that cools the intake air after the turbocharger before going to the intake manifold, by using ambient air.
alcohol	Any of a group of distillate hydrocarbon liquids containing at least one hydroxyl group; sometimes referred to as oxygenates.
aldehydes	A class of chemical compounds having the general formula RCHO, where R is an alkyl (aliphatic) or aryl (aromatic) radical (SAE J1213 NOV82).
alloy	The mixing of a molten base metal with metallic or non-metallic elements to alter the metallurgical characteristics.
alternating current	Electric current that reverses cyclically due to reversal of

	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 *crosshead piston.*
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 *tattletale.*

B

backfire	Ignition/combustion of the fuel in an oxy-acetylene torch in the torch tip causing a popping and squealing noise.
backlash	The clearance or "play" between two parts, such as the teeth of two gears.
battery	A device containing one or more cells that produces electricity through electrochemical action.
battery capacity	The amount of current a battery is capable of delivering.
battery charging	The process of restoring a battery's charge by passing current through it in a reverse direction (positive to negative).
battery plate	Battery components made of lead peroxide in sponge form and porous lead.
battery rating	Standardized measurement of a battery's ability to deliver an acceptable level of energy under specified conditions. Standards established by the battery council international (BCI).
baud	Times per second that a data communications signal changes and permits one bit of data to be transmitted.
baud rate	The speed of a data transmission.
Bernoulli's Principle	the statement that an increase in the speed of a fluid produces a decrease in pressure and a decrease in the speed produces an increase in pressure
beta ratio	The beta ratio or rating is used for fine filters and is determined under laboratory testing. Although not a true measure of how well a filter will do in an operating system, the beta rating is a good indicator of the filter performance. The beta ratio of an operating filter during steady state flow test is simply the count upstream divided by the count downstream of fine test dust, based on any selected particle size.
binary system	A two-digit arithmetic, numeric system commonly used in computer electronics.
blower	A low-pressure air pump used on diesel engines to increase the amount and pressure of the air coming into the engine. Sometimes referred to as a *supercharger.*

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 *brake*. Factored by *torque* 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.

C

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 *condenser*.
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_2)	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 colourless, 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 *bypass* type.
centrifugal force	The force acting outward on a rotating body.
centrifuge	A device that uses centrifugal propulsion or a centrifugal force principle of operation.
centripetal force	Tendency to move toward a center; such as water draining from a bathtub.
cetane	A colourless liquid ($C_{16}H_{34}$). Used as a basis to test the performance characteristics of diesel fuel.
cetane improver	A diesel fuel additive designed to increase the *cetane number* rating or ignition quality. Cyclohexanol nitrate is a commonly used cetane improver.
cetane number (CN)	The standard rating of a diesel fuel's ignition quality. It is a comparative rating method that measures the ignition quality of a diesel fuel verses that of a mixture of cretonne (good ignition characteristics). A mixture of 45% cretonne and 55% would have a CN of 45. Diesel fuels refined for use in North America are classified by the ASTM as #1D and #2D and must have a minimum CN of 40.
CFM	Cubic Feet per Minute. Used as a measurement for the amount of air entering an engine’s intake.

Charles' s Law	See Gay-Lussac's Law.
CI	Compression ignition; an engine in which the fuel/air mixture is ignited by the heat of compression.
clearance	A given space between two parts such as a piston and cylinder.
clearance volume	Volume in an engine cylinder when the piston is at TDC.
clockwise rotation	Rotation is the same as the direction as the movement of the hands of a clock.
coefficient of friction	A rating of a material's ability to generate friction. Describes the "aggressiveness" of materials in contact with each other. Affected by temperature and the presence of lubricants.
Cold crank rating (CCR)	Standard battery rating system that identifies the maximum current drain a fully charged battery can deliver at 0 degrees F or -17 degrees C - measured in cold cranking amps (CCA).
Combustion	The act of burning, *oxidation.*
Combustion chamber	In most current S.I. and C.I. engines, the engine cylinder and the geometry of the head and piston crown form the combustion chamber. In I.D.I. diesel engines, the combustion chamber is a separate cell connected to, but not integral with, the cylinder. Also, the area above the piston with the piston at TDC. Measured in cubic centimeters.
Combustion cycle	The thermodynamic process of a heat engine cycle through induction, compression, oxidation, and exhaust.
Compound	(i) A substance consisting of two or more elements held together by chemical force and not necessarily retaining any of the characteristics of the composite elements; i.e., Water: H_2O: (ii) Auxiliary gearbox that "compounds" the main transmission by increasing the available ratios and ranges.
Compression	The process by which a confined fluid is reduced in volume and increased in density with the application of pressure.
Compression ratio	The ratio of the piston swept volume to the total cylinder volume with the piston at BDC - a volumetric ratio and not a pressure ratio.
Communication Protocol	SAE has specific protocols for mobile equipment communication, such as J1939 J1587/1708
Concentric	Circles having a common centre.
Conductance	The ability of a material to carry an electrical current.
Conductors	Materials that readily permit the flow of electrons from atom to atom; usually metallic elements that have less than 4 electrons in their outer shells.
Conduction	Heat transmission through solid matter, also the transfer of heat from one object to another by being in direct contact.
Connecting rod	The rigid mechanical link between the piston wrist pin and the crankshaft throw.
Constant horsepower	Sometimes used to describe a high *torque rise* engine.
Co-requisite	A unit of learning that can be taken concurrently with another subject, but in order to be successful, both subjects must be completed successfully.
Conventional theory	(Of current flow) asserts that current flows from a positive

	source to a negative source. Despite the fact that it is fundamentally incorrect, it is nevertheless widely accepted and used.
Convection	A transfer of heat from one object to another through a liquid. Also heat transfer occasioned by the upward flow of hot air and the downward flow of cool air.
Counterbore	Cylindrical enlargement of the cylinder bore at the block deck to seat a liner flange.
Crankshaft	A shaft with offset throws designed to convert the reciprocating movements of the pistons into torque.
Crank throw	The offset part of the crankshaft where the connecting rods fasten.
Creep	Describes the independent movement of two components clamped by fasteners when they have different coefficients of thermal expansion or have different mass, which means their expansion and contraction rates do not concur.
Cross flow	Describes a four-stroke cycle engine breathing configuration where intake and exhaust manifolds are located on opposite sides of the cylinder head so gas flow is across the piston crown.
Crosshead	Part of the valve train in an engine that actuates two valves per cylinder. Permits two valves in the same cylinder to be opened simultaneously by a single rocker arm.
Crosshead piston	An articulating piston with separate crown and skirt assemblies in which the connecting rod is bolted directly to the wrist pin.
Crude oil	The organic fossil fuel pumped from the ground from which diesel fuel, gasoline, and many other petroleum products are refined; raw petroleum.
Current	The flow of free electrons through a conductor.
Curriculum hour	Is described as the breakdown of time for theory and practical in-school delivery. It is timed at 50 minutes per curriculum hour listed in the document.
Cycle time	A reoccurring period in which a series of actions take place in a definite order. Also used in hydraulics as the time it takes for an actuator or function to complete full extend to full retract: thus a cycle time.
Cylinder block	The main frame of any engine to which all the other components are attached.
Cylinder head	A detachable portion of an engine that covers the upper end of the cylinder bores and forms part of the combustion chamber. Also includes the valves in the case of overhead valve engines.
Cylinder sleeve	A liner or sleeve interposed between the piston and the cylinder wall or water jacket to provide an easily replaceable surface for the cylinders.

D

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

Database	A data storage location or program.
Data link	The connection point or path for data transmission in networked devices.
Data link connector	Plastic plug-in terminal with two or more electrical connections used to interface with engine or vehicle's computers.
DC	Direct current.
DCA	Diesel coolant additives. A proprietary supplemental coolant additive.
DI	Direct injection. Fuel is injected directly into the engine cylinder. This is the common means of injecting, current C.I. engines and used in some gasoline-fueled engines.
Dial indicator	Tool used to precisely measure linear travel.
Diesel cycle	A four-stroke cycle similar to the Otto cycle (intake, compression, expansion, and exhaust strokes) but where ignition of the fuel charge is occasioned by the heat of compression. A true diesel cycle engine is known as a *constant pressure* engine, meaning that fuel is metered into the cylinder at a rate that will produce constant pressure for a number of crank angle degrees.
Digital signal	An electronic signal that uses on and off pulses.
Diode	A semiconductor device that allows current flow in one direction but resists it in the other, which acts like an electrical check valve.
Displacement	The total volume displaced by the cylinders when moving from BDC to TDC.
Direct current (DC)	Electric current that flows steadily in one direction only.
Droop	An engine governor term denoting a transient speed variation that occurs when engine loading suddenly changes.
Droop curve	A required hydro-mechanical governor characteristic in which fueling drops off in an even curve as engine speed increases from the rated power value to high idle.
Dry air filter	A filter element that requires no oil or other liquid medium to trap dirt particles. Most motive power air filters are of the dry type.
Dry liners	Liners that are fitted either with fractional looseness or fractional interference that dissipate cylinder heat to the cylinder block bore and have no direct contact with the water jacket.

E

Electromagnetism	Describes any magnetic field created by current flow through a conductor.
Electron	A negatively charged component of an atom.
Electrolyte	A solution capable of conducting electrical current.
Electron theory	The theory that asserts that current flow through a circuit is by electron movement from a negatively charged point to a positively charged one. See *conventional theory*.
Electronic engine management	Computerized engine control.
Electronic control unit (ECU)	Refers to the computer and integral switching apparatus in an 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 *antifreeze.*
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.

F

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 *hydraulics* and *pneumatics.*
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 though 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 *full-floating piston pin* is retained in the pin boss, but permits independent movement

	of both the piston and the rod eye.
Full floating axle	A drive axle design where the axle shafts provide wheel torque only and bear no part of the vehicle load.

G

Gay-Lussac's Law	The law that at constant pressure the volume of a fixed mass or quantity of gas varies directly with the absolute temperature; a close approximation. Also known as Charles's Law.
General Learning Outcomes	Learning outcomes represent culminating demonstrations of learning and achievement. Outcomes are not simply a listing of discrete skills, nor broad statements of knowledge and comprehension. Outcomes describe performances that demonstrate that significant learning has been achieved and applied.
General Practices	This section captures concepts and topics that must be integrated into the learning for each unit. No specific time is allocated for these items as it is deemed to be accounted for in the learning content.
Governor	A component that manages engine fueling on the basis of fuel demand (accelerator) and engine RPM; may be hydro-mechanical or electronic.
Grade markings	Lines placed on the heads of some bolts to indicate tensile strength.
Gross Horsepower	The brake horsepower of an engine with optimum settings and without allowing for power absorbed by the engine-driven accessories.
Gross Torque	The maximum torque produced when measured at the engine's crankshaft. Does not allow for torque consumed by the engine-driven accessories.

H

Hall Effect	A method of accurately sensing rotational speed and digitally signaling it. A rotating metallic shutter alternately blocks and opens a magnetic field from a semiconductor sensor.
Hazardous Waste	Any chemical or material that has one or more characteristics that make it hazardous to health, life, and/or the environment.
Heat	A form of energy associated with the motion of atoms or molecules and capable of being transmitted by conduction, convection, and radiation.
Helix	A spiral groove or scroll. The helical cut recesses in some injection pumping plungers that are used to meter fuel delivery. Plural: *helices.*
Hg manometer	A mercury (Hg) filled manometer.
High Idle Speed	The highest no load speed of an engine.
Hooke's Law	The law that the stress of a solid is directly proportional to the strain applied to it.
Horsepower (hp)	Measurement of an engine's ability to perform work. One horsepower is defined as the ability to move 33,000 pounds one foot in one minute.
H_2O 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	(i) In hydromechanical governor terminology, a response lag. (ii) Molecular friction caused by the lag between the formation of magnetic flux behind the magnetomotive force that creates it.

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 *brake power* 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 1st Law	States that the current flowing into a point or component in an electrical circuit must equal the current flowing out of it.
Kirchhoff's 2nd Law	States that the voltage will drop in exact proportion to the resistance in a circuit component and that the sum of the voltage drops must equal the voltage applied to the circuit; also known as Kirchhoff's Law of voltage drop.
L	
Lambda sensor	An exhaust gas sensor used on electronically managed, SI gasoline-fueled engines to signal the ECM the oxygen content in the exhaust gas.
Laminar flow	A condition where the fluid particles move in continuous parallel paths; streamline flow.
Lead acid battery	Standard vehicle battery consisting of lead acid cells in series. Twelve volt batteries have become standard and they can be used in multiples in parallel or series for heavy duty applications.
L-head engine	An in-line engine configuration where the intake and exhaust valve ports are located adjacent to the cylinder in the block. Seldom used in current engines.
Learning outcome	Learning outcomes are discrete statements that describe the elements leading to attainment of the general learning outcome.
Learning content	The learning activities required for the learner to achieve the Learning Outcomes. A comprehensive list of activities to guide the trainer.
Liner protrusion	The amount the liner protrudes above the deck of the block, thus allowing retention when the head is properly torqued.
Logic	(i) The science of reasoning. (ii) Arithmetic and data comparison protocols of a microprocessor.
M	
Magnetism	The phenomenon that includes the physical attraction for iron observed in lodestone and associated with electric current flow. It is characterized by fields of force, which can exert a mechanical and electrical influence on anything within the

	boundaries of that field.
Manometer	A tubular, U-shaped column mounted on a calibration scale. The tube is water or mercury-filled to balance at 0 on the scale and the instrument is used to measure light pressure or vacuum conditions in fluid circuits.
Mechanical efficiency	A measure of how effectively *indicated power* is converted into *brake power;* factors in pumping and friction losses.
Micrometer	A precision instrument for measuring either internal, external, or depth dimensions to within thousands or ten thousands of an inch or millimeter.
Micron	One millionth of a meter or .000039 inch. The term used to rate the size of filters for liquids, such as engine oil or hydraulic fluids.
Muffler	An *engine silencer* that uses sound absorption and 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.

N

Nitrogen dioxide	One of the oxides of nitrogen produced in vehicle engines and a significant contributor in the formation of photochemical smog.
Non-ferrous metal	Metals and alloys that contain little or no iron.
Non-volatile RAM	NVRAM-read-write RAM device capable of data retention in cells in a vehicle module after the ignition circuit is opened; also known as KAM
Normal rated power	The highest power specified for continuous operation of an engine.

O

O. Reg.631/94 section 3	Is an Ontario regulation for regulations as they apply to overhead cranes.
OEM	Original equipment manufacturer.
Ohm	A unit for quantifying electrical resistance in a circuit.
Ohm's Law	The formula used to calculate electrical circuit performance. It asserts that it requires 1 v of potential to pump 1 A of current through a circuit resistance of 1 ohm.
Ohmmeter	An instrument for measuring resistance in an electric component or circuit.
Opacity meter	A light extinction means of testing exhaust gas particulate and liquid emission that rates density of exhaust smoke based on the percentage of emitted light that does not reach the sensor, so the higher the percentage reading, the more dense the

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

P

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

Power	The rate of accomplishing work; it is necessarily factored by time.
Practical	The hands-on element of learning in the curriculum document. Apprentice activities develop skills to achieve completion of psychomotor learning outcomes.
Preloading	Process of adjusting a bearing so that it has a mild pressure placed upon it, beyond zero endplay.
Prerequisite	Learning that must be achieved prior to taking a given subject.
Pressure	Force exerted per unit of area.
Pulse width modulation	The shaping of pulses and waveforms for purposes of digital signaling. Acronym PWM is often used.
Pyrometer	A thermocouple type, high temperature sensing device used to signal exhaust temperature. Consists of two dissimilar wires (pure iron and constantan) joined at the hot end with a millivoltmeter at the read end. Increase in temperature will cause a small current to flow, which is read at the voltmeter as a temperature value.

Q

Quenching	Process of dipping a heated object into water, oil, or other substance to quickly reduce its temperature.
Quiescent Combustion	Non-turbulent flame propagation characteristic of slow running diesel engines that are direct injected.

R

Radial	A line at right angles to a shaft, cylinder, etc., Centerline.
RAM	Random access memory. Electronically retained "main memory."
Rated power	The highest power specified for continuous operation.
Rated speed	The RPM at which an engine produces peak power.
Reluctor	Term describing a number of devices that use magnetism and motion to produce an AC voltage-a pick-up coil.
Rebound	Reactive response of a spring, the opposite of jounce.
Reportable Subject	(i) A clustering or grouping of related or like learning outcomes. (ii) A standalone learning unit with a distinct start and end. (iii) A course or module.
Reserve Capacity	The amount of time a battery can produce an acceptable current when not charged by the alternator.
Rheostat	A two terminal, variable resistor.

S

SAE	Society of Automotive Engineers.
SAE horsepower	A structured formula used to calculate brake horsepower data that can be used for comparison purposes.
Scoring	Scratch/gouge damage to a surface finish.
Semiconductor	A substance, such as silicon, that acts as a conductor or insulator, depending on its operating condition and 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.

T

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 potential) of a material failure caused by engine performance.
Thermistor	A commonly used temperature sensor that is supplied with a

	reference voltage and by using a temperature sensitive variable resistor, signals back to the ECM portion of it.
Thrust faces	A term used to describe loading of surface area generally but most often of pistons. When the piston is subject to cylinder gas pressure there is a tendency for it to cock (pivot off a vertical centerline) and load the contact faces off its axis on the pin.
Torque	Twisting effort or force. Torque does not necessarily result in accomplishing work.
Torque rise	The increase in torque potential designed to occur in a diesel engine as it is lugged down from the rated power RPM to the peak torque RPM, during which the power curve remains relatively flat. High torque rise engines are sometimes described as constant horsepower engines.
Training Standards	Training standards are created by the MTCU with the Industry Committee and are intended to be used by the apprentice, instructors, and companies as a "blueprint" for on-the-job training, or as a prerequisite for government certification.
Transducer	A device that coverts energy from one power form to another for instance, a physical pressure value to an electrical pressure value.
Trunk piston	A single piece piston usually constructed of aluminum alloy.
Turbocharger	A turbine device that utilizes exhaust pressure to increase the air pressure going into the cylinders. Used particularly in reference to movement of air in the cylinder and combustion chamber.
Turbulence	A violent irregular movement or agitation of a fluid or gas. Violent swirling motion. Fuel injection provided some turbulence. Additional turbulence is provided by the design features of the combustion space.
Turbulent Flow	A condition where the fluid particles move in random paths rather than in continuous parallel paths.
Two-stroke cycle	An engine that requires one complete revolution of the crankshaft to fire each piston once. An engine requiring only one complete revolution of the crankshaft to complete the cycle of events.

U

Unit injector	A diesel fuel injector which receives fuel at charging pressure and performs the functions of metering, creating injection pressure values and atomizing fuel-usually directly to the engine cylinder. Mechanically or electronically controlled, mechanically or hydraulically actuated.
Universal joint	A flexible joint that permits changes in driving angles between a driving and driven shaft.
Urea	The chief solid component of mammalian urine; synthesized from ammonia and carbon dioxide and used as fertilizer and in animal feed and in plastics

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, and are classified by yield strength rating.

Z

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