ONTARIO COLLEGE OF TRADES

ORDRE DES MÉTIERS DE L'ONTARIO

Apprenticeship Curriculum Standard

Commercial Vehicle And Equipment

Level 2

For the following Motive Power trades:
Agricultural Equipment Technician – 425A
Heavy Duty Equipment Technician – 421A

Date: 2010

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<u>Please Note</u>: 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

Introduction

The Commercial Vehicles and Equipment Curriculum (CVAE) Level 2 has been developed in keeping with the prescribed Ministry of Training, Colleges and Universities (MTCU) Training Standards, which are common in the two trades of Agricultural Equipment Technician and Heavy Duty Equipment 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 practical aspects of the trade, but who also have a sound theoretical knowledge of the inspecting, diagnosing, repair, and servicing requirements. The curriculum has been developed to provide this theoretical knowledge and to offer some practical applications to complement the on-the-job work experiences of the Agricultural Equipment and Heavy Duty Equipment 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 five 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)(CVAE level 2 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

Industry Representatives:

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

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

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

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

Commercial Vehicle and Equipment

Level 2

Program Summary of Reportable Subjects - Level 2

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S1248	Trade Practice	24	11.5	12.5
S1249	Fluid Power Systems	56	38	18
S1250	Engine Systems	32	19	13
S1251	Electrical Systems	40	29	11
S1252	Fuel Systems	32	19	13
S1253	Drive Train Systems	32	18	14
S1254	Steering, Tires & Brake Systems	24	17	7
	Total	240	154.5	85.5

Number: **S1248**

Reportable Subject: **TRADES PRACTICES**

Duration: Total 24 hours Theory 11.5 hours Practical 12.5 hours

Prerequisites: C.V.A.E. Level 1

1.1 Oxy-fuel Processes

11 Total Hours Theory: 3 hours Practical: 8 hours

1.2 Air Conditioning Systems

8 Total Hours Theory: 5 hours Practical: 3 hours

1.3 Heating, Ventilation and Air Conditioning (HVAC) Systems

4 Total Hours Theory: 3 hours Practical: 1 hour

1.4 Operator Protection Devices

1 Total Hours Theory: 0.5 hour Practical: 0.5 hour

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:

Basic hand tools	Infra-red temperature measurement tool
Oxygen and acetylene torch assemblies	Dye type leak detection equipment
Air conditioning reclaiming/ charging equipment	Air conditioner components
Nitrogen pressure testing equipment	Thermometer
Manifold gauge set	Equipment with a ROPS, FOPS, OPS.

S1248.1 **Oxy-fuel Processes**

Duration: Total 11 hours Theory 3 hours Practical 8 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5924.03, 5928.03, 5930.03, 5932.03, 5933.03, 5935.03, 5937.03, 5938.03, 5939.03
HDET	5893.03, 5897.03, 5897.06, 5899.03, 5899.06, 5900.03, 5903.03, 5904.06, 5906.03

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform heating, cutting, fusion welding and brazing activities following manufacturers' recommendations, government regulations, and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.1.1 Explain manufacturers' precautions for using oxy-fuel equipment.

[1/0]
- **case hardening effects**
- **effects of overheating forged and cast components**
- **protecting seals and gaskets**
- **fire prevention practices**
- **personal protective equipment**

1.1.2 Identify oxy-fuel equipment safe operating practices.

[0.5/0]
- **review pressure settings**
- **plan and prepare the work area**

1.1.3 Describe the manufacturers' oxy-fuel equipment diagnostic procedures.

[1/0]
- **flash back**
- **gas leakages**
  - hoses
  - valves
  - regulators
  - gauges
  - fittings

1.1.4 Describe start-up and shutdown of oxy-fuel equipment.

[0.5/0]
- **start-up**
  - fuel selection and oxygen
  - selection of tips
  - ignition procedures
- **shutdown**
  - sequential torch shutoff of fuel and oxygen gas valves
  - shut off of cylinder valves

1.1.5 Perform oxy-fuel processes following manufacturers' recommendations, government regulations, and safe work practices.

[0/8]
- **heat seized fasteners**
- **fusion welding**
- **brazing**
- **surface preparation and finishing**

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 section.

- **safety precautions**
  - eye, face, hand, foot, and clothing protection
  - fire prevention
  - ventilation
  - cut and burn treatment
  - flammable container welding precautions
  - electrical shock prevention
  - butane lighters
- **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

S1248.2 **Air Conditioning Systems**

Duration: Total 8 hours Theory 5 hours Practical 3 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5934.01, 5934.05, 5934.06, 5934.07
HDET 5902.01, 5902.05, 5902.06, 5902.06

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe air conditioning system testing and repair procedures following manufacturers' recommendations, government regulations, and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.2.1 Explain the purpose and fundamentals of air conditioning systems.

[1/0]
- **methods of heat transfer**
- **temperature and humidity relationship**
- **solid, liquid and gas states**
- **properties of refrigerants**
- **alternative refrigerants**
- **gas laws, temperature, pressure and volume**
- **air conditioning thermo-dynamics**
  - heat absorption
  - liquid and gas states
  - temperature effects
- **thermal expansion and contraction**
- **Ozone Depletion Program (ODP) certification requirements**

1.2.2 Identify the function, construction features, composition, types, and application of refrigerants and air conditioning components.

[2/0]
- **refrigerant characteristics**
- **R12**
  - dichlorodifluoromethane
  - boiling point, toxicity, flammability, etc.
- **R134a**
  - tetrafluoroethane
  - boiling point, toxicity, flammability, etc.
- **lubricants for refrigerants—R12 and R134a systems**
- **refrigerant identifying devices**

- **air conditioning thermo-dynamics**
- **identify the major components used in mobile air conditioning**
- **identify the location of major components and controls**
  - condenser
  - receiver dehydration
  - accumulator-dryer
  - evaporator
  - compressor
  - hoses, lines and fittings
- **describe the function of air conditioning control system components:**
  - low and high pressure cut-out
  - low charge protection
  - evaporator temperature control
  - cycling clutch control
  - orifice tubes
  - expansion valves
  - fan controls

1.2.3 Describe the principles of operation of air conditioning systems.

[1/0]
- **thermostatic expansion valve system**
- **refrigerant compressors**
- **system lubrication**
- **control valves**
  - low and high pressure cut-out
  - low charge protection
  - evaporator temperature control, including expansion valves
  - cycling clutch control
  - orifice tube
  - low temperature lockout
- **condenser**
- **receiver dryer (dehydrator)**
- **accumulator-dryer (dehydrator)**
- **evaporator**
- **compressors**
  - piston
    - axial
    - radial
  - variable displacement
  - scroll
  - vane

1.2.4 Demonstrate inspection and testing procedures following manufacturers' recommendations, government regulations, and safe work practices for air conditioning systems.

[0.5/1]
- **outline major differences in testing R12 and R134A systems**
- **testing for refrigerant leaks**
- **testing of system operating pressures and control functions**
- **system performance tests**
- **identify leak testing methods**
  - dyes
  - electronic leak detectors (must meet SAEJ1627 and SAEJ1628 standards)
  - bubble producing solutions
  - nitrogen testing
  - trace gas testing
- **identify potential location of leaks**
  - fittings
  - lines
  - seals
  - compressor
  - evaporator
  - condenser

1.2.5 Recommend reconditioning or repairs following manufacturers' recommendations and government regulations for air conditioning systems.

[0.5/2]
- **describe the recommended procedures to remove and replace lines, hoses and fittings**
- **describe the recommended procedures to remove and replace compressors, evaporators, condensers, and control devices**
- **perform a demonstration of compressor drive belt adjustment procedures**
- **perform a demonstration of the discharging, evacuating, recovery, recycling, and recharging 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 section.

- **safety precautions**
  - eye, hand, face protection
  - high pressure
  - high temperature liquids
- **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

S1248.3 **Heating, Ventilation and Air Conditioning (HVAC) Systems**

Duration: Total 4 hours Theory 3 hours Practical 1 hour

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5934.01, 5934.02, 5934.04
HDET 5902.01, 5902.02, 5902.03, 5902.04

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the operation of automatic climate control systems (HVAC), testing and repair procedures following manufacturers' recommendations, government regulations, and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.3.1 Explain the purpose and fundamentals of (HVAC) automatic climate control systems.

[0.5/0]
- **air flow characteristics**
- **inside and outside ventilation**
- **air quality**
  - air filtration
    - fresh air filter
    - recirculating filter
    - particulate removal
    - chemical removal
- **electronics fundamentals enhancement**
- **body control module (BCM) and electronic control module (ECM) input and output**
- **thermistors**
- **effects of humidity and sources of heat in the mobile equipment environment**

1.3.2 Identify the construction features, composition, types, and application of (HVAC) automatic climate control systems.

[0.5/0]
- **blower motors and wheels**
- **plenum chambers and ducts**
- **air doors**
- **heater cores**
- **controls**
- **body control module assembly**

- **radiator fan circuit**
- **compressor clutch circuit**
- **blower motor circuit**
- **programmer solenoids**
- **air mixture doors circuits**
- **switches and valves**
  - evaporator pressure control valves
- **oil bypass lines**
- **condensate drain tubes**

1.3.3 Describe the principles of operation of (HVAC) automatic climate control systems.

[1/0]
- **ventilation systems**
- **blower motor and wheels**
- **plenum air flow**
- **air doors**
- **heater cores**
- **controls**
- **defrost**
- **body control module assembly**
- **radiator fan circuit**
- **compressor clutch circuit**
- **blower motor circuit**
- **programmer solenoids and air mixture doors circuit**
- **switches and valves**
- **evaporator pressure control valves**
- **oil bypass lines**
- **condensate drain tubes**

1.3.4 Demonstrate the inspection and testing procedures following manufacturers' recommendations and government regulations for (HVAC) automatic climate control systems.

[0.5/1]
- **heater assemblies:**
  - leaks (air, coolant)
  - loose mountings
  - door operation
  - blower operation
  - contamination
- **climatic control system circuits using test equipment**

- **body control module and electronic control module system diagnosis**
  - fault code interpretation using onboard diagnostics and scan tools
- **outline the most common failures in the:**
  - refrigerant systems
  - control systems
- **outline the recommended test procedures for R12 and R134A refrigerant systems**

1.3.5 Recommend reconditioning or repairs following manufacturers' procedures, government regulations, and safe work practices for (HVAC) automatic climate control systems.

[0.5/0]
- **identify the recommended repairs based on test results of the system**
- **outline the replacement procedures for**
  - heater cores
  - heater hoses
  - ventilation controls

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 section.

- **safety precautions**
  - eye, hand, face protection
  - high pressure
  - high temperature liquids
- **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

S1248.4 **Operator Protection Devices**

Duration: Total 1 hours Theory 0.5 hour Practical 0.5 hour

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5903.01, 5903.02, 5903.03, 5903.04
HDET	5903.01, 5903.02, 5903.03, 5903.04

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to identify unsafe/faulty operator protection devices following manufacturers' recommended practices and government regulations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

1.4.1 Explain and identify the purpose and functions of operator protection devices.

[0.5/0]
- **Roll Over Protection Systems (ROPS)**
- **Falling Object Protection Systems (FOPS)**
- **Operator Protection Systems (OPS)**
- **seat belts**
- **noise control**
- **operator's compartment shielding**
- **legal requirements**
- **fire extinguishers**

1.4.2 Demonstrate the inspection and diagnostic procedures following manufacturers' recommendations and government regulations for operator protection devices.

[0/0.5]
- **Roll Over Protection Systems (ROPS)**
  - fastener torque
  - alterations
  - additions
- **Falling Object Protection Systems (FOPS)**
  - fastener torque
  - alterations
  - additions
- **Operator Protection Systems (OPS)**
  - fastener torque
  - alterations
  - additions

- **seat belts**
- **noise control**
- **operator's compartment shielding**
- **fire extinguishers**

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 section.

- **safety precautions**
  - eye and skin protection
  - control of hazardous material/solvents
  - 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

Number: **S1249**

Reportable Subject: **FLUID POWER SYSTEMS**

Duration: Total 56 hours Theory 38 hours Practical 18 hours

Prerequisites: C.V.A.E. level 1

2.1 Graphic Symbols and Calculations

9 Total Hours Theory: 5 hours Practical: 4 hours

2.2 Fluids and Conditioners

11.5 Total Hours Theory: 7 hours Practical: 4.5 hours

2.3 Fluid Conductors and Fittings

10.5 Total Hours Theory: 7 hours Practical: 3.5 hours

2.4 Hydraulic Control Valves

12 Total Hours Theory: 9 hours Practical: 3 hours

2.5 Hydraulic Pumps

13 Total Hours Theory: 10 hours Practical: 3 hours

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

Mark Distribution:

Theory Testing	Practical Application Testing
70%	30%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Equipment with open centre hydraulic system	Hydraulic flow meters
Equipment with closed centre hydraulic system (pressure compensated)	Pressure testing equipment: mechanical gauges, electronic gauges
Equipment with closed centre hydraulic system (pressure and flow compensated)	Hydraulic cylinders, control valves, and motors
Axial piston pumps	Fluids, Fluid Conductors and Fittings

S1249.1 **Graphic Symbols and Calculations**

Duration: Total 9 hours Theory 5 hours Practical 4 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5922.02, 5922.05
HDET 5895.02, 5895.05, 5895.08

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to interpret schematics and perform pressure, force, and area calculations related to hydraulics.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.1.1 Explain the fundamental principles of hydraulic circuit schematics.

[1/0]
- **graphic symbols**
- **hydraulic circuit layouts**
- **pictorial drawings**
- **diagrams**
- **schematics**
- **Society of Automotive Engineers (SAE)**
- **International Standards Organisation (ISO)**

2.1.2 Identify hydraulic component on diagrams and schematics.

[1.5/0]
- **pumps**
- **valves**
- **actuators**
- **conductors**

2.1.3 Draft a sample of a basic hydraulic system schematic.

[0.5/0]
- **open centre circuit**
- **closed centre circuit**

2.1.4 Perform basic mathematical calculations and identification for hydraulic system applications.

[2/4]
- **pressure**
- **force**
- **area**
  - imperial
  - système international d'unités (s.i.)
- **flow rate**
- **fluid velocity**
- **rod velocity**
- **head pressure calculation**
- **Identify components using manufacturers schematics**
- **locate system test points and components on equipment**

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 section.

- **safety precautions**
  - eye and hand, hearing protection
  - high pressure concerns for skin penetration
  - chemical hazards—WHMIS
  - high temperature
- **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

S1249.2 **Fluids and Conditioners**

Duration: Total 11.5 hours Theory 7 hours Practical 4.5 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5922.01, 5922.02
HDET 5895.01, 5895.02

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the service procedures of hydraulic fluids, reservoirs, and conditioners following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.2.1 Explain the purpose and fundamental information of hydraulic fluids and conditioners.

[2/0]
- **fluid type**
  - petroleum base
  - fire resistant
  - synthetic
- **viscosity/index**
- **friction**
- **cavitation**
- **velocity**
  - laminar flow
  - turbulent flow
  - pressure and force
- **flow rate**
- **aeration**
- **wear prevention**
- **oxidation inhibitors**
- **rust and corrosion inhibitors**
- **anti-foaming**
- **water control**
- **energy transmission**
  - Pascal's law
  - potential, heat, and kinetic
- **displacement**
- **thermal expansion**

- **contamination**
  - sources
  - oil analysis
- **post failure cleanout**
  - **procedures**
  - **equipment**
    - **clean out filters**
    - **auxiliary filtration**

2.2.2 Identify the purpose and fundamentals of fluid conditioners.

[1/0]
- **filter requirements**
- **cleanliness requirements**
- **schematics/symbols**
- **filters**
  - flow capacity
  - element rating
    - micron rating
    - beta ratio
  - type and location
  - pressure drop
  - indicators
- **coolers**
  - flow capacity
  - oil to air
  - oil to oil
  - oil to coolant
  - pressure drop
  - indicators
- **reservoirs**
  - vented
  - pressurized
  - physical features
- **oil heaters**
  - electrical immersion
  - electrical surface mount
  - coolant to oil

2.2.3 Describe the construction features of fluid conditioners.

[2/0]
- **filters and strainers**
  - surface media elements
  - depth media elements
  - type and location
  - pressure drop
  - restriction indicators

- **oil coolers**
  - air to oil
  - coolant to oil
  - oil to oil
    - tube
    - tube and fin
    - radiator
- **oil heaters**
- **reservoirs**
  - capacity
  - baffles
  - outlet and return
  - drain plugs
  - intake filter
  - venting
  - pressurized

2.2.4 Describe the principles of operation of hydraulic fluid conditioners.

[2/0]
- **filters and strainers**
  - surface media elements
  - depth media elements
  - micron rating
  - beta ratio
  - type and location
  - pressure drop
  - restriction indicators
- **oil coolers**
  - air to oil
  - coolant to oil
  - oil to oil
    - tube
    - tube and fin
    - radiator
- **oil heaters**
  - electrical immersion
  - electrical surface mount
  - coolant to oil
- **reservoirs**
  - pressurized
  - cooling
  - aeration
  - venting

2.2.5 Demonstrate the inspection and testing procedures following manufacturers' recommendations for oil conditioners.

[0/4.5] - **the removal and replacement of filters and strainers**

- oil filters
- strainers
- coolers
- heaters
- oil sampling

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 section.

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

S1249.3 **Fluid Conductors and Fittings**

Duration: Total 10.5 hours Theory 7 hours Practical 3.5 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5992.01, 5992.02, 5992.03, 5992.04, 5992.05, 5922.06
HDET	5895.01, 5895.02, 5895.03, 5895.04, 5895.05, 5895.06, 5895.07

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to replace hydraulic lines and fittings following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.3.1 Explain the purpose and fundamental information of hydraulic fluid conductors.

[1/0]
- **pipes**
- **tubes**
- **hoses**
- **fittings**
- **adapters**
- **Society of Automotive Engineers (SAE)**
- **système international d'unités (s.i.)**

2.3.2 Identify the types and construction features of hydraulic fittings and conductors.

[3.5/0]
- **pipe**
  - schedules
  - threading
  - sizing
- **tubing**
  - plastic
  - steel
  - sizing
  - bending
  - fabricating
  - sizing

- **hoses**
  - sizing
  - pressure/vacuum ratings
    - non-braiding types
    - braiding types
    - spiral wraps
- **fittings**
  - permanent
  - reusable
  - hose assembly
- **adapters**
  - thread forms
  - sealing element
- **fittings identification**
  - Society of Automotive Engineers (SAE)
  - Joint Industry Conference (JIC)
  - O-Ring Face Seal (ORFS)
  - O-Ring Boss (ORB)
  - National Pipe (NP)
  - adapters
  - British Standard Pipe/Japanese Industrial Standard (BSP/JIS)
  - Système International d'Unités (s.i.)

2.3.3 Describe the principles of operation of hydraulic conductors and fittings.

[2/0]
- **sealing methods**
- **minimum bend radius**
- **operating pressure ratings**
- **burst pressure ratings**

2.3.4 Demonstrate inspection, testing, and diagnostic procedures following manufacturers' recommendations for hydraulic conductors.

[0.5/2.5]
- **identify potential for oil injection injuries**
  - cracks
  - leaks
  - use a mechanical device to move hydraulic lines when looking for leaks.
- **hydraulic conductor failures**
  - fractures
  - restrictions

2.3.5 Recommend reconditioning or repairs following manufacturers' recommendations for hydraulic conductors.

[0/1] - **demonstration of repairing and replacing hydraulic conductors**
- depressurizing system
  - accumulator circuits
  - pressurized reservoirs
  - vacuum transducers
  - mechanical lock-outs
- hose replacement
  - contamination prevention

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 section.

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

S1249.4 **Hydraulic Control Valves**

Duration: Total 12 hours Theory 9 hours Practical 3 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5922.01, 5922.02, 5922.03, 5922.04, 5922.05, 5922.06, 5922.07
HDET	5895.01, 5895.02, 5895.03, 5895.04, 5895.05, 5895.06, 5895.07, 5895.08, 5895.09, 5895.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs of hydraulic control valves 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 control valves.

[1/0]
- **pressure control**
- **flow control**
- **directional control**
- **fundamentals enhancement**
  - contamination and importance of cleanliness

2.4.2 Identify the types and construction features of hydraulic control valves.

[3/0]
- **pressure control valves**
  - direct-acting relief
  - pilot-operated relief
  - pressure reducing
  - unloading
  - sequence
  - counter balance
  - brake valve
- **flow control valves**
  - flow dividers
  - priority
  - proportional
  - pilot-operated
  - pressure compensated
  - restrictors
  - check valves

- **directional control valves**
  - mono-block
  - sectional
  - serial/ parallel passage (normally open)
  - activation
    - manual
    - solenoid
    - pilot
    - pneumatic
  - spool
  - poppet
  - cartridge
  - rotary

2.4.3 Describe the principles of operation of hydraulic control valves.

[4/0]
- **pressure control valves**
  - simple relief
  - pilot-operating relief
  - pressure reducing
  - unloading
  - sequence
  - counterbalance
  - brake valve
- **flow control valves**
  - flow dividers
  - priority
  - proportional
  - pilot-operated
  - pressure compensated
    - restrictors
  - check valves
- **directional control valves**
  - oil flow circuit
    - parallel passage
  - centre types
  - poppet
  - cartridge
  - rotary
- **monoblock**
- **sectional**
- **parallel passage**

2.4.4 Demonstrate inspection and diagnostic procedures following manufacturers' recommendations for hydraulic control valves.

[1/3]
- **inspect and examine control valves for physical damage**
- **identify primary causes of failure**
- **disassemble and reassemble hydraulic control valves**
- **recommend reconditioning or repairs of hydraulic control valves**

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 section.

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

S1249.5 **Hydraulic Pumps**

Duration: Total 13 hours Theory 10 hours Practical 3 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5922.01, 5922.02, 5922.03, 5922.04, 5922.05, 5922.06, 5922.07
HDET	5895.01, 5895.02, 5895.03, 5895.04, 5895.05, 5895.06, 5895.07, 5895.08, 5895.09, 5895.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repairs of a hydraulic pump following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

2.5.1 Explain the purpose and fundamentals of hydraulic pumps.

[2/0]
- **inlet pressure-parameters**
- **internal oil flow**
  - internal lubrication
- **pressure management**
  - seals
- **bearing load**
- **wear points**
- **fundamentals enhancement**
  - energy
  - contamination and importance of cleanliness
  - displacement calculations
  - delivery calculations
  - power calculations
    - Imperial
    - système international d'unités (s.i.)

2.5.2 Identify the types and construction features of hydraulic pumps.

[3/0]
- **positive and non-positive displacement pumps**
- **gear pumps**
  - external
  - internal
- **piston**
  - radial
  - axial
  - fixed displacement
  - variable displacement
  - pressure compensated
  - flow compensated
- **vane pumps**
  - balanced
  - unbalanced
  - fixed displacement
  - variable displacement
  - pressure compensated
  - flow compensated

2.5.3 Describe the principles of operation of hydraulic pumps.

[4/0]
- **gear pumps**
  - external
  - internal
- **piston**
  - radial
  - axial
  - fixed displacement
  - variable displacement
  - pressure compensated
  - flow compensated
- **vane pumps**
  - balanced
  - unbalanced
  - fixed displacement
  - variable displacement
  - pressure compensated
  - flow compensated

2.5.4 Demonstrate-inspection, testing, and diagnostic procedures following manufacturers' recommendations for fixed displacement hydraulic pumps.

[1/3]
- **relationship between flow and pressure**
- **inspect gear, vane, and piston pumps**
- **pump failures and relate to damaged components**
- **outline the recommended disassembly and reassembly procedures**
- **disassembly and reconditioning procedures for a hydraulic pump 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 section.

- **safety precautions**
  - eye and hand protection
  - high pressure concerns for skin penetration
  - chemical hazards—WHMIS
  - high temperature
- **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: **S1250**

Reportable Subject: **ENGINE SYSTEMS**

Duration: Total 32 hours Theory 19 hours Practical 13 hours

Prerequisites: C.V.A.E. Level 1

3.1 Diesel Engine Fundamentals

4 Total Hours Theory: 2 hours Practical: 2 hours

3.2 Cylinder Heads, Valve Train Assemblies, and Components

10 Total Hours Theory: 6 hours Practical: 4 hours

3.3 Cooling Systems

6 Total Hours Theory: 3 hours Practical: 3 hours

3.4 Lubricating Systems

4 Total Hours Theory: 2 hours Practical: 2 hours

3.5 Air Induction and Exhaust Systems

8 Total Hours Theory: 6 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
60%	40%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Diesel engines (parent block / wet sleeve)	Cylinder Sleeve puller
Pressure gauge set / Manometer gauge set	Seal removal/ installation tools
Cylinder protrusion/ Counterbore measuring tools	Engine timing tools
Bore Gauges / Inside Micrometers	Piston ring and Piston installation tools
Magnetic crack detection equipment	Basic hand tools / Torque wrenches
Precision measuring tools	

S1250.1 **Diesel Engine Fundamentals**

Duration: Total 4 hours Theory 2 hours Practical 2 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5923.01, 5923.08, 5923.09, 5923.10
HDET 5891.09, 5891.10, 5891.11

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe testing procedures for combustion chamber condition following manufacturers' recommendations and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.1.1 Explain the fundamentals of applied calculations for compression pressure, cylinder balance, and cylinder leakage.

[1/0]
- **clearance volume vs. pressure**
- **mathematical formulas**
- **effects of cylinder sealing defects on balance and leakage**

3.1.2 Identify the procedures for diagnosing-combustion chamber conditions.

[1/2]
- **determine combustion chamber conditions using the following tests:**
  - compression test
  - cylinder leakage test
  - cylinder balance test

GENERAL PRACTICES

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

- **safety precautions**
  - eye, hearing, breathing, and hand protection
  - rotating components
  - 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

S1250.2 **Cylinder Heads, Valve Train Assemblies, and Components**

Duration: Total 10 hours Theory 6 hours Practical 4 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5923.01, 5923.08, 5923.09, 5923.10
HDET 5891.08, 5891.09, 5891.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the testing and servicing procedures for cylinder heads, valve trains, and related components following manufacturers' recommendations and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.2.1 Explain the fundamentals of cylinder heads, valve train assemblies, and components.

[1/0] - **purpose and application of cylinder heads and valve train assemblies**
- interpret and draw valve timing diagrams including duration, overlap, lead, and lag
- cylinder head resurfacing
- cylinder head torquing procedures when hot, cold, wet or dry
- seat width, undercutting, fitting, and sealing
- interference angle and multi-angle seats
- variable valve timing

3.2.2 Identify the construction features of cylinder heads, valve train assemblies, and related components.

[1/0] - **function and types of major components**
- **drive mechanisms**
- **combustion chambers**
- **gasket surfaces, gaskets and seals**

3.2.3 Describe the principles of operation of cylinder heads, valve trains, and related components.

[1.5/0]
- **combustion chamber operation**
- **valve timing diagrams, including duration, overlap, lead, and lag**
- **valve components**
  - valves
    - metallurgy
    - sodium filled
  - seats and guides
  - seals
  - springs, rocker arms, ~~and~~ shafts
  - pushrods, lifters, camshafts.
  - drive mechanisms
    - exhaust brakes
- **cylinder head gaskets and seals**

3.2.4 Perform inspection and testing procedures following manufacturers' recommendations on cylinder heads and valve train components.

[1.5/3]
- **outline removal and replacement procedures**
  - de-torquing/torquing procedures
  - identification of head fasteners
  - inspection of head fasteners
  - inspection of reconditioned components
- **inspection of all accessible components with the head removed**
  - timing marks
  - lobe wear
  - cam followers
- **inspection on cylinder heads for:**
  - cleaning procedure
    - external / internal thread inspection
    - blind hole clean-out
  - warpage
  - loose valve seats
  - guide wear
  - distortion
  - spring condition
  - valve protrusion
  - valve leakage test
  - valves
    - wear/scoring
    - stretch
    - cracks
    - overheating
    - seizure
    - corrosion

3.2.5 Recommend reconditioning or repairs following manufacturers' recommendations for cylinder heads and valve train components.

[1/1]
- **disassembly and assembly of a cylinder head**
- **crack detection procedure**
- **machining operations for:**
  - valve and seat cutting and grinding
    - seat replacement
    - valve to seat contact
- **installation of:**
  - valve guides
    - reaming
  - valve seal

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 section.

- **safety precautions**
  - eye 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

S1250.3 **Cooling Systems**

Duration: Total 6 hours Theory 3 hours Practical 3 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5923.01, 5923.02, 5923.03, 5923.04
HDET 5891.02, 5891.03, 5891.04

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the testing and servicing procedures for cooling systems components and coolants following manufacturers' recommendations and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.3.1 Explain the fundamentals of inspecting and testing engine cooling system components, and coolants.

[1/0] - **explain the significance of**
- heat transfer
- coolants
- cavitation
- air cooling concepts

3.3.2 Identify the process of testing and inspecting cooling systems.

[1/0] - **radiator shutters and controls**
- **control fans**
- **heat exchangers and coolers**
- **air cooling**

3.3.3 Perform inspection and testing procedures following manufacturers' recommendations for cooling systems.

[0.5/2] - **inspection, cleaning and testing procedures for:**
- in/out temperatures using pyrometer
- heat exchangers and coolers
- fan controls
- hydraulically controlled
- operation cycle (fan)
- coolant filters
- pH levels of coolant
- coolant strengths and condition
- pressure test cooling system

3.3.4 Recommend reconditioning or repairs following manufacturers' recommendations for cooling systems.

[0.5/1] - **demonstrate:**
- cooling system air-entrapment removal procedures
- coolant filter service procedures
- cooling system flushing procedures

- **explain coolant additive packages and contamination checks**
- **explain coolant pump shaft sealing devices and packing**

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 section.

- **safety precautions**
  - eye and hand protection
  - hot coolant concerns
  - rotating 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

S1250.4 **Lubricating Systems**

Duration: Total 4 hours Theory 2 hours Practical 2 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5923.01, 5923.05, 5923.06, 5923.07
HDET 5891.05, 5891.06, 5891.07

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the testing and servicing of lubricating system, components, and lubricants following manufacturers' recommendations and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.4.1 Explain the fundamentals of testing and servicing lubricating system components and lubricants.

[0.5/0] - **purpose, function, types, styles, and application**
- crude oils
- synthetic oils
- significance of selecting correct lubricating oils for engine service
- viscosity ratings
- grades
- service ratings

3.4.2 Identify the principles of testing and servicing filters, heat exchangers, and oil coolers.

[1/0] - **filters**
- by-pass
- full flow
- centrifugal

- **heat exchangers**
- **oil coolers**
- **pressure regulator**
- **pressure relief valve**
- **filter bypass valve**
- **oil cooler bypass valve**
- **thermostatic control**

3.4.3 Perform inspection and testing procedures following manufacturers' recommendations for lubricating system components and lubricants.

[0/1.5] - **service procedures for:**
- bearing leak down test
- oil pressure tests
- oil cooler test
- vacuum test (coolers)
- pressure test (coolers)

3.4.4 Recommend reconditioning or repairs following manufacturers' recommendations and for lubricating system components.

[0.5/0.5] - **demonstrate service procedures for:**
- changing oil and oil filters
- centrifugal filters
- by-pass filter
- removing and installing oil pumps

- **explain oil and oil filter change interval requirements**
- **describe requirements for priming oil pump and 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 section.

- **safety precautions**
  - eye and hand protection
  - hot oil concerns
- **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

S1250.5 **Air Induction and Exhaust Systems**

Duration: Total 8 hours Theory 6 hours Practical 2 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5924.01, 5924.02, 5924.03, 5924.04, 5924.05, 5924.06, 5924.07
HDET	5893.01, 5893.02, 5893.03, 5893.04, 5893.05, 5893.06, 5893.07, 5893.08, 5893.09, 5893.10

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the testing and servicing procedures for air induction and exhaust systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

3.5.1 Explain the fundamentals of commercial vehicle air induction and exhaust systems.

[1/0]
- **purpose, function, types, styles, and application**
  - air cleaners
  - turbochargers
  - Exhaust Gas Recirculation (EGR) Valves
  - volumetric efficiency
  - air charge temperature
  - cubic feet and cubic meters/minute air flow rate
  - mean effective pressure
  - exhaust system component overview

3.5.2 Identify the construction features of turbochargers, exhaust gas recirculation (EGR) valves and air cleaners.

[2/0]
- **turbochargers**
  - housing, shafts, turbine wheels, seals, bearings
  - variable geometry controls
- **intercoolers and aftercoolers**
- **controls**
  - wastegate
  - boost
  - variable volute
- **lubrication**
  - oils, passages, lines
- **exhaust gas recirculation (EGR) valves**

- **air cleaners**
  - oil bath
  - dry type
  - pre-cleaners
  - two-stage
- **manifolds**
  - intake
  - exhaust
  - exhaust gas recirculation (EGR) plumbing
- **exhaust after treatment**
  - exhaust scrubbers
  - muffler
    - water injection (spark arrest)
  - catalytic converters
    - ceramic
    - palladium
  - diesel particulate filter
  - aqueous urea injection

3.5.3 Describe the principles of operation of turbochargers, exhaust gas recirculation (EGR) valves and air cleaners.

[2/0]
- **turbochargers**
  - boost control, tip turbines, air flow, exhaust thrust, wastegate, intercoolers, aftercoolers
  - variable geometry controls
  - thermodynamics of turbine operation
- **exhaust gas recirculation (EGR) valves**
- **compare effectiveness of turbochargers**
  - variable geometry controls
- **air cleaners**
  - oil bath
  - dry
  - pre cleaners
  - two-stage

3.5.4 Demonstrate inspecting and testing procedures for air induction, exhaust systems, turbochargers and exhaust gas recirculation (EGR) valves following manufacturers' recommendations.

[0.5/1]
- **air induction system restrictions tests**
- **exhaust system restrictions**
- **air flow restriction indicators**
- **noise level tests**
- **turbocharger oil leak tests**
- **air intake temperature test**
- **boost pressure**
- **wastegate operations**

- **axial and radial movement**
- **recommended start-up/shutdown procedures**
- **exhaust gas recirculation (EGR) operation**

3.5.5 Recommend reconditioning or repairs following manufacturers' recommendations for air induction, exhaust systems, exhaust gas recirculation (EGR) valves, and turbochargers.

[0.5/1]
- **demonstrate turbocharger**
  - pre-lubrication requirements
  - lubrication requirements
  - clean air flow passages
  - mounting bolt torque
- **servicing air filters**
- **servicing exhaust systems**
- **servicing inter-coolers and after-coolers**
- **installation precautions for turbocharger**
  - pre-lubrication
- **servicing EGR (exhaust gas recirculation) valves**

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 section.

- **safety precautions**
  - eye and hand protection
  - hot housings
  - lubrication requirements on start-up
- **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: **S1251**

Reportable Subject: **ELECTRICAL/ELECTRONIC SYSTEMS**

Duration: Total 40 hours Theory 29 hours Practical 11 hours

Prerequisites: C.V.A.E. Level 1

4.1 Electrical Fundamentals

4 Total Hours Theory: 4 hours Practical: 0 hours

4.2 Chassis Electrical and Power Accessories

11 Total Hours Theory: 8 hours Practical: 3 hours

4.3 Cranking Systems

16 Total Hours Theory: 10 hours Practical: 6 hours

4.4 Basic Electronic Devices

9 Total Hours Theory: 7 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
70%	30%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Heavy duty starters	Starter test stand
Heavy duty carbon pile	High Impedance multi-meters
Equipment (with electronic control systems)	(EST) Electronic service tool capable of connection to onboard ECM systems
Sealed wiring connector repair kits	Personal computers PCs
Digital multimeters (DMMs)	Internet access

S1251.1 Electrical Fundamentals

Duration: Total 4 hours Theory 4 hours Practical 0 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5921.00, 5921.01, 5924.02, 5921.03, 5921.04, 5921.05, 5921.06, 5921.07, 5921.08, 5921.09, 5921.10, 5921.11
HDET	5892, 5894.00, 5903.00

GENERAL LEARNING OUTCOME

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

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

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

[4/0]
- **principles of electricity**
  - electron theory
  - magnetism
  - left and right hand rules
  - units of measure
  - Ohm's Law
  - Kirchoff's Laws
  - capacitance, induction
- **perform circuit calculations for:**
  - series, parallel, and series-parallel 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 section.

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

S1251.2 **Chassis Electrical and Power Accessories**

Duration: Total 11 hours Theory 8 hours Practical 3 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5921.01, 5921.04, 5921.07, 5921.10, 5921.11
HDET 5894.00, 5903.00

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to trace current flow through circuits with the use of an electrical schematic

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.2.1 Explain wiring fundamentals.

[1/0] - **wiring gauge numbers, colour**
- temperature effects of current flow through a conductor
- SAE wire specifications
- AWG wire specifications

4.2.2 Identify the construction features of chassis electrical and power accessory systems.

[2/0] - **wiring**
- **lighting**
  - signal circuits
  - headlamp circuits
  - clearance circuits
- **wiper circuits**
- **blower motor circuits**
- **warning and monitoring devices for:**
  - temperature
  - pressure
  - vacuum
  - engine speed
  - noise
  - fuel supply
  - charging
- **engine shut down systems**
- **engine starting aid circuits**
  - glow plugs
  - manifold heaters
  - starting fluid injection circuits

4.2.3 Describe the principles of operation of chassis electrical and power accessory systems.

[4/0]
- **wiring circuits**
- **lighting**
  - signal circuits
  - headlamp circuits
  - clearance circuits
- **wiper circuits**
- **warning and monitoring devices for**
  - temperature
  - pressure
  - vacuum
  - engine speed
  - noise
  - fuel supply
  - charging
- **engine shut down**
- **engine starting aid circuits**
  - glow plugs
  - manifold heaters
  - starting fluid injection circuits

4.2.4 Perform inspection and testing procedures following manufacturers' recommendations for chassis electrical and power accessory systems.

[1/3]
- **trace wiring circuits using manufacturers' wiring diagrams**
- **demonstration of wiper and warning system component tests**
- **identify circuit protection devices**
- **develop a chronological sequence to trace wiring faults**
- **demonstration of instrumentation troubleshooting**
  - electronic service tools (EST)
  - visual

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 section.

- **safety precautions**
  - eye and hand protection
  - polarity
- **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

S1251.3 **Cranking Systems**

Duration: Total 16 hours Theory 10 hours Practical 6 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5921.04, 5921.05, 5921.06
HDET 5894.00

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend repair of a cranking system following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.3.1 Explain the purpose and fundamentals of cranking systems

[1/0]
- **battery**
  - cables and connectors
  - switches, relays, condensers, and solenoids
- **cranking motor**
  - thermal protection
  - starter drives

4.3.2 Identify the construction features of cranking system components.

[3/0]
- **cranking motors**
  - configuration
  - internal circuits
  - thermal protection
- **starter drives**
- - overrunning clutch
  - spragg
  - ramp and roller
  - posi-torque
- **control devices**
  - relays
  - solenoids
  - series-parallel switch
  - master disconnect
  - pre-lubrication starting circuit
  - neutral safety switch

4.3.3 Describe the principles of operation of cranking systems and components.

[4/0]
- **electromagnetic principles**
- **cranking motors**
  - series
  - series-shunt
  - series-parallel
  - counter-electromotive force effect on current flow
  - temperature effect on load and torque output
  - configuration adjustment
  - thermal protection
- **drives**
  - overrunning clutch
  - spragg clutch
  - ramp and roller
  - posi-torque
- **control devices**
  - relays
  - solenoids
  - series-parallel switch
  - master disconnect
  - pre-lubrication starting circuit
  - neutral safety switch

4.3.4 Perform inspection, testing, and diagnostic procedures following manufacturers' recommendations for cranking motors and control devices.

[2/4]
- **outline the recommended diagnostic sequence for cranking system malfunctions**
- **battery condition tests**
- **cranking circuit current draw and voltage drop tests**
- **identify specific cranking system faults from test results**
- **demonstration of cranking no-load bench test**
- **cranking motor component tests**
- **demonstration of relay and solenoid testing**
- **component failure analysis**
- **outline the recommended procedures for boosting multiple batteries**
  - 12 volt circuits
  - 24 volt circuits
- **ring gear inspection**
  - drive gear and ring gear
  - starter gear reduction

4.3.5 Recommend reconditioning or repairs following manufacturers' recommendations for cranking motors and control devices.

[0/2] - **perform a starter motor removal and replacement procedure as recommended by the manufacturer**

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 section.

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

S1251.4 **Basic Electronic Devices**

Duration: Total 9 hours Theory 7 hours Practical 2 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5926.01, 5926.02, 5926.05, 5926.08, 5926.13
HDET 5892.08, 5892.09

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to test basic electronic components following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

4.4.1 Explain the purpose and fundamentals of basic electronics.

[1/0]
- **semi-conductor materials**
- **waveforms**
- **voltage spike control**
- **static electricity**
  - electrostatic discharge
- **shielding**
- **grounding**

4.4.2 Identify the function, construction features, composition, types, and application of electronic devices.

[2/0]
- **diodes**
  - rectifying
  - zener
  - light emitting
  - photo
- **transistors**
  - Positive-Negative-Positive (PNP)
  - Negative-Positive-Negative (NPN)

- **sensors**
  - reluctors
  - thermistors
  - piezoelectric
  - peizoresistive
- **variable resistor**
  - rheostat
  - potentiometers
- **optical devices**
- **capacitors**

4.4.3 Describe the principles of operation of electronic devices.

[3/0]
- **diodes**
  - forward and reverse bias
  - current control
- **transistors**
  - forward and reverse bias
  - positive-negative-positive (PNP) and negative-positive-negative (NPN)
  - gate controls
  - switching
  - amplification
- **capacitors**
- **sensors**
  - reluctors
  - thermistors
  - piezoelectric
  - piezorestive
- **variable resistor**
  - rheostat
  - potentiometers
- **binary logic**

4.4.4 Perform inspection and testing procedures following manufacturers' recommendations for electronic devices.

[1/2]
- **diodes**
- **transistors**
- **capacitors**
- **resistors**
- **potentiometer**
- **sensors**
  - reluctors
  - thermistors
  - piezoelectric
  - piezorestive

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 section.

- **safety precautions**
  - eye, hearing, breathing, and face protection
  - battery gas precautions
  - explosion precautions
- **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: **S1252**

Reportable Subjects: **FUEL SYSTEMS**

Duration: Total 32 hours Theory 19 hours Practical 13 hours

Prerequisites: C.V.A.E. Level 1

5.1 Governor Systems

4 Total Hours Theory: 2 hours Practical: 2 hours

5.2 In-Line Injection Pump Systems

6 Total Hours Theory: 3 hours Practical: 3 hours

5.3 Distributor Injection Pump Systems

8 Total Hours Theory: 5 hours Practical: 3 hours

5.4 Unit Injector Systems

8 Total Hours Theory: 5 hours Practical: 3 hours

5.5 Introduction to Electronic Fuel Injection

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
70%	30%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Running diesel engine equipped with distributor pump fuel system	Primary fuel system components
Assortment of EUI's Electronic Unit Injectors	Inline / distributor Injection pumps with governors
Hydraulic unit Injectors	Fuel injection system
Running diesel engine equipped with inline	Fuel system components

S1252.1 **Governor Systems**

Duration: Total 4 hours Theory 2 hours Practical 2 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5925.05, 5925.06, 5925.07, 5926.12
HDET 5892.02, 5892.02

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the testing procedures for mechanical governor systems following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.1.1 Explain the purpose and fundamentals of diesel engine fuel injection system governors.

[0.5/0] - **define terms**
- high idle
- rated speed
- governor cut-off
- droop curve
- torque curve
- hysteresis
- hunting
- torque rise
- aneroid

5.1.2 Identify the construction features of mechanical governors.

[0.5/0] - **mechanical governors**
- variable speed
- limiting speed
- isochronous
- linkages and control levers

- **aneroid**
- diaphragm, piston, or bellows
- spring
- boost pressure inlet
- linkage rods
- atmospheric vent

- **altitude compensators**

5.1.3 Describe the principles of operation of mechanical governors.

[1/0]
- **mechanical governors**
  - variable speed
  - limiting speed
  - isochronous
  - springs and flyweights
  - linkages and control levers
  - thrust collars
- **aneroid**
  - diaphragm, piston, or bellows
  - spring
  - boost pressure inlet
  - linkage rods
  - atmospheric vent
- **altitude compensators**

5.1.4 Perform testing procedures following manufacturers' recommendations for mechanical governor assemblies.

[0/2]
- **demonstrate testing engine-governed speed**
  - high idle speed
  - low idle speed

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 section.

- **safety precautions**
  - eye protection
  - spontaneous combustion
  - CSA approved equipment for emptying tanks and storing fuel
  - priming and starting procedures, starting fluid applications
  - hazards of solvents
  - high pressure fuel lines
  - emergency shutdown procedures
  - high pressure injector spray precautions
- **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

S1252.2 **In-Line Injection Pump Systems**

Duration: Total 6 hours Theory 3 hours Practical 3 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5925.05, 5925.06, 5925.07
HDET 5892.02, 5892.04, 5892.05

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe diesel in-line fuel injection pump system service procedures following manufacturers' recommendations and government policies.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.2.1 Explain the purpose and fundamentals of diesel in-line injection pumps systems.

[0.5/0] - **in-line pumps, metering, and controls**
- pump housing
- camshaft
- charging gallery
- pumping elements
  - port/helix
  - sleeve metering
- delivery valves
- lubrication
- high pressure lines

5.2.2 Identify the component construction features of diesel in-line injection pumps.

[0.5/0] - **pump housing**
- **camshaft**
- **charging gallery**
- **pumping element**
- **plunger and barrel spill ports**
- **delivery valves**

5.2.3 Describe the principles of operation of diesel in-line injection pumps.

[2/0] - **metering in-line injection pumps**
- gallery charging
- pumping element operation
- port closure and effective stroke
- racks
- cam profile and injection rate
- delivery valves
- residual line pressure
- lubrication
  - cam box
  - viscous sealing
- heat dissipation

5.2.4 Recommend reconditioning or repairs following manufacturers' recommendations for in-line injection pump systems.

[0/3] - **demonstrate in-line injection pump static and dynamic timing**
- timing pins
- electronic alignment
- dial indicator
- high and low speed adjustment
- spill port timing

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 section.

- **safety precautions**
  - eye protection
  - spontaneous combustion
  - CSA approved equipment for emptying tanks and storing fuel
  - priming and starting procedures, starting fluid applications
  - hazards of solvents
  - high pressure fuel lines
  - emergency shutdown procedures
  - high pressure injector spray precautions
- **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

S1252.3 **Distributor Injection Pump Systems**

Duration: Total 8 hours Theory 5 hours Practical 3 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5925.05, 5925.06, 5925.07
HDET 5892.02, 5892.04, 5892.05

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the timing procedures for distributor pump 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 inlet metering, opposed plunger and sleeve metering distributor injection pump systems.

[0.5/0]
- **housing**
- **opposed plungers**
- **rotor**
- **cam ring**
- **hydraulic head**
- **regulator assembly**
- **timing advance**
- **metering valve**
- **transfer pump**
- **fluid flow and capacity measurement**
- **fuel supply system**

5.3.2 Identify the construction features of inlet metering, opposed plunger and sleeve metering distributor high-pressure pumps and controls.

[1.5/0] - **distributor pump and controls**
- opposed plunger
- single plunger
- rotor
- plungers
- cam ring
- hydraulic head
- pressure regulator assembly
- advance mechanism
- metering valve
- transfer pump

5.3.3 Describe the principles of operation of inlet metering, opposed plunger and sleeve metering distributor high-pressure pumps and controls.

[2/0] - **distributor pump and controls**
- opposed plunger
- single plunger
- rotor
- plungers
- cam ring
- hydraulic head
- pressure regulator assembly
- advance mechanism
- metering valve
- transfer pump

5.3.4 Recommend reconditioning or repairs following manufacturers' recommendations for inlet metering, opposed plunger and sleeve metering-distributor pumps.

[1/3] - **demonstrate distributor pump timing and indexing procedures**
- **high and low speed 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 section.

- **safety precautions**
  - eye protection
  - spontaneous combustion
  - CSA approved equipment for emptying tanks and storing fuel
  - priming and starting procedures, starting fluid applications
  - hazards of solvents
  - high pressure fuel lines
  - emergency shutdown procedures
  - high pressure injector spray precautions
- **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

S1252.4 **Unit Injector Systems**

Duration: Total 8 hours Theory 5 hours Practical 3 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5925.05, 5925.06, 5925.07
HDET 5892.02, 5892.04, 5892.05

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the diesel unit injection system repair procedures 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 fuel unitized injection systems.

[1/0]
- **fuel flow**
- **fuel delivery**
- **injector types**
- **controls**
- **actuation**

5.4.2 Identify the construction features of diesel fuel unitized injection system components.

[2/0]
- **fuel delivery**
  - fuel manifolds
  - jumper pipes
- **transfer pump**
- **unit injectors**
  - body
  - pumping element
    plunger and bushing
    upper and lower bushing ports
    helix designs
  - needle valves
- **control rack assembly**
  - tube
  - rack levers

5.4.3 Describe the principles of operation of diesel fuel unitized injection systems.

[1/0]
- **transfer pump**
  - positive displacement gear
- **mechanically actuated unit injectors**
  - effective stroke
  - timing of injection
  - nozzle-opening valves
  - pumping principle
  - upper and lower bushing ports
  - helix designs
- **control rack and cam shaft**
  - injection rate
  - fuel flow

5.4.4 Demonstrate inspecting, testing, and diagnostic procedures following manufacturers' recommendations for unit injectors and control devices.

[1/1]
- **diagnostic procedures of common failures**
- **troubleshooting techniques**
  - isolate faulty injector
  - engine misfire

5.4.5 Recommend reconditioning, repairs, or adjustment procedures following manufacturers' recommendations for diesel fuel unitized injection systems.

[0/2]
- **demonstrate diagnostic procedures for:**
  - unit injectors
  - return flow assessment
    - temperature
    - aeration
    - volume
  - suction
  - pressure
  - high and low speed 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 section.

- **safety precautions**
  - eye protection
  - spontaneous combustion
  - CSA approved equipment for emptying tanks and storing fuel
  - priming and starting procedures, starting fluid applications
  - hazards of solvents
  - high pressure fuel lines
  - emergency shutdown procedures
  - high pressure injector spray precautions
- **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

S1252.5 **Introduction to Electronic Fuel Injection**

Duration: Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5926.01, 5926.02, 5926.03, 5926.04
HDET	5892.06, 5892.07, 5892.08, 5892.09

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to identify injector replacement procedures following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

5.5.1 Explain the purpose and fundamentals of electronic fuel injection systems.

[0.5/0]
- **emission control**
- **power/torque**
- **economy**
- **service intervals**

5.5.2 Identify the construction features of electronic fuel injector components.

[1.5/0]
- **electronic unit injectors**
  - poppet valve
  - nozzle
  - plunger
  - high pressure circuit
  - low pressure circuit
  - pressure regulation
    - high pressure
    - low pressure
- **hydraulic electronic unit injectors**
  - poppet valve
  - nozzle
  - plunger
  - hydraulic control circuit
    - pressure regulation
  - fuel circuits
    - high pressure
    - low pressure

5.5.3 Describe the principles of operation of electronic fuel injector system devices.

[1.5/0]
- **electronic unit injectors**
  - fuel circuit
    - low pressure
    - cooling
    - lubrication
    - high pressure
    - atomization
    - fuel control
    - metering
    - delivery
    - timing
- **hydraulic electronic unit injectors**
  - hydraulic control circuit
    - pressure regulation
  - fuel circuits
    - high pressure
    - low pressure

5.5.4 Perform replacement procedures following manufacturers' recommendations operations for electronic fuel injectors.

[0.5/2]
- **demonstrate injector replacement procedures**
- **outline servicing precautions for injector replacement**
  - electrical
  - hydraulic
  - fuel
  - mechanical

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 protection
  - spontaneous combustion
  - CSA approved equipment for emptying tanks and storing fuel
  - priming and starting procedures, starting fluid applications
  - hazards of solvents
  - high pressure fuel lines
  - emergency shutdown procedures
  - high pressure injector spray precautions
- **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: **S1253**

Reportable Subject: **DRIVE TRAIN SYSTEMS**

Duration: Total 32 hours Theory 18 hours Practical 14 hours

Prerequisites: C.V.A.E. Level 1

6.1 Differential, Final Drives, and Power Dividers

14 Total Hours Theory: 8 hours Practical: 6 hours

6.2 Power Shift Transmission Systems

18 Total Hours Theory: 10 hours Practical: 8 hours

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

Mark Distribution:

Theory Testing	Practical Application Testing
60%	40%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:

Recommended Minimum Equipment:

Precision measuring tools	Basic hand tools
Pressure test equipment	Assortment of drive axle, power dividers and final drives.
Powershift transmissions	Hydraulic clutch packs
Single and Double speed Differentials	Planetary wheel end gear sets
Internet access	EST's Electronic service tools
Measuring Tools	Magnetic Dial indicator
Mechanical face seals, Lip seals.	Assortment of wheel end bearings
Hydrostatic drive pumps and motors (from heavy equipment)	Bearing pullers and presses

S1253.1 **Differential, Final Drives, and Power Dividers**

Duration: Total 14 hours Theory 8 hours Practical 6 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5928.01, 5928.02, 5928.03, 5928.04
HDET 5897.02, 5897.04, 5897.05, 5987.07

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe repair procedures of drive train systems following manufacturers' recommendations and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.1.1 Explain the purpose and fundamentals of drive train systems.

[2/0]
- **differentials**
- **final drives**
- **power dividers**
- **fundamentals enhancement**
  - centrifugal force
  - linear movement
  - angular movement
  - lubricating oils, including temperature and load requirements
  - planetary gear sets

6.1.2 Identify the construction features of drive train system components.

[2/0]
- **differentials**
  - single- and two-speed
    - standard
    - no-spin and locking
    - torsion
  - air shift
  - electrical shift
- **final drives**
  - bevel gear
  - spiral gear
  - helical and hypoid gear
  - planetary
  - inboard and outboard
- **power dividers**

6.1.3 Describe the principles of operation of drive train systems.

[3/0]
- **differentials**
  - single- and two-speed
    - standard (open)
    - no-spin
    - locking
    - limited slip
    - torsen-gleason
    - planetary
  - air shift
  - electrical shift
  - hydraulic shift
- **final drives**
  - bevel gear
  - spiral gear
  - helical and hypoid gear
  - planetary
  - inboard and outboard
- **power dividers**

6.1.4 Perform inspection, testing, and diagnostic procedures following manufacturers' recommendations for drive train systems.

[0.5/3]
- **differentials, final drives and power dividers :**
  - pinion cone point adjustment
  - gear contact patterns
  - gear backlash
  - bearing pre-load
- **identify component failures and determine potential causes for:**
  - noises
  - wear
  - malfunctions
  - shift problems
  - overheating
  - lack of proper lubrication

6.1.5 Demonstrate service procedures following manufacturers' recommendations for drive train systems.

[0.5/3]
- **lubricating oil**
  - level checks
  - breather service
  - filter service
- **seal replacement procedures**
  - mechanical face-type seal
  - rubber packing
  - lip seals

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 section.

- **safety precautions**
  - eye and hand protection
  - dismantling
  - use of brass drifts
  - control of snap ring or circlip removal
  - hoist and stand use
- **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

S1253.2 **Power Shift Transmission Systems**

Duration: Total 18 hours Theory 10 hours Practical 8 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5927.08, 5927.09, 5927.10, 5927.11, 5927.12, 5927.13
HDET 5896.11, 5896.13, 5896.14, 5896.16

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe testing and repair procedures following manufacturers' recommendations and safe work practices of power shift transmissions.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

6.2.1 Explain the purpose and fundamentals of power shift transmission systems.

[1/0]
- **control systems**
  - hydraulic
  - pneumatic
  - electronic
  - manual
- **planetary gear sets**
  - simple
  - compound
  - ratio calculations
- **countershaft gear sets**
  - ratio calculations
- **lubrication**
  - filtration

6.2.2 Identify the construction features of power shift transmission system components.

[4/0]
- **control system**
  - lubrication and cooling circuits
  - oil pump
  - filtration
    - by-pass
  - pressure regulating valve
  - oil cooler
  - oil passages

- **control circuit**
  - pressure regulating valve
  - adjustable orifice
  - modulation
  - accumulator
  - shift valves
    - mechanical
    - electrical
    - rotary
    - spool
  - inching pedal
  - transmission interlock (enable) circuit
- **holding and locking devices**
  - hydraulic clutch assembly
  - discs and plates
  - pistons
  - input drum
  - hub and output shaft
    - park lock
    - dry disconnect clutch
    - tow disconnect
- **planetary gear sets**
  - simple
  - sun gear
  - planet pinions and carrier
  - ring gear
  - compound
- **counter shaft gear sets**
- **electronic controls**
  - controller
  - solenoids
    - latching
    - non-latching
  - on-off
  - modulation
  - sensors
    - speed
    - pressure
    - temperature
  - dump valves

6.2.3 Describe the principles of operation of power shift transmission systems.

[5/0]

- **control system**
  - oil pump
  - lubrication and cooling circuits
  - pressure regulating valve
  - oil cooler
  - control circuit
  - pressure regulating valve
  - adjustable orifice
  - accumulator
    - spring
    - pneumatic
  - shift valves
    - rotary
    - spool
    - mechanical
    - electrical
  - inching pedal
- **holding and locking devices**
  - dry disconnect clutch
  - tow disconnect
  - hydraulic clutch assemblies
    - holding clutch (brake pack)
    - rotating clutch
    - high and low speeds
    - park lock
- **planetary gear sets**
  - simple
  - compound
- **counter shaft gear sets**
- **electronic controls**
  - calibration

6.2.4 Perform inspection, testing, and diagnostic procedures following manufacturers' recommendations for power shift transmission systems.

[0/6]

- **check and test fluid levels and condition**
- **trace the power flow through gear sets and clutch packs**
  - under drive
  - direct drive
  - overdrive
- **test transmission clutch and lube pressures and flow rates according to recommended procedures**
- **perform component examination, measurements, clearance, and end play check**
- **relate component failures to operational problems and diagnostic procedures**

- **outline the recommended procedures to test the power shift transmission electronic control devices**

6.2.5 Demonstrate service procedures following manufacturers' recommendations for power shift transmission systems.

[0/2]
- **outline oil and filter changes**
  - **service intervals**
  - **oil sampling**
- **adjust transmission regulating valve pressures**
- **procedures to retrieve diagnostic codes**
  - **interpret diagnostic codes**
- **recommended disassembly and reassembly 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 section.

- **safety precautions**
  - eye and hand protection
  - dismantling
  - use of brass drifts
  - control of snap ring or circlip removal
  - hoist and stand use
- **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: **S1254**

Reportable Subject: **Steering, Tires and Brake Systems**

Duration: Total 24 hours Theory 17 hours Practical 7 hours

Prerequisites: C.V.A.E. Level 1

7.1 Steering Systems

12 Total Hours Theory: 8 hours Practical: 4 hours

7.2 Tires, Wheels, and Hubs

6 Total Hours Theory: 4 hours Practical: 2 hours

7.3 Hydraulic Brake Systems

6 Total Hours Theory: 5 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
50%	50%

Instructional and Delivery Strategies:
Lecture and assignment work

Reference Materials:
O.E.M. Equipment Documentation

Recommended Minimum Equipment:

Operational equipment with hydraulic brakes	Assortment of pneumatic and mechanical suspension components
Equipment with suspension systems	Disassembled hydraulic brake components
Equipment with articulating steering systems	Precision measuring equipment
Equipment with conventional steering systems	Equipment with Inboard hydraulic brakes
Equipment with outboard hydraulic brakes	Assortment of hydraulic brake components

S1254.1 **Steering Systems**

Duration: Total 12 hours Theory 8 hours Practical 4 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5930.01, 5930.02, 5930.03, 5930.04
HDET	5898.01, 5898.02, 5898.03, 5898.04, 5898.05, 5898.06, 5898.07

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to recommend testing and servicing of steering systems following manufacturers' recommendations and safe work practices.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.1.1 Explain the purpose and fundamentals of steering systems.

[1/0]
- **Ackerman's principles**
- **parallelograms**
- **steering geometry**
- **centre of gravity**
- **levers, mechanical advantage**
- **linear and angular measurement**
- **metric and imperial units**
- **hydraulic principles**
- **outline the features of steering systems:**
  - two wheel
    - front axle
    - rear axle
  - all wheel
    - crab
    - coordinated
  - articulated
    - axle tracking
  - steering clutches
  - differential steering

7.1.2 Identify the types and construction features of steering system components.

[3/0]

- **mechanical components**
  - steering gear
  - steering arms and linkages
  - oscillating axle housing
  - variable tread width axle
- **hydraulic assist**
  - pump and reservoir
  - power cylinder
  - gear assembly
- **fully hydraulic**
  - reservoir
  - power cylinder
  - directional steering pump
  - steering arms and linkages
  - pilot operated
  - stick steer
  - wheel lean (graders)
- **dual steering axles**
  - inter axle drag link
- **steering clutches**
  - wet
  - dry
- **differential steering**
- **hydrostatic steering**
  - skid steer (wheel/track**)**
- **articulating steering**
  - steering stops
    - mechanical stops
    - soft stops

7.1.3 Describe the principles of operation of steering systems.

[4/0]

- **hydraulic assist**
  - pump and reservoir
  - power cylinder
  - gear assemblies
- **fully hydraulic**
  - reservoir
  - power cylinder
  - directional steering pump
  - steering arms and linkages
  - pilot operated
  - stick steer
  - supplemental steering
    - ground drive
    - electric
    - accumulator

- **dual steering axles**
- **steering clutches**
- **differential steering**
  - start up precautions
- **hydrostatic steering**
  - skid steer (wheel/track**)**
  - independent track steer
- **articulating steering**
  - steering stops
    - mechanical stops
    - soft stops

7.1.4 Demonstrate inspection, servicing, testing, and diagnostic procedures following manufacturers' recommendations for steering systems.

[0/2]
- **visual inspection~~s~~**
- **steering pump pressure tests**
- **steering pump flow rate tests**
- **pump internal leakage test**
- **describe diagnostic procedures**
  - malfunctions
- **service requirements**
  - intervals
  - lubrication points
  - lubricant type
  - filter replacement
  - oil sampling

7.1.5 Demonstrate service procedures following manufacturers' recommendations for steering systems.

[0/2]
- **steering system adjustments for:**
  - toe-in
  - steering gear
  - steering clutches
  - hydraulic pressures
  - steering columns

GENERAL PRACTICES

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

- **safety precautions**
  - eye and skin protection
  - equipment lifting and supports
  - high pressure concerns
  - pinch points (articulating)
- **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

S1254.2 **Tires, Wheels, and Hubs**

Duration: Total 6 hours Theory 4 hours Practical 2 hours

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET	5930.01, 5930.02, 5930.03, 5930.04
HDET	5904.01, 5904.02, 5904.03, 5904.04

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to describe the testing and servicing procedures for tires, wheels, and hubs following manufacturers' recommendations.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.2.1 Explain the fundamentals of tires, wheels, and hubs.

[1/0]
- **purpose, function, types, styles, and application**
  - tires, wheels, and hubs
- **fundamentals**
  - tire composition
  - centrifugal force
  - centripetal force
  - sliding and rolling friction
  - ferrous and non-ferrous materials
  - fastener torque
  - rim sizing details
    - tire/rim dimension matching
  - rolling radius
  - ballast
  - dual wheels

7.2.2 Identify the construction features of tires, wheels, and hubs.

[1/0]
- **tires**
  - materials
  - radials, bias ply
  - floatation type
  - solid
  - semi-pneumatic
  - tread patterns
- **wheel rims**
  - drop centre
  - lock rings

- **hubs**
  - cast spoke
  - mounting fasteners

7.2.3 Describe the operating principles of tires, wheels, and hubs.

[1/0]
- **tires**
  - radial and bias ply
  - floatation type
  - solid
  - semi-pneumatic
  - pneumatic
    - nitrogen
    - air
  - ballasting
    - liquid
    - solid
- **tire matching for:**
  - radials and bias ply
  - dual wheels
  - tandem axles
- **wheel:**
  - rims
    - single piece
    - multi piece
    - lock rings
    - lock ring safety
    - drive lugs
    - lock ring retainers
- **hubs**
  - fasteners
  - cast
  - steel
  - wedge lock safety

7.2.4 Demonstrate inspection, safe servicing and testing procedures following manufacturers' recommendations for tires, wheels, and hubs.

[0/2]
- **inspect tires, wheels, and hubs for:**
  - wear
  - fractures
  - leaks
- **test tires and wheels for:**
  - pressure
  - distortion

7.2.5 Recommend reconditioning or repair procedures following manufacturers' recommendations for tires, wheels, and hubs.

[1/0]
- **outline the recommended procedures for dismantling and assembly of tires and rims**
  - safe handling practices
    - heating or welding practices (explosion risks)
  - multi piece/one piece wheels
    - deflate before removing from equipment (heavy equipment)
- **outline the recommended maintenance procedures for hub assemblies**

GENERAL PRACTICES

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

- **safety precautions**
  - eye and skin protection
  - inflating precautions
  - caging of split rim assemblies
  - jacking and stand use
  - mounting and dismounting (off machine)
- **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

S1254.3 **Hydraulic Brake Systems**

Duration: Total 6 hours Theory 5 hours Practical 1 hour

Prerequisites: C.V.A.E. Level 1

Cross-Reference to Training Standard:

AET 5930.01, 5930.02, 5930.03, 5930.04
HDET 5891.01, 5891.02, 5891.03, 5891.04

GENERAL LEARNING OUTCOME

Upon successful completion the apprentice is able to perform repairs following manufacturers' recommendations and safe work practices of hydraulic brake systems.

LEARNING OUTCOMES AND CONTENT

Upon successful completion, the apprentice is able to:

7.3.1 Explain the fundamentals of hydraulic brake systems.

[2/0] - **brake assemblies**
- multi-disc
- inboard/outboard
- spring applied hydraulic release
- hydraulic applied spring release
- external disc brakes
- brake components

7.3.2 Identify the construction, composition features, types, styles, and application of hydraulic brake systems.

[1/0] - **brake components**
- pistons
- seals
- springs
- disc/plates
- housings
- retractors
- calipers

7.3.3 Describe the principles of operation of hydraulic brake systems.

[1/0] - **brake components**
- pistons
- seals
- springs
- disc/plates
- housings
- retractors
- calipers

7.3.4 Perform inspection, testing, and diagnostic procedures following manufacturers' recommendations and safe work practices on brake systems.

[0/1] - **interpret test results and performance problems**
- noises
- drag or lockup
- vibrations
- imbalance

- **check park brake operation**

7.3.5 Recommend reconditioning or repairs following manufacturers' recommendations for hydraulic brake systems.

[1/0] - **identify corrective repair actions according to manufacturers' recommended 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 section.

- **safety precautions**
  - pressure escape and containment
  - eye and skin protection from hot fluids
  - hazardous materials
  - lifting and hoisting
  - ventilation of work area
  - fire hazard
  - high pressure fluid injection/skin penetration
  - supporting and blocking of 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

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 colorless, odorless gas that is formed when fuel is not burned completely.
carcinogen	Any substance, such as asbestos, and carbon tetrachloride, that can cause cancer.
cardan joint	A universal joint commonly used as a driveshaft coupler permitting articulation. Two yokes are united by a rigid cross whose races run in a yoke supported needle bearings or races.
case-harden	A process of heating a piece of steel to harden its surface while the inside remains relatively soft.
catalyst	A substance that stimulates, accelerates, or enables a chemical reaction without itself undergoing any change.
catalytic converter	An exhaust system device that enables oxidation and reduction reactions; in lean burn truck diesel engines, only oxidation catalytic converters are used at this moment in time.
cavitation	Describes metal erosion caused by the formation and subsequent collapse of vapor pockets (bubbles) produced by physical pulsing into a liquid such as that of a wet liner against the wall of coolant that surrounds it. Bubble collapse causes high unit pressures and can quickly erode wet liners when the protective properties of the coolant diminish. Also known in hydraulics as a gaseous condition within a liquid stream causing the rapid implosion of a gaseous bubble.
CCW	Counter-clockwise or left hand rotation.
CD	Compact disk. Optically encoded, digital data storage.
CD-ROM	An optically encoded data disk that is read by a laser in the same way an audio CD is read and is designed for read-only data.
centrifugal filter	A filter that uses a centrifuge consisting of a rotating cylinder charged with pressurized fluid and canted jets to drive it; centrifugal filters often have high efficiencies and are often of the *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 hydro-mechanical governor terminology, a response lag. (ii) Molecular friction caused by the lag between the formation of magnetic flux behind the magneto motive 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, 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.