Apprenticeship Manitoba

Manitoba

# Heavy Duty Equipment Technician
# Level 3

Rev. December 2004

Apprenticeship Manitoba

# Heavy Duty Equipment Technician

## Unit: D2 Diesel Fuel Injection, Emission Control; Engine Diagnosis, Startup, Tuneup & Engine Brakes

**Level:** Three

**Duration:** 90 hours

Theory: 45 hours

Practical: 45 hours

**Overview:**

This unit of instruction provides the Heavy Duty Equipment Technician apprentice an overall understanding of fuel characteristics and systems. It also provides the working knowledge required to diagnose and repair fuel injection and emission control systems. The unit also provides the apprentice with the working knowledge required to diagnose engine problems, do startup/tune-up procedures, as well as understand engine brakes.

| **Objectives and Content:** | **Percent of Unit Mark (%)** |
|---|---|
| **1. Describe diesel fuel characteristics.** | **3%** |
| a. Cetane number | |
| b. Diesel fuel grades (summer and winter) | |
| c. Specific gravity testing | |
| d. Viscosity | |
| e. Flash & pour point | |
| f. Sulphur | |
| g. Volatility | |
| h. Carbon residue | |
| i. Fuel additives | |
| j. Interpretation of fuel specifications | |
| k. Advantages and disadvantages of various fuels | |
| l. Performance characteristics of gasoline | |
| m. Cetane number | |
| **2. Describe delivery, injection and combustion.** | **3%** |
| a. Overall description and purpose | |
| b. Injection lag | |
| c. Ignition lag | |
| d. Combustion | |
| e. Nozzle closure lag | |
| f. After burn | |
| **3. Describe the fundamentals of diesel fuel injection systems.** | **3%** |
| a. Timing | |
| b. Pressurizing | |

c. Metering
d. Distribution
e. Units of pressure and linear measurement
f. Key engine management objectives

**4. Describe charging pumps.** **3%**

a. Charging pumps/pressure
b. Lubrication

**5. Describe diesel injection pumps.** **3%**

a. Overall description and purpose
b. Technical description
   - Camshaft
   - Tappets
   - Plunger design & metering
   - Barrel
   - Delivery valve
   - High pressure pipes
c. Pump types
   - Distribution pumps
   - Pressure time ("PT") pumps
   - Sleeve metering pumps
   - Port & helix pumps

**6. Describe alternative injectors.** **3%**

a. Cummins unit injector
b. Detroit unit injector
c. HEUI unit injector
d. Others

**7. Describe hydraulic injector nozzles.** **3%**

a. Overall purpose
b. Nozzle opening pressure
c. Poppet & pintle nozzles
   - Action
   - Atomization
d. Orifice nozzles
   - Back leakage
e. Action
   - Peak pressure
f. Nozzle differential ratio
   - Residual line pressure
g. Nozzle holders/injectors
   - Pencil-type injector nozzles

**8. Describe governors.** **3%**

a. Overall function
b. Terminology
c. Mechanical governor
   - Limiting & variable speeds
   - In synchronous

d. Servo-type governor
e. Hydraulic governor
   - Direct & indirect
f. Electronic governor

**9. Describe and perform nozzle testing and reconditioning. 3%**

a. Overall description and purpose
b. Safety precautions
c. Removal of injectors from the cylinder head
d. Testing: procedures
e. Reconditioning
f. Reinstallation of injectors
g. High pressure pipes

**10. Describe and perform the timing of injection pumps. 3%**

a. Overall description and purpose
b. Spill timing procedure
c. Static timing
d. Removal of a port helix metering injection pump
e. Reinstallation

**11. Describe emissions, emissions testing and controls. 5%**

a. Overall description and purpose
b. Overall context of emissions legislation
c. Photochemical smog
   - Sulfur dioxide
   - Hydrocarbons
   - Ingredients
d. Hydrocarbons
e. Volatile organic compounds
f. Carbon monoxide (CO)
g. Ozone
h. Oxides
i. Nitrous oxides
j. Aneroids
   - Puff limiters
   - Turbo-boost sensors
   - AFC valves
k. Altitude compensator
l. Emissions testing and controls
   - Opacity meter
   - Current emission controls
     -ECM inputs
     -Management of combustion temperatures
     -Aneroid or fuel-ratio control
     -Particulate traps
     -Reduction of SAC volume
     -Cooling of intake air
     -Variable geometry turbochargers
     -Exhaust gas recirculation
     -Oxidation catalytic converters
     -Physical entrapments of particulates
     -Gas analyzers

**12. Describe engine horsepower and torque.** **5%**

a. Graphing of horsepower curve
b. Graphing of torque curve
c. Graphing of fuel consumption

**13. Describe and use specialized diagnostic measuring and diesel tools.** **5%**

a. Diagnostic measuring tools
   - Infrared thermometer
   - Cylinder compression gauge
   - Manometer
   - Leakdown tester
   - Use of dynamometer

b. Diesel tools
   - Injection puller/extractor
   - Diesel injector service set
   - Nozzle pop tester
   - Diesel injection timer
   - Opacity smoke meter
   - Computer system diagnostic tools
     -General description (covered in Level 3)

**14. Describe and perform the diagnosis of engine problems.** **20%**

a. Electronic diagnostics
   - Fault codes

b. Primary engine checks
c. Cylinder balance
   - Procedures for various fuel and ignition systems
   - Evaluate results

d. Vacuum tests
   - Cranking vacuum test
   - Idle and running test
   - Restricted exhaust test
   - Effects of valve train problems on vacuum readings

e. Air induction system pressure test
f. Air inlet restriction pressure test
g. Air box pressure / turbocharger discharge pressure
h. Crankcase pressure testing
   - Verification of PCV system operation
   - Identification of cylinder sealing problems
   - External oil leak diagnosis

i. Exhaust back pressure test
j. Compression tests
   - Test preparation procedures (fuel and ignition system)
   - Test procedures & interpretation of test results

k. Cylinder leakdown tests
   - Procedures and precautions
   - Interpretation of results

**15. Describe engine troubleshooting and smoke analysis.** **10%**

a. Concept of troubleshooting as it applies to engines

- Role of sequential troubleshooting charts
- Failure analysis

b. Smoke analysis
- Overall concept
- State of emission
- White, black vs. blue smoke

c. Black smoke
- Insufficient combustion air
- Exhaust system restriction
- Excess fuel / irregular fuel distribution
- Improper fuel grade

d. Blue smoke

e. White smoke
- General cause
- Cylinder misfire
- Low cylinder compression pressure
- Low cetane number
- Air pumping: injection pump circuit
- Coolant leakage to cylinders
- Low combustion temperatures

f. Smoke density/opacity standards

**16. Describe and perform troubleshooting strategies. 15%**

a. Overall purpose and benefits

b. Need for troubleshooting guidelines

c. Need for structure and sequence.

d. Low oil pressure
- Procedures to verify problem
- Causes and solutions

e. High oil consumption
- Procedures to verify problem
- Causes and solutions

f. High oil temperature
- Procedures to verify problem
- Causes and solutions

g. High coolant temperature
- Procedures to verify problem
- Causes and solutions

h. Low coolant temperature
- Procedures to verify problem
- Causes and solutions

i. Cylinder compression problems
- Problems created
- Compression test
- Cylinder leakage test

j. High exhaust pyrometer readings
- Installation of master pyrometer
- Chassis dynamometer
- Causes and solutions

k. Sudden engine stoppage
- Causes and solutions

l. Rough running engines
   - Causes and solutions

m. Engine blowby
   - Causes and solutions

n. Engine not cranking
   - Causes and solutions

o. Lack of power
   - "Lack of power" checklist
   - Possible causes and solutions

p. Engine vibration
   - Cylinder misfire
   - Loose or defective vibration damper
   - Defective external component
   - Solutions

q. Soot in inlet manifold
   - Moderate vs. excessive soot

r. Mechanical engine knock
   - Bottom end knock
   - Failed crankshaft
   - Damaged gears
   - Failure of feedback circuit component
   - Solutions

s. Combustion knock
   - Fuel injection timing
   - Air in fuel
   - Low grade fuel
   - Out-of-balance MUIs
   - Solutions

**17. Describe and perform engine startup and break-in. 5%**

a. Use of manuals as reference
b. Cooling system filling and bleeding
c. Static timing adjustment
d. Lubrication system (prelube)
e. Turbocharger; air intake & cooling systems
f. Fuel system precautions
g. Proper startup procedures
h. Final inspection
i. Engine dynamometer run-in
   - Overall purpose
   - Gauge monitoring
   - Dynamometer operation and check

**18. Describe engine brakes fundamentals, inspection, repair and adjustment procedures; diagnose engine brake and retarder problems. 5%**

a. Overall purpose
b. Engine brake types
   - Service vs. engine brakes: overall types
     -Concept of retarder; brake fade
   - Internal engine compression brake types
     -C-Brake; Jacobs compression brakes; Macks Dynatard
   - External engine compression (exhaust) brakes

-Types, operation and components

c. Engine brake operation & components
   - Operation
   - Components
     -Hydraulic, electric & control circuits
   - Troubleshooting, testing and adjustment procedures
   - Maintenance recommendations

d. Inspection, repair and adjustment procedures
   - Testing procedures
   - Operation
   - Components
     -Hydraulic and electric circuits

e. Diagnosis of engine brake and retarder problems
   - Maintenance recommendations
   - Troubleshooting and testing procedures

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Apprenticeship Manitoba

# Heavy Duty Equipment Technician

## Unit: F3 HVAC

**Level:** Three

**Duration:** 50 hours

Theory: 10 hours

Practical: 40 hours

**Overview:**

This unit of instruction will provide the Heavy Duty Equipment Technician apprentice with the knowledge required to understand important Manitoba Ozone Protection Industry Association (MOPIA) issues, and how they relate to shop operations. The unit also provides apprentices with the working knowledge required to diagnose, service and repair problems related to all key aspects of HVAC.

| **Objectives and Content:** | **Percent of Unit Mark (%)** |
|---|---|
| **1. Describe the fundamentals of CFCs, HFCs, HCFCs and refrigerants.** | **10%** |

a. Environmental damage potential of compounds
- CFC and the ozone layer
- The Montreal Protocol / disposal methods
- CFC: refrigeration and manufacturing industries

b. Ozone depletion potential (ODP)
- Chemical makeup and stability
- ODP factors for various refrigerants
- Global warming

c. Control strategies for CFCs, HFCs, and HCFCs
- Environment Canada's role
- Code of Practice
- Responsibilities of service personnel
- Implementation dates of legislation

d. Refrigerant characteristics

e. R134A
- Tetrafluoroethane
- Boiling point, toxicity, flammability, etc.
- Lubricants for refrigerants
- Air conditioning thermodynamics

f. Other refrigerants

| | |
|---|---|
| **2. Describe health and safety issues relating to the handling of ozone depleting substances.** | **10%** |

a. Personal safety equipment used when handling compounds
- Eye, hand and face protection

b. Handling dangers: CFCs, HFCs, and HCFCs

c. Toxicity and flammability
d. Handling precautions
e. Inhalation, skin and eye contact
f. Cylinder temperature and pressures

**3. Describe the procedures required to eliminate the release of ozone depleting substances.** **10%**

a. The four "Rs" of emission reduction
   - Recovery
   - Re-use
   - Recycle
   - Reclaim

b. Equipment used to cover refrigerants
c. Recordkeeping requirements
   - Recovered refrigerant
   - Vehicle tagging
   - Cylinder inventories
   - Refrigerant transfers

d. Maintenance procedures: recovery and recharging equipment
e. Safe operating procedures: recovery and recharging equipment
   - Safety wear
   - Overpressure, overfilling

f. Identification and use of reclaim cylinders
   - Identification bands
   - Contents, recycled gas

g. Types of quick disconnects and one-way check valves

**4. Identify the legal requirements for the handling of recovered ozone depleting substances.** **5%**

a. Available refrigerant recovery and recycling equipment
b. Refrigerant storage tank types: implications of use
c. Provincial regulations: handling of recovered ozone depleting substances
d. CFC code of practice

**5. Describe leak testing procedures.** **5%**

a. Dyes
b. Electronic leak detectors
c. Bubble producing solutions
d. Nitrogen testing

**6. Describe the fundamentals of air conditioning systems.** **10%**

a. Methods of heat transfer
   - A/C thermodynamics
   - Refrigerant compressors
   - System lubrication

b. Temperature and humidity relationship
c. Solid, liquid and gas states
d. Properties of refrigerants
e. Alternative refrigerants
f. Gas laws, temperature, pressure and volume
g. Air conditioning thermo-dynamics
   - Heat absorption

- Liquid and gas states
- Temperature effects

h. Thermal expansion and contraction

i. Refrigerant waste law requirements

**7. Describe the design, function and operation of air conditioning systems. 10%**

a. Major components used in mobile air conditioning

b. Major components and control location
- Condenser
- Receiver dehydration
- Accumulator-dryer
- Evaporator
- Compressor
- Hoses, lines and fittings
- Cooling fan
- Axial recirculating
- Radial
- Variable displacement

c. Major components of A/C control systems
- Low and high pressure cutout
- Low charge protection
- Evaporator temperature control
- Cycling clutch control
- Orifice tubes
- Expansion valves
- Fan controls
- Low temperature lockout

d. Refrigerant oils

e. System operation
- Control valves
  -Low and high pressure cutout
  -Low charge protection
  -Evaporator temperature control, including expansion valves
  -Cycling clutch control
  -Orifice tube
- Condenser
- Receiver dryer (dehydrator)
- Accumulator-dryer (dehydrator)
- Evaporators
- Compressors

**8. Perform diagnostic, inspection and testing procedures on air conditioning systems. 15%**

a. Testing

b. Refrigerant identification

c. Testing for refrigerant leaks
- Dyes
- Electronic leak detectors
- Bubble producing solutions
- Nitrogen testing
- Fittings, lines & seals
- Compressors

- Evaporator
- Condenser

d. Testing system operating pressures and control functions
e. Observations during performance tests
f. Observance of government regulations for testing
g. System tests for low and high pressures using a manifold gauge set
h. Testing overall system for leaks using recommended equipment and procedures

**9. Repair air conditioning systems and components. 15%**

a. Removal and replacement
   - Compressors, evaporators, condensers and control devices

b. Compressor drive belt adjustment procedures
c. Discharging, evacuating recovery, recycling and recharging
d. Line and leakage repairs
e. Service procedures
f. Refrigeration systems service
g. Retrofitting

**10. Perform inspection, testing and diagnostic procedures on climate control systems. 10%**

a. System and component diagnosis with recommended repair
b. Control system circuit operation (using appropriate test equipment)

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Apprenticeship Manitoba

# Heavy Duty Equipment Technician

## Unit: G1 Hydraulics & Hydrostatic Drives

**Level:** Three

**Duration:** 30 hours

Theory: 13 hours

Practical: 17 hours

**Overview:**

This unit of instruction will provide the Heavy Duty Equipment Technician apprentice with a broad background in hydraulic systems and concepts. As well, this unit will provide the working knowledge required to work on hydraulics and hydrostatic drives.

| **Objectives and Content:** | **Percent of Unit Mark (%)** |
|---|---|
| **1. Describe basic hydraulic principles.** | **5%** |

a. Pascal's Law
b. Multiplication of force
c. Formulas: area, pressure, force
d. Displacement
e. Thermal expansion
f. Bermoulli's principle
g. Advantages of hydraulic systems
h. Hydrodynamics
i. Hydrostatic
j. Force
k. Energy (potential, heat, kinetic)
l. Work
m. Power
n. Torque
o. Pressure gauge
p. Absolute pressure
q. Hydraulic fluid properties
   - Viscosity
   - Friction
   - Flow rate
   - Volume
   - Velocity
   - Laminar
   - Pressure
   - Cavitation
   - Imperial/metric

- Pour point
- Lubricating ability
- Oxidation resistance
- Corrosion & rust protection
- Foaming & emulsion resistance

**2. Describe hydraulic oil and service requirements. 5%**

a. Safety precautions
   - Blocking procedures prior to removal
   - Releasing of system pressure

b. Indicators of oil contamination & other indicators re: oil change
c. Draining of oil
d. Cleaning or replacement of filtration devices
e. Appropriate selection of hydraulic oil
f. Refilling the system
g. Type and grade
h. Cleanliness; avoidance of contaminants
i. Proper oil level
j. Machinery operation re: oil
   - Flushing the system

**3. Describe hoses, fluids, fittings, tubing, filters and their installation. 5%**

a. Filters and strainers
   - Construction
     -Surface
     -Depth
     -Sizes
     -Micron rating
     -Beta ratio
   - Contamination
     -Internal and external sources
   - Ratings
     -Absolute, nominal and beta
   - Locations
     -Strainer
     -Pressure line filters
     -Return line filters

b. Filter bypass devices and restriction indicators
   - Oil viscosity
   - Filter media permeability

c. Pipes and tubes
   - Copper, aluminum, plastic and steel
   - Sizing
   - Pipe connections and fittings
   - Flared tubing connections

d. Pipe couplers
e. Quick disconnect couplers
f. Tube fittings
   - Flared
   - Compression fittings
   - Tightening procedures

g. Hoses
   - Fabric braid

- Single-wired braid
- Double-wired braid
- Spiral-wire fittings & couplers
- Sizes
- Connectors & couplers
- Adapters

h. Hose fittings
- Permanent
- Reusable
  -Installation

i. Seals
- Static and dynamic (positive & non-positive)

j. Fluids
- Viscosity, additives

k. Fluid circuits

**4. Describe basic hydraulic system components and their operation. 15%**

a. Overall purpose
b. Pumps
c. Control valves
- Directional
- Pressure release
- Pressure reducing
- Volume control valve
- Load checks
- Quick drops
- Float control valves
- Safety pressure valves

d. Actuators
- Linear
- Rotary

e. Reservoirs
- Functions
- Types
- Features

f. Accumulators
g. Cylinders
- Single & double acting
- Series telescoping

**5. Describe hydraulic pumps and their operation. 5%**

a. Overall purpose
b. Basic pump cycle
c. Pump displacement
- Non-positive displacement pumps
- Positive displacement pumps

d. Pump flow ratings
e. Pump efficiency
- Mechanical efficiency
- Volumetric efficiency

f. Pressure rating

g. Pump inlet design
   - Cavitation
   - Aeration

h. Gear type pumps
   - Overall purpose
   - External gear pumps
   - Internal gear pumps

i. Vane pumps
   - Overall purpose
   - Unbalanced vane pumps
   - Balanced vane pumps

j. Piston type pumps
   - Overall purpose
   - Radial piston pumps
   - Axial piston pumps
   - Bent-axis piston pumps

**6. Describe hydraulic motors and their operation. 5%**

a. Overall purpose and function

b. Motor ratings
   - Displacement
   - Maximum pressure rating
     -Torque generation

c. Motor types
   - Gear motors
     -External gear motors
     -Gerotor motors
   - Vane motors
   - Piston motors
     -Radial: crankshaft & cam type
     -Axial
     -Bent-axis

**7. Describe hydraulic valves and their operation. 5%**

a. Overall purpose

b. Pressure control valves
   - Direct acting
   - Pilot-operated

c. Flow control valves
   - Principles of hydraulic flow control
   - Types
     -Fixed & variable

d. Directional control valves
   - Construction
     -Poppet
     -Rotary
     -Spool directional
   - Actuation methods
     -Mechanical
     -Pilot
     -Electrical
   - Valve centre & work port condition
     -Open centre
     -Closed centre

**8. Describe hydraulic cylinders and their operation.** **5%**

a. Overall purpose
b. Single acting
c. Double acting
d. Construction

**9. Describe hydraulic accumulators and their operation.** **5%**

a. Overall purpose
   - Energy storage
   - Shock absorption
   - Pressure buildup
   - Constant pressure maintenance

b. Weighted
c. Spring loaded
d. Gas-charged
   - Piston
   - Bladder

**10. Describe hydraulic heat exchangers and their operation.** **5%**

a. Overall purpose
b. Oil heaters
c. Oil coolers
   - System efficiency
   - System duty cycles

**11. Interpret and use hydraulic symbols and diagrams.** **30%**

a. Common hydraulic symbols and diagrams
b. Interpretation of schematics and diagrams
   - Pictorial, cutaway and symbol drawings
   - Exploded views

**12. Describe the fundamentals, design and operation of hydrostatic drives; perform assembly, disassembly and maintenance.** **10%**

a. Hydrostatic drive theory
   - Beneficial properties of liquids in hydraulic systems

b. Overall purpose and advantages
   - Hydrostatic drives vs. mechanical transmissions

c. Basic components
   - Pistons and cylinder block
   - Swashplate
     -Fixed displacement
     -Variable displacement
   - Hydrostatic drive axles
   - Cam lobe motor
   - Brake
   - Destroke pump
   - Charge circuit
   - Control circuits
     -Electric & hydraulic

d. Basic operation
   - Oil flow

-Rate
-Direction
-Pressure
- Neutral
- Forward
- Reverse

e. System design, assembly and disassembly
- Fixed displacement driving variable/fixed motor
- Variable displacement driving variable/fixed motor
- Open hydrostatic system
  -Low-range operation
  -High-range operation
- Closed loop hydrostatic drive
  -Neutral operation
  -Forward operation
  -Reverse operation

f. Maintenance procedures
- Key preventative precautions
  -Excessive speed
  -Heat & pressure
  -Contamination
- Maintenance preparation items
- Troubleshooting symptoms and remedies
  -System testing procedure
- Priming and startup procedure

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Apprenticeship Manitoba

# Heavy Duty Equipment Technician

## Unit: I4 Electronic Control Management Systems and Diagnostic Tools

**Level:** Three

**Duration:** 20 hours

Theory: 6 hours

Practical: 14 hours

**Overview:**

This unit of instruction provides the Heavy Duty Equipment Technician apprentice with the working knowledge required to understand and perform engine electronic programming. The unit also provides the working knowledge for using of diagnostic tools. As well, apprentices will learn to understand, diagnose and repair electronic control management systems.

**Objectives and Content:** **Percent of Unit Mark (%)**

**1. Review the components and operation of motive power computers.** **10%**

a. Input circuits
- Digital inputs
- Analogue inputs
- 2-wire sensor systems
- 3-wire sensor systems
- Parallel or serial communications

b. Output circuits
- High & low side circuit control
- Pulse With Modulation (PWM)

c. Sensing devices
- Switches
- Thermistors
- Potentiometers
- Pressure sensors
- Permanent magnet (PM) generators
- Hall effect switches
- Optical sensors
- Knock sensors
- Oxygen sensors

d. Feedback systems
- Open vs. closed loop operation

e. Adaptive learning
- Purpose for adaptive strategies of computer systems
- Short vs. long-term memories
- Variation: counts or percentages

**2. Describe diagnostic tool fundamentals and how to use them. 20%**

a. Principles of digital computers
- Analogue and digital signals
- Digital computers
- Analogue to digital converters
- Data storage

b. Overall purpose and concept of diagnostic tools
- Test circuitry for operation and defects
- Performing output control tests
  -Solenoids on/off & PWM
  -Relays
  -Stepper motors
  -Lights
  -Trouble codes & diagnostic information retrieved
- Reading of serial data

c. Data link connectors (DLCs)
- Location and purpose

d. Diagnostic tool usage
- Monitoring of data streams
- Access to freeze frame data
- Obtaining stored Diagnostic Trouble Codes (DTCs)
- Clearance of stored DTCs
- Bi-directional functions
- “Snapshot” data recording
- Road test with scanners & data recorders

e. Datalink protocols

f. Logical approach to diagnosis
- Verify complaint
- Preliminary checks (visual, operational & other systems)
- Diagnostic systems & service bulletins check
- Wiring diagrams
- Check for DTCs
- Use of symptoms diagnostic charts
- Repair and operation check

g. Diagnostic tools
- Power and ground wiring & connectors
- Shop manuals
- Other print or electronic service information
- Digital VOM
- Scan tools
- Pressure gauges
- Injector testers
- Test connector sets (for weatherproof terminal circuits)

h. Specific tests
- Precautions w/static electricity
- Diagnostic system check
- Computer feeds & grounds (voltage drops)
- Check of inputs
- VOM & oscilloscopes to check inputs
- Scan tool snapshot functions
- Fuel injector balance & current tests
- Fuel pump output

**3. Describe electronic control management system types and functions. 20%**

a. Full authority systems
   - Full authority systems
   - Partial authority systems

b. Functions
   - Control of timing and air and fuel ratios
   - Control of emission control devices

**4. Describe electronic management system components and operation 20%**

a. Components
   - Input sensors
     -A/C
     -Brake switch
     -Barometric pressure
     -Camshaft position
     -EGR diagnostic switch & valve position sensor
     -Engine speed
     -Feedback pressure EGR sensor
     -High gear switch
     -Intake air temperature
     -Knock sensor
     -MAP & MAF sensor
     -Neutral drive and gear switch
     -Oxygen sensors
     -Power steering switch
     -System battery voltage
     -Throttle position sensor
     -Vehicle speed sensor
   - Actuator (output)
     -Air management solenoids
     -EVAP valve
     -EGR flow solenoids
     -Fuel injectors
     -Idle speed controls
     -Ignition module
     -Mixture control solenoids
     -Motors and lights
     -Other solenoids

b. Operation
   - Computer and PCM (data processor)
     -Computer logic
     -System adaptive strategy
     -Look-up tables
   - Basic purpose of control loops
   - PCM's role in diagnostics
   - Closed & open-loop mode
   - Fail safe or limp-in mode
   - Spark control systems
   - Fuel control systems
   - Emission control system (OBD II Standards)
     -Catalyst efficiency monitor
     -Engine misfire monitor
     -Fuel system monitor
     -Heated exhaust gas oxygen sensor monitor
     -Evaporative system monitor
     -Secondary air injection monitor

**5. Describe and perform diagnostic and repair procedures for electronic control management systems.** **20%**

a. Understanding system's capabilities
b. Use of knowledge, logic and system together
c. Logical diagnosis
   - Likely to most unlikely cause
   - Consideration of all factors before final conclusion
   - Non-electronic check prior to electronic control check
d. Input sensors and wiring
   - Checking of sensors/wiring first, then output devices, then computer
e. Visual inspection
f. Ground circuit check with voltage drop test
g. Ohmmeter / voltmeter / lab scope checks
h. Vehicle's service history and TSBs
i. Compression, ignition system and air/fuel system
j. Intermittent faults
k. Service bulletin information
l. Preliminary system checks
m. Malfunction indicator lamp (MIL)
   - System check if MIL on while engine running

**6. Describe ECM reprogramming.** **10%**

a. Construction and programmability of computers
   - OEM requirements re: noncompliance consequences
b. Original PROMS and knock sensor calibrators
c. Programming of reprogrammable type before use

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Apprenticeship Manitoba

# Heavy Duty Equipment Technician

## Unit: J2 Fuel Systems and Alternative Fuels

**Level:** Three

**Duration:** 20 hours

Theory: 15 hours

Practical: 5 hours

**Overview:**

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with an overall understanding of alternative fuels. As well, apprentices will acquire a working knowledge of fuel systems - including diagnosis, repair and service procedures.

| **Objectives and Content:** | **Percent of Unit Mark (%)** |
|---|---|
| **1. Describe alternative fuels.** | **10%** |

a. Fuel types
- Gasoline
- Alternate fuels (LP, natural gas)
- Safety considerations

b. Source and refining process

c. Relative heat produced by various fuels
- Gasoline vs. alternate fuels

d. Advantages and disadvantages of various fuels
- Gasoline
- Alternate fuels

e. Performance characteristics of gasoline
- Anti-knock quality and octane rating
- Volatility and its effects
- Combustion process
- Octane rating
- Chemical control of detonation

f. Gasoline additives
- Anti-icing or de-icer
- Metal deactivators and rust inhibitors
- Gum or oxidation inhibitors
- Detergents
- Ethanol
- Methanol
- Methyl tertiary butyl ether (MTBE)
- MMTs

g. Safety precautions when handling gasoline

- Danger of explosion
- Storage

h. Regulatory requirements

**2. Describe tanks, lines and related service/repair procedures. 5%**

a. Fuel tank construction
- Plated pressure steel, aluminum or molded plastic polyethylene
- Baffles
- Pick-up tubes
- Passage for fuel transfer
- Venting
- Drain (optional)
- Ridges

b. Location and arrangement
- Dual tanks

c. Pressure and vacuum filler cap
- Normal operating conditions
- Pressure or vacuum conditions
- Relief of vacuum pressure

d. Venting of fuel tanks
- Vapour separator and storage canister
- Rollover protection (valve; inertia switch)

e. Fuel re-circulating system
- In-pump
- In-line

f. Fuel tank inspection
- Fuel lines
- Fuel leaks
- Types
- Fittings
- Road damage
- Corrosion
- Rust
- Loose
- Defective seams

g. Fuel tank removal and replacement procedures

h. Fuel tank repair procedures

i. Storage precautions: prevention of fuel contamination

j. Safety precautions for fuel tanks
- Disconnection of negative battery
- Danger of heating bolts on fuel tank
- Appropriate disposal of used rags and fuel
- Leaks in steel tubing
- Fuel line fittings to torque specifications
- Proper fuel transfer system
- Static electricity precautions

k. Fuel lines
- Types
- Fittings
- Removal and installation procedures
- Repair procedures

**3. Describe fuel filters and their replacement.** **5%**

a. Overall purpose and function
b. Types
   - Cartridge
   - Canister
   - In-tank
   - Pleated paper
   - Screen
   - Stone or ceramic filter – sintered bronze
   - In-line filters
c. Primary filters
d. Secondary filters
e. Restriction indicator
f. Water indicator
g. Water separators
h. Limitation of filters
i. Location
j. Service procedures
k. Filling and bleeding procedures
l. Fuel heater and filter
   - Removal procedures
   - Design & testing
m. Installation procedures
n. Replacement precautions
   - Use of drain pan
   - Direction of flow and leaks in fuel line connections
   - Proper start of nuts threads
   - Importance of cleanliness
o. Bleeding the system

**4. Describe fuel pumps and delivery systems.** **5%**

a. Fuel tank sending units
b. Fuel charging/transfer pumps
c. Gear-type pumps
d. Hand primer pumps
e. Mechanical fuel pump
   - Intake stroke
   - Outlet stroke
   - Rest stroke (chamber full, needle valve closed)
   - Pulsation damper principle and operation
   - Check valve
   - Diaphragm & spring
   - Rocker arm & spring
   - Pulsator diaphragm
   - Pump body (valve and lower body)
f. Electrical fuel pump
   - Impeller – rotor type
   - Pulsating – bellows type
   - Diaphragm
   - Plunger

- Demand-style fuel pumps
  -Operation
  -Purpose of inertia switch

**5. Diagnose problems in fuel systems. 10%**

a. Low fuel pump pressure
b. High fuel pump pressure
c. Low fuel pump volume
d. Volume
e. Fuel pump leaks (fuel)
f. Fuel pump leaks (oil)
g. Fuel pump noise
h. Flooding
i. Choke malfunctioning
j. Hard starting
k. Loss of power
l. Poor economy
m. Poor idling & acceleration
n. Fuel line restriction or leakage
o. Clogged fuel filters
p. Defective speed control linkage
q. Low fuel pump pressure

**6. Describe procedures to test, repair and service fuel pumps. 5%**

a. Testing
   - Pressure
   - Vacuum
   - Delivery volume
b. Removal procedures
c. Disassembly of pump
d. Identification of parts
e. Reassembly procedures
   - Importance of cleanliness
f. Installation procedures
g. Priming a fuel system
h. Importance of refueling
i. Service intervals

**7. Describe carbureted fuel systems. 25%**

a. Overall purpose
b. Principles of carburetion
   - Venture effect
   - Atomization, evaporation, vaporization
c. Types of carburetors
   - Single-barrel
   - Two and four-barrel
   - Downdraft carburetor
   - Updraft carburetor
   - Side-draft carburetor
d. Carbureted fuel system components
   - Fuel tank
   - Fuel lines – metal tubing; flexible nylon; synthetic rubber hose

- Fuel pump & filter
- Carburetor

e. Carburetor circuits
- Float circuit
- Idle circuit
- Low-speed circuit
- High-speed circuit or main metering circuit
- Acceleration circuit
- Choke circuit

f. Air-fuel ratio in varying conditions
- Choke – 8:1
- Idle – 14.7:1; pre-emission control 11:1
- Cruise – 14:7:1
- Full power 13:1

**8. Describe LPG fuel system operation and components; perform related testing. 35%**

a. Safety
b. Tools and valves
c. Fuel lock
d. Converter regulators
e. Mixing device
f. Engine setup & changes
- Fuel pump output

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