



## COURSE OUTLINE: TCT812 - ENGINE SYSTEMS

Prepared: Sylvain Belanger

Approved: Corey Meunier, Chair, Technology and Skilled Trades

<b>Course Code: Title</b>	TCT812: ENGINE SYSTEMS
<b>Program Number: Name</b>	6082: T/C TECHN-LEVEL III
<b>Department:</b>	MOTIVE POWER APPRENTICESHIP
<b>Semesters/Terms:</b>	20F
<b>Course Description:</b>	Upon successful completion the apprentice is able to understand the principles of operation, diagnose and repair heavy duty, diesel engine intake systems, exhaust systems, turbochargers, heavy duty cooling systems, and diesel engine brakes and retarders, is able to describe the operating principles of heavy duty lubricating systems and oils, and repair typical lubricating circuit problems, is able to understand the principles of failure analysis and implement them on failed diesel engine components, is able to understand the principles and practices of sequential troubleshooting strategies and symptom based diagnostic routines on heavy duty diesel engines, and is able to describe how to break-in a new or rebuilt diesel engine and interpret dynamometer test results on diesel engines.
<b>Total Credits:</b>	5
<b>Hours/Week:</b>	0
<b>Total Hours:</b>	40
<b>Prerequisites:</b>	There are no pre-requisites for this course.
<b>Corequisites:</b>	There are no co-requisites for this course.
<b>Essential Employability Skills (EES) addressed in this course:</b>	EES 2 Respond to written, spoken, or visual messages in a manner that ensures effective communication. EES 3 Execute mathematical operations accurately. EES 4 Apply a systematic approach to solve problems. EES 5 Use a variety of thinking skills to anticipate and solve problems. EES 6 Locate, select, organize, and document information using appropriate technology and information systems. EES 7 Analyze, evaluate, and apply relevant information from a variety of sources. EES 10 Manage the use of time and other resources to complete projects.
<b>General Education Themes:</b>	Science and Technology
<b>Course Evaluation:</b>	Passing Grade: 50%, D  A minimum program GPA of 2.0 or higher where program specific standards exist is required for graduation.
<b>Other Course Evaluation &amp; Assessment Requirements:</b>	Theory testing 60% Practical application testing 40% Grade

In response to public health requirements pertaining to the COVID19 pandemic, course delivery and assessment traditionally delivered in-class, may occur remotely either in whole or in part in the 2020-2021 academic year.



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Definition Grade Point Equivalent

A+ 90 - 100% 4.00

A 80 - 89%

B 70 - 79% 3.00

C 60 - 69% 2.00

D 50 - 59% 1.00

F (Fail) 49% and below 0.00

CR (Credit) Credit for diploma requirements has been awarded.

S Satisfactory achievement in field /clinical placement or non-graded subject area.

U Unsatisfactory achievement in field/clinical placement or non-graded subject area.

X A temporary grade limited to situations with extenuating circumstances giving a student additional time to complete the requirements for a course.

NR Grade not reported to Registrar's office.

W Student has withdrawn from the course without academic penalty.

**Books and Required Resources:**

medium/heavy duty truck engines, fuels and computerized management systems by Sean Bennett

Publisher: cengage Edition: 6th

**Course Outcomes and Learning Objectives:**

Course Outcome 1	Learning Objectives for Course Outcome 1
Upon successful completion, the apprentice is able to understand the principles of operation, diagnose and repair heavy duty, diesel engine intake systems.	<p>Explain the purpose and fundamentals of heavy-duty intake systems.</p> <ul style="list-style-type: none"><li>- diesel engine theory</li><li>- thermodynamics</li><li>- volumetric efficiency</li><li>- air charge temperature</li><li>- manifold boost</li><li>- heat exchanger</li><li>- positive filtration principle</li></ul> <p>Identify the functions, construction, types, styles and application of heavy-duty intake systems.</p> <ul style="list-style-type: none"><li>- pre-cleaners</li><li>- positive dry air cleaners</li><li>- intake manifold design</li><li>- valve configuration</li><li>- inlet restriction sensor</li><li>- mass airflow sensor</li><li>- charge air coolers</li><li>- exhaust gas recirculation (EGR)</li><li>- venture / pressure differential</li><li>- intake manifold temperature sensor</li><li>- intake air heaters</li></ul> <p>Describe the principle(s) of operation of heavy-duty intake systems.</p> <ul style="list-style-type: none"><li>- positive principle dry air filters</li><li>- cyclonic precleaners</li><li>- volumetric efficiency</li></ul>

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		<ul style="list-style-type: none"> <li>- lean burn technology</li> <li>- engine breathing</li> <li>- thermal efficiency</li> <li>- gas dynamics</li> <li>- intake Air Heaters</li> </ul> <p>Perform inspection, testing and diagnostic procedures on diesel intake systems.</p> <ul style="list-style-type: none"> <li>- air induction inlet restriction test</li> <li>- outline methods of tracing boost side and charge air cooler leakage</li> <li>- analyze filter element conditions</li> <li>- outline requirements for servicing air filters</li> <li>- charge air cooler restrictions / leaks</li> </ul> <p>Recommend reconditioning or repairs following manufacturers' procedures on diesel intake systems.</p> <ul style="list-style-type: none"> <li>- verify the readings of an in-dash, inlet restriction gauge with a water manometer</li> <li>- outline method of locating manifold boost leakage</li> <li>- outline method of replacing charge air coolers</li> <li>- outline OEM method for determining air filter serviceability</li> </ul>
	<b>Course Outcome 2</b>	<b>Learning Objectives for Course Outcome 2</b>
	<p>Upon successful completion, the apprentice is able to understand the principles of operation, diagnose and repair heavy duty, diesel engine exhaust systems.</p>	<p>Explain the purpose and fundamentals of heavy duty exhaust systems.</p> <ul style="list-style-type: none"> <li>- engine theory</li> <li>- thermodynamics</li> <li>- volumetric efficiency</li> <li>- air charge temperature</li> <li>- manifold boost</li> <li>- heat exchanger</li> <li>- air charge density</li> <li>- exhaust backpressure factors</li> </ul> <p>Identify the functions, construction, composition, types, styles and application of heavy duty exhaust systems.</p> <ul style="list-style-type: none"> <li>- exhaust manifold</li> <li>- exhaust piping</li> <li>- pyrometers</li> <li>- engine silencers</li> <li>- catalytic converters</li> <li>- exhaust stacks</li> <li>- rain caps</li> <li>- particulate traps</li> <li>- diesel particulate filters</li> <li>- aqueous urea</li> <li>- dosing injectors</li> </ul> <p>Describe the principle(s) of operation of heavy duty exhaust</p>

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		<p>systems.</p> <ul style="list-style-type: none"> <li>- exhaust gas dynamics</li> <li>- sound analysis energy and noise suppression</li> <li>- sound absorption principles</li> <li>- resonator principles</li> <li>- particulate traps</li> <li>- diesel particulate filters</li> <li>- oxidation catalytic converters</li> <li>- exhaust gas chemical characteristics</li> <li>- dosing requirements of reduction catalysts</li> </ul> <p>Perform inspection, testing and diagnostic procedures on diesel engine exhaust systems.</p> <ul style="list-style-type: none"> <li>- test exhaust gas backpressure</li> <li>- outline procedure for analyzing exhaust gas chemistry</li> <li>- demonstrate opacity meter smoke analysis</li> </ul> <p>Recommend reconditioning or repairs following manufacturers' procedures on diesel engine exhaust systems.</p> <ul style="list-style-type: none"> <li>- outline procedure for replacing engine silencers</li> <li>- outline procedure for replacing exhaust piping</li> <li>- outline procedure for replacing a pyrometer</li> <li>- outline procedure for replacing a catalytic converter</li> </ul>
	<p><b>Course Outcome 3</b></p> <p>Upon successful completion, the apprentice is able to understand the principles of operation, diagnose and repair turbochargers.</p>	<p><b>Learning Objectives for Course Outcome 3</b></p> <p>Explain the purpose and fundamentals of turbocharging.</p> <ul style="list-style-type: none"> <li>- turbine theory</li> <li>- thermodynamics</li> <li>- volumetric efficiency</li> <li>- air charge temperature</li> <li>- manifold boost</li> <li>- heat exchanger</li> <li>- air charge density</li> </ul> <p>Identify the functions, construction, composition, types, styles and application of turbocharging.</p> <ul style="list-style-type: none"> <li>- pulse air manifolds</li> <li>- turbine housing</li> <li>- divided chamber</li> <li>- ceramic turbine wheels</li> <li>- high alloy steel turbine wheels</li> <li>- volute</li> <li>- constant geometry</li> <li>- variable geometry</li> <li>- waste gate</li> <li>- variable volute</li> <li>- variable nozzle</li> <li>- methods of control</li> <li>- compressor housing</li> </ul>

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- impellers
- volute
- compounding
- viscous coupling
- gear train
- series turbocharging
- primary
- secondary
- parallel turbocharging
- exhaust pressure governor (EPG)
- discharge recirculation valve

Describe the principle(s) of operation of turbochargers.

- tuned exhaust manifolds
- pulse exhaust manifolds
- 4-stroke cycle boost requirements
- turbine theory
- hydrodynamic suspension
- turbocharger lubrication and cooling
- constant geometry turbocharger principles
- variable geometry turbocharger principles
- compound
- series
- turbocharger efficiency and torque rise

Perform inspection, testing and diagnostic procedures on turbochargers.

- test manifold boost pressure
- test manifold boost temperature
- check for manifold boost leaks
- measure exhaust gas temperature
- visually inspect a turbocharger
- test axial and radial run-out
- verify wastegate operation

Recommend reconditioning or repairs following manufacturers' procedures on turbochargers.

- outline procedure for replacing a turbocharger
- outline procedure for replacing a boost sensor
- outline procedure for recoring a turbocharger
- outline procedure for reconditioning and balancing a turbocharger
- outline procedure for replacing a defective wastegate assembly

#### Course Outcome 4

Upon successful completion, the apprentice is able to understand the principles of operation,

#### Learning Objectives for Course Outcome 4

Explain the purpose and fundamentals of heavy duty cooling systems and components.

- thermodynamics
- heat rejection and transfer

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diagnose and repair heavy duty cooling systems.

Identify the functions, construction, composition, types, styles and application of heavy duty cooling systems and coolants.

- heavy-duty radiators
- down flow
- cross flow
- up flow
- double pass
- expansion tanks
- conventional
- multi chamber
- controlled fans
- variable pitch
- thermatic
- electronic
- heat exchangers
- air to air
- intercooler
- tip turbine
- coolants
- properties coolant mixture characteristics
- EG (ethylene glycol)
- PG (propylene glycol)
- ELC (extended life coolant)
- coolant filters
- coolant pumps
- high capacity coach engine coolant pumps
- centrifugal
- thermostats
- actively pressurized cooling systems
- coolant temperature sensor
- radiator coolant level switches
- EPA requirements

Describe the principle(s) of operation of heavy duty cooling systems and coolants.

- heavy-duty radiators
- down flow
- cross flow
- up flow
- double pass
- controlled fans
- fan drives
- fan clutches
- coach oil driven fan hubs
- heat exchangers
- air to air
- intercooler
- actively pressurized cooling systems
- coolant properties
- coolant mixture characteristics
- coefficient of heat transfer

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- coolant filters
- chemical balance
- analysis coolant
- analysis SCAs
- coolant pumps
- thermostat
- liner cavitation
- properties of coolants
- properties of water
- properties of anti-freeze
- coolant mixture characteristics
- coefficient of heat transfer
- analyzing coolants
- cooling system electrolysis
- chemistry of:
  - EG
  - PG
  - ELC
- coolant test instruments
- refractometer
- hydrometer
- pH analysis
- electrical conductivity
- chemical balance

Perform inspection, testing and diagnostic procedures on diesel engine cooling systems and coolants.

- heat exchangers and cooler performance efficiency
- temperature controlled fans operating cycles
- perform coolant and SCA analysis
- test operations of thermostat
- pressure test radiator
- perform visual and pressure tests on hoses
- radiator cap testing
- coolant analysis
- pH levels of coolant
- coolant strengths and condition
- test coolant SCA level
- test coolant TDS level
- outline procedure for mixing anti-freeze and water to engine cooling requirements
- outline procedure for adding premix
- outline procedure for ELC recharge

Recommend reconditioning or repairs following manufacturers' procedures on diesel engine cooling systems.

- diagnose coolant related overheating
- coolant filters
- service and service intervals
- flushing cooling systems procedure

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		<ul style="list-style-type: none"> <li>- oil contamination</li> <li>- coolant</li> <li>- additive packages</li> <li>- service intervals</li> <li>- cooling system failure analysis</li> <li>- liner cavitation failure</li> <li>- premix requirements</li> <li>- refortifying ELCs</li> </ul>
	<b>Course Outcome 5</b>	<b>Learning Objectives for Course Outcome 5</b>
	<p>Upon successful completion, the apprentice is able to describe the operating principles of heavy duty lubricating systems and oils and repair typical lubricating circuit problems.</p>	<p>Explain the purpose and fundamentals of heavy duty lubricating systems.</p> <ul style="list-style-type: none"> <li>- diesel engine fundamentals</li> <li>- heavy duty lubricating oils, synthetic oils</li> <li>- significance of selecting correct lubricating oils for engine service</li> <li>- service ratings</li> <li>- Society of Automotive Engineers (SAE) viscosity ratings</li> <li>- American Petroleum Institute (API) grades</li> </ul> <p>Identify the functions, construction, composition, types, styles and application of heavy duty lubricating systems.</p> <ul style="list-style-type: none"> <li>- significance of selecting correct lubricating oils for engine service</li> <li>- service ratings</li> <li>- Society of Automotive Engineers viscosity ratings</li> <li>- American Petroleum Institute grades</li> <li>- OEM requirements of engine lubricants</li> <li>- lubricating circuits</li> <li>- bypass valve</li> <li>- relief valve</li> <li>- filter types</li> <li>- bypass</li> <li>- full flow</li> <li>- centrifugal</li> <li>- oil pumps</li> <li>- heat exchangers</li> <li>- bundle type</li> <li>- plate type</li> <li>- temperature management</li> <li>- mechanical</li> <li>- electronic</li> </ul> <p>Describe the principle(s) of operation of heavy duty lubricating systems.</p> <ul style="list-style-type: none"> <li>- lubricating circuits</li> <li>- bypass valve</li> <li>- relief valve</li> <li>- filter types</li> <li>- bypass</li> <li>- full flow</li> <li>- centrifugal</li> </ul>

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		<ul style="list-style-type: none"> <li>- oil pumps</li> <li>- heat exchangers</li> <li>- oil cooler</li> <li>- bearings</li> <li>- hydrodynamic suspension</li> <li>- lubricant as coolant</li> <li>- temperature management apparatus</li> </ul> <p>Perform inspection, testing and diagnostic procedures on diesel engine lubrication systems.</p> <ul style="list-style-type: none"> <li>- demonstrate bearing leakdown test</li> <li>- demonstrate oil pressure tests</li> <li>- demonstrate oil cooler test</li> <li>- vacuum test bundle</li> <li>- pressure test bundle</li> <li>- oil condition</li> <li>- contaminants</li> </ul> <p>Recommend reconditioning or repairs following manufacturers' procedures on diesel engine lubrication systems.</p> <ul style="list-style-type: none"> <li>- oil analysis</li> <li>- priming oil pump and lubrication circuit</li> <li>- outline start-up and engine run-in procedure</li> </ul>
	<b>Course Outcome 6</b>	<b>Learning Objectives for Course Outcome 6</b>
	<p>Upon successful completion, the apprentice is able to understand the principles of operation, diagnose and repair diesel engine brakes and retarders</p>	<p>Explain the function, types and application of internal and external engine brakes.</p> <ul style="list-style-type: none"> <li>- retarder principles</li> <li>- cylinder breathing</li> <li>- vehicle braking dynamics</li> <li>- power absorption equations</li> </ul> <p>Identify the principles of operation of internal and external engine brakes and hydraulic retarders.</p> <ul style="list-style-type: none"> <li>- internal compression brakes</li> <li>- cycle management</li> <li>- switching devices</li> <li>- external compression brakes</li> <li>- hydraulic retarders</li> </ul> <p>Describe, test, diagnose and adjust internal and external engine brakes.</p> <ul style="list-style-type: none"> <li>- mean effective pressure</li> <li>- power absorption</li> <li>- internal compression brakes</li> <li>- exhaust choke brakes</li> <li>- double cycle braking</li> <li>- flywheel hydraulic retarders</li> </ul> <p>Perform internal and external engine brake removal,</p>

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	<p>installation, and adjustments.</p> <ul style="list-style-type: none"> <li>- outline installation and removal procedure</li> <li>- overhead adjustments</li> <li>- programming brake cycles</li> <li>- brake generated camshaft failures</li> </ul>
<b>Course Outcome 7</b>	<b>Learning Objectives for Course Outcome 7</b>
<p>Upon successful completion, the apprentice is able to understand the principles of failure analysis and implement them on failed diesel engine components.</p>	<p>Explain the purpose and fundamentals of diesel engine component failure analysis.</p> <ul style="list-style-type: none"> <li>- engine theory</li> <li>- thermodynamics</li> <li>- lubrication circuits</li> <li>- cooling systems</li> <li>- temperature and stress related failures</li> </ul> <p>Identify the functions, construction, composition, types, styles and application of diesel engine component failure analysis.</p> <ul style="list-style-type: none"> <li>- catastrophic failures</li> <li>- stress failures</li> <li>- high temperature failures</li> <li>- torsional failures</li> <li>- compressional failures</li> <li>- tensile failures</li> </ul> <p>Describe the principle(s) of operation of diesel engine component failure analysis.</p> <ul style="list-style-type: none"> <li>- catastrophic failures</li> <li>- stress failures</li> <li>- high temperature failure</li> <li>- compressional failures</li> <li>- tensile failures</li> <li>- diagnosing operator related failures</li> <li>- diagnosing technician related failures</li> <li>- diagnosing manufacturing/material related failures</li> </ul> <p>Perform inspection, testing and diagnostic procedures on diesel engine failed components.</p> <ul style="list-style-type: none"> <li>- analyze major component failures</li> <li>- outline procedure for determining cause of a catastrophic failure</li> <li>- analyze sub-component failures</li> <li>- match failed components to cause</li> <li>- use OEM photography to determine sub-component serviceability</li> </ul> <p>Recommend reconditioning or repairs following manufacturers' procedures on diesel engine failed components.</p> <ul style="list-style-type: none"> <li>- determine serviceability of failed components</li> <li>- review the criteria to determine whether components should be reconditioned</li> </ul>

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	<p>or replaced</p> <ul style="list-style-type: none"> <li>- tracking of coincidental patterns</li> <li>- analyses of OEM warranty practices</li> </ul>
<b>Course Outcome 8</b>	<b>Learning Objectives for Course Outcome 8</b>
<p>Upon successful completion, the apprentice is able to understand the principles and practices of sequential troubleshooting strategies and symptom based diagnostic routines on heavy duty diesel engines.</p>	<p>Explain the purpose and fundamentals of diesel engine diagnostic procedure and practices.</p> <ul style="list-style-type: none"> <li>- engine theory</li> <li>- electricity</li> <li>- electronics</li> <li>- computers</li> <li>- sequential fault flow chart</li> <li>- electronic schematics</li> <li>- test instrumentation</li> <li>- electronic service tools (EST)</li> </ul> <p>Identify the principle(s) of diesel engine diagnostic procedure and practices.</p> <ul style="list-style-type: none"> <li>- troubleshooting hydro mechanically governed engines</li> <li>- troubleshooting electronically managed engines</li> <li>- distinguishing hydro mechanical and electronic malfunctions on these engines</li> <li>- sequential troubleshooting procedures</li> <li>- EST snapshot testing</li> <li>- EST performance test</li> <li>- engine dynamometer</li> <li>- chassis dynamometer</li> <li>- road test procedures</li> </ul> <p>Describe the principles of symptom based engine diagnosis.</p> <ul style="list-style-type: none"> <li>- low power complaints</li> <li>- engine vibration</li> <li>- misfire complaint</li> <li>- low oil pressure</li> <li>- engine oil consumption</li> <li>- high crankcase pressure</li> <li>- component failures</li> <li>- pistons</li> <li>- turbochargers</li> <li>- engine bearings</li> <li>- crankshafts</li> <li>- engine overheating</li> <li>- hard starting problems</li> <li>- exhaust smoke analysis</li> <li>- black smoke</li> <li>- blue smoke</li> <li>- white smoke</li> </ul> <p>Perform inspection, testing and diagnostic procedures on diesel engines.</p>

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	<p>Outline/perform:</p> <ul style="list-style-type: none"> <li>- troubleshooting hydro mechanically governed engines</li> <li>- troubleshooting electronically managed engines</li> <li>- distinguishing hydro mechanical and electronic malfunctions on these engines</li> <li>- cylinder leakage</li> <li>- cylinder balance</li> <li>- compression testing</li> <li>- sequential troubleshooting procedures</li> <li>- software driven sequential troubleshooting</li> <li>- EST snapshot testing</li> <li>- EST performance test</li> <li>- engine dynamometer</li> <li>- chassis dynamometer</li> <li>- road test procedures</li> </ul>
<b>Course Outcome 9</b>	<b>Learning Objectives for Course Outcome 9</b>
Upon successful completion, the apprentice is able to describe how to break-in a new or rebuilt diesel engine and interpret dynamometer test result on diesel engines.	<p>Identify the functions, construction, composition, types, styles and application of diesel engine run-in and testing.</p> <ul style="list-style-type: none"> <li>- monitoring instrumentation</li> <li>- engine and chassis onboard diagnostics</li> <li>- chassis dynamometer</li> <li>- engine dynamometer</li> <li>- road test</li> <li>- microprocessor base test instrumentation</li> <li>- SAE J1939 protocols</li> </ul> <p>Explain the principle(s) of diesel engine run-in and testing</p> <ul style="list-style-type: none"> <li>- brake power calculations</li> <li>- electromotive dynamometers</li> <li>- hydro mechanical dynamometers</li> <li>- microprocessor based test instrumentation</li> </ul> <p>analyzing performance graphs</p> <p>Describe inspection, testing and diagnostic procedures on diesel engines.</p> <ul style="list-style-type: none"> <li>- outline procedure for mounting diesel engines to an engine dynamometer test bed</li> <li>- outline procedure for mounting trucks and coaches to a chassis dynamometer test bed</li> <li>- review dynamometer safety procedures</li> <li>- outline procedure for run-in testing of diesel engines</li> <li>- outline procedure for diagnostic testing of diesel engines</li> <li>- analyze download dynamometer test data</li> </ul>

**Evaluation Process and Grading System:**

Evaluation Type	Evaluation Weight
practical application testing	40%

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	theory testing	60%
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**Date:** September 2, 2020

**Addendum:** Please refer to the course outline addendum on the Learning Management System for further information.

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