Skilled Trades Ontario | Métiers spécialisés Ontario

Apprenticeship Curriculum Standard

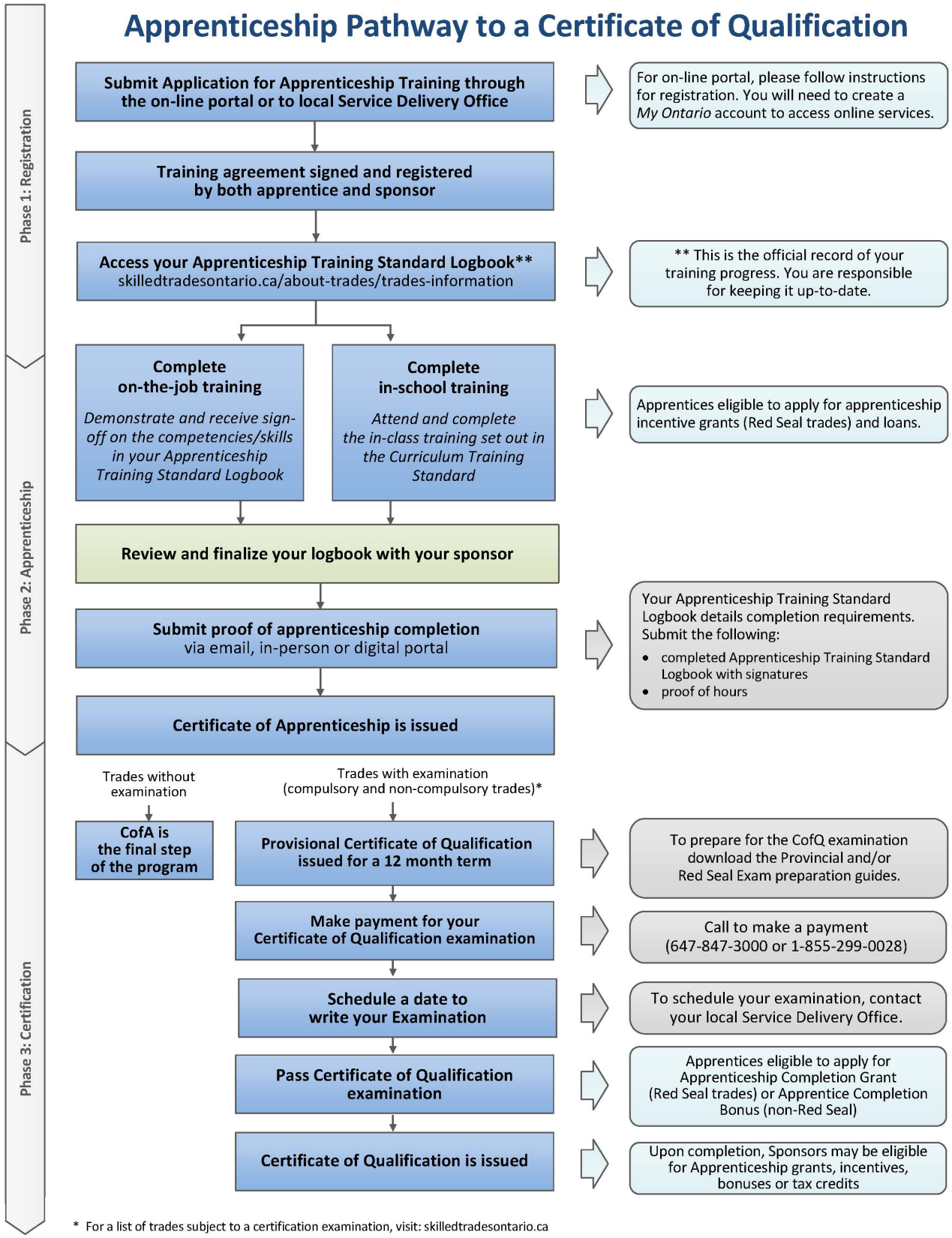
Small Engine Technician, Marine Engine Technician & Turf Equipment Technician

Level 2

435A, 435B & 421C

2014

Apprenticeship Pathway to a Certificate of Qualification



* For a list of trades subject to a certification examination, visit: skilledtradesontario.ca

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Please Note: This Standard has been revised to reflect the visual identity of Skilled Trades Ontario (STO) which replaced the Ontario College of Trades on January 1, 2022. The content of this Standard may refer to the former organization; however, all trade specific information or content remains relevant and accurate based on the original date of publishing.

Please refer to STO's website: **skilledtradesontario.ca** for the most accurate and up to date information. For information about BOSTA and its regulations, please visit ***Building Opportunities in the Skilled Trades Act, 2021* (BOSTA).**

Any updates to this publication are available on-line; to download this document in PDF format, please follow the link: Skilled Trades Ontario.ca.

Maintained with transfer to Skilled Trades Ontario 2014 (V100)

Preface

This curriculum standard for the Small Engine Technician, Marine Engine Technician & Turf Equipment Technician trade programs is based upon the on-the-job performance objectives, located in the industry-approved training standard.

The curriculum is organized into 3 levels of training. The Reportable Subjects Summary chart (located on page 4) summarizes the training hours for each reportable subject.

The curriculum identifies the learning that takes place in-school. The in-school program focuses primarily on the theoretical knowledge and the essential skills required to support the performance objectives of the Apprenticeship Training Standards.

Employers/Sponsors are expected to extend the apprentice's knowledge and skills through practical training on a work site. Regular evaluations of the apprentice's knowledge and skills are conducted throughout training to verify that all apprentices have achieved the learning outcomes identified in the curriculum standard.

It is not the intent of the in-school curriculum to perfect on-the-job skills. The practical portion of the in-school program is used to reinforce theoretical knowledge. Skill training is provided on the job.

Please refer to Skilled Trades Ontario website (www.skilledtradesontario.ca) for the most accurate and up-to-date information about Skilled Trades Ontario. For information on *Building Opportunities in the Skilled Trades Act, 2021 (BOSTA)*) and its regulations, please visit Building Opportunities in the Skilled Trades Act, 2021, S.O. 2021, c. 28 - Bill 288 (ontario.ca)

Pre-requisites
In order to advance to Level 2 of the apprenticeship program, an individual must have completed all of the units outlined in Level 1. Similarly, in order to advance to Level 3 of the program, an individual must have completed all of the units outlined in Level 1 and 2.

Hours Disclaimer (if applicable)
It is agreed that Training Delivery Agents (TDAs) may need to make slight adjustments (with cause) according to particular apprentice needs and may deviate from the unit sequencing and the prescribed practical and theoretical hours shown within the standard. However, all TDAs will comply with the hours at the reportable subject level.

Suggested Equipment for Training Delivery Agencies
Personal and Safety Equipment: Personal protective equipment is at the discretion of the TDA who must conform to Ontario Provincial Health and Safety Regulations.

Introduction

This curriculum standard for the Small Engine Technician & Marine Engine Technician trades is designed down from the learning outcomes, which were in turn developed from the industry-approved apprenticeship training standard.

The curriculum is organized into three levels of training, each including reportable subjects containing like or similar learning outcomes to reflect the units of the training standard. The hours charts indicates how the curriculum can be delivered in the current block release format and summarizes the hours of training for each reportable by level.

The reportable subjects are cross referenced to the training standard for ease of comparison.

Each reportable subject and learning outcome identifies a recommended number of training hours. This hour allotment is broken into hours for instruction in theory and practical application. The division of the curriculum into reportable subjects that follow a natural progression of learning through the levels and branches of training will allow training centres and apprentices, flexibility in program delivery while still observing the importance of sequencing learning in a logical progression.

The curriculum is framed by and includes specific references to performance objectives in the Apprenticeship Training Standards for Small Engine Technician and Marine Engine Technician. However, it identifies only the learning that takes place off the job, in a training centre. The in-school program focuses primarily on the theoretical knowledge required to master the performance objectives of the Training Standards. Employers are expected to extend the apprentice's knowledge and skills through appropriate practical training on the work site. Regular evaluations of the apprentice's knowledge and skills is conducted throughout training to assure that all apprentices have achieved the learning outcomes identified in the curriculum standard. The balance between theoretical and practical evaluation is identified for each unit of learning outcomes.

Level 2

Program Summary of Reportable Subjects

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practical
S1437	Work Practices and Procedures	36	15	21
S1438	Electrical and Electronic Systems	45	23	22
S1439	Engine Fuel Management Systems	45	28	17
S1440	Engine Systems	24	11	13
S1441	Steering, Suspension and Brake Systems	42	24	18
S1442	Transmission and Auxiliary Drive Systems	48	30	18
	Total	**240**	**131**	**109**

Number:	S1437		
Title:	**Work Practices and Procedures**		
Duration:	Total Hours: 36	Theory: 15	Practical: 21
Prerequisites:	Level I, Reportable Subjects		
Content:	1.1 Unit Assembly, Accessories and Pre-Delivery Inspection (4/2)		
	1.2 Compressed Air Supply and Pneumatic Tools (3/2)		
	1.3 Welding and Materials (8/16)		

Evaluation & Testing

Minimum of one mid-term test during the 8 week term
Final exam at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Assignments related to theory and appropriate application skills

Reference Materials:
Workplace Safety and Insurance Act, 1997
Occupational Health and Safety Act, 1990
Employment Standards Act, 2000
Labour Relations Act, 1995
Employment Insurance Act, 1996
Ontario College of Trades and Apprenticeship Act, 2009
Apprenticeship and Certification Act, 1998
Canadian Standards Association (CSA)
Workplace Hazardous Materials Information System (WHMIS)
Canadian Coast Guard

Recommended Equipment List:
Approved storage and disposal containers
WHMIS materials
Approved fire extinguishers
Metal inert gas (MIG) welding equipment
Tungsten inert gas (TIG) welding equipment
Appropriate welding supplies
Appropriate hand and power tools
Appropriate lifting, rigging and blocking equipment
Compressed air supply equipment

Number:	S1437.1		
Title:	**Unit Assembly, Accessories and Pre-Delivery Inspection**		
Duration:	Total Hours: 6	Theory: 4	Practical: 2
Prerequisites:	None		
Cross Reference to Training Standard: 6402.01 to 6402.06; 6383.01 to 6383.06, 6394.01, 6394.02			

General Learning Outcomes

Upon successful completion, the apprentice is able to describe and perform unit assembly, accessories and pre-delivery inspection procedures in accordance with government safety regulations, equipment manufacturers' recommendations and approved industry standards.

Learning Outcomes and Content

1.1.1 Identify the types and applications of powered equipment and unit vehicles. (1/1)

Identify type and application

Identify the model, serial numbers, and Vehicle Identification Number (VIN)

Identify original equipment manufacturer (OEM) components

Identify original equipment manufacturer (OEM) service literature

1.1.2 Follow procedures for assembly and pre-delivery inspection of powered equipment, Unit vehicles, and accessories. (3/1)

Identify various types of inspection check charts and rigging/assembly manuals

Clean and visually inspect unit:
- structural integrity
- loose, missing or damaged components

Plan installation of requested accessories

Perform required assembly and rigging procedures according to manufacturers' specifications:

- install required attachments
- install accessories

Complete pre-delivery inspection as per checklist

Verify operation of machinery and accessories

Test performance of machinery as per manufacturers' specifications

Number:	S1437.2		
Title:	**Compressed Air Supply and Pneumatic Tools**		
Duration:	Total Hours: 6	Theory: 3	Practical: 3
Prerequisites:	None		
Cross Reference to Training Standard: 6410.01 to 6410.04; 6382.01 to 6382.04			

General Learning Outcomes

Upon successful completion, the apprentice is able to describe the use and application of compressed air supply and pneumatic tool procedures in accordance with government safety regulations, equipment manufacturers' recommendations and approved industry standards.

Learning Outcomes and Content

1.2.1 Define the fundamentals of compressed air supply systems used in repair shops. (1/0)

Types of compressors

Lines, hoses, and fittings

Water separation, filter and drying systems

Automatic oilers

Regulators

1.2.2 Maintain compressed air supply systems used in repair shops. (1/1)

Daily maintenance

Weekly maintenance

Yearly maintenance

1.2.3 Define the construction features and application of pneumatic tools, systems and components. (1/0)

Blowers

Tire chucks

Ratchets

Impact guns

Air chisels

Die grinders

Cut-off tools

1.2.4 Use and maintain pneumatic tools, systems and components. (0/1)

Blowers

Tire chucks

Ratchets

Impact guns

Air chisels

Die grinders

Number:	S1437.3		
Title:	**Welding and Materials**		
Duration:	Total Hours: 24	Theory: 8	Practical: 16
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6401.08 to 6401.13; 6381.07 to 6381.13			

General Learning Outcomes

Upon successful completion, the apprentice is able to identify types of metals, perform plasma cutting and Metal Inert GAS (MIG), and define and describe Tungsten Inert Gas (TIG) welding procedures in accordance with government safety regulations, equipment manufacturers' recommendations and approved industry standards.

Learning Outcomes and Content

1.3.1 Define the fundamentals, set up and safety procedures for plasma cutting equipment and TIG and MIG welding equipment. (4/0)

Metallurgy:
- heat treating of metals
- intro to corrosion
- galvanic table
- types of metals
- crack detection

1.3.2 Describe the function, construction features and safe operation of plasma cutting and TIG and MIG welding equipment. (4/0)

DC power source:
- rectifier
- inverter
- generator

Shielding inert gas

Torch assembly

Electrodes

Water cooling supply

Plasma Cutting

MIG welding:
- transformers, cables and wires

- travel speeds
- welding angles
- gas flow rates

TIG welding:
- transformers
- gun angle and travel speeds
- gas flow rates
- power source characteristics
- metal preparation
- edges and surfaces

1.3.3 Perform plasma cutting and MIG welding procedures and demonstrate TIG welding procedures. (0/16)

Plasma Cutting

MIG welding:
- metal edge and surface preparation
- lap and tee joint welds

TIG welding:
- metal edge and surface preparation
- lap and tee joint welds

Safety precautions:
- pressure settings
- eye protection, helmet and face shields
- gloves, boots, leather aprons, protective screens
- fire extinguisher availability
- set up and shut down sequence

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
35%	35%	30%

Number:	S1438		
Title:	**Electrical and Electronic Systems**		
Duration:	Total Hours: 45	Theory: 23	Practical: 22
Prerequisites:	Level I, Reportable Subjects		
Content:	2.1 Electrical and Electronic System Fundamentals and Applications (23/22)		

Evaluation & Testing:

Minimum of one mid-term test during the 8 week term
Final exam at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Assignments related to theory and appropriate application skills

Reference Materials:
Workplace Safety and Insurance Act, 1997
Occupational Health and Safety Act, 1990
Employment Standards Act, 2000
Labour Relations Act, 1995
Employment Insurance Act, 1996
Ontario College of Trades and Apprenticeship Act, 2009
Apprenticeship and Certification Act, 1998
Canadian Standards Association (CSA)
Workplace Hazardous Materials Information System (WHMIS)
Canadian Coast Guard

Recommended Equipment List:
Approved storage and disposal containers
WHMIS materials
Approved fire extinguishers
Appropriate lifting, rigging and blocking equipment Appropriate equipment and unit vehicles
Appropriate hand and power tools
Digital volt ohmmeters/multi-meters
Battery load testers
Ignition spark testers
Module testers
Service information systems
Soldering equipment
Compressed air supply equipment

Number:	S1438.1		
Title:	**Electrical and Electronic System Fundamentals and Applications**		
Duration:	Total Hours: 45	Theory: 23	Practical: 22
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6403.01 to 6403.15; 6384.01 to 6384.15			

General Learning Outcomes

Upon successful completion, the apprentice is able to test and service electrical and electronic systems and components in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

2.1.1 Describe the construction features and principles of operation of charging systems. (10/0)

Lighting coils and assemblies

Magneto charging systems:
- half wave
- full wave
- bridge rectifier

Battery charging systems:
- AC/DC generators
- rotors
- stator
- field windings
- voltage regulators
- rectifiers
- permanent magnet rotor alternator
- excited field alternator

2.1.2 Identify, test and diagnose charging systems. (0/9)

Magneto charging systems:
- non-rectified
- half wave
- full wave
- bridge rectifier

Battery charging system components

2.1.3 Describe the construction features and principles of operation of electrical starting systems. (6/0)

Starter motors:
- parallel wound, series wound
- permanent magnet
- brushes

Relays

Starter switch

Starter solenoid:
- pull-in windings
- hold-in windings

Starter drives:
- Bendix
- sprag and roller type one-way clutch
- gear reduction

2.1.4 Identify, test and diagnose electrical starting systems and components. (0/6)

Perform starter system inspection and tests:
- starter load test (current)
- voltage drop test
- relay inspection
- starter cut-out relay resistance
- switch resistance/continuity
- inspect starter drive mechanisms
- inspect internal components of starter motor

2.1.5 Inspect, test and diagnose lighting and accessory circuits. (3/3)

Light assemblies

Horn

Instrumentation

Switches

Tachometer

Fuel / temperature gauges

Instrument lights

Sender units

2.1.6 Inspect, test and diagnose complete electrical/electronic systems. (4/4)

Follow sequential troubleshooting techniques

Use diagnostic flow charts

Select and utilize meters for voltage, amperage and resistance tests

Use applied electrical schematic

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
35%	35%	30%

Number:	S1439		
Title:	**Engine Fuel Management Systems**		
Duration:	Total Hours: 45	Theory: 28	Practical: 17
Prerequisites:	Level I, Reportable Subjects		
Content:	3.1 Gasoline Fuel Systems (11/12)		
	3.2 Diesel Fuel Systems (9/3)		
	3.3 Intake and Exhaust Systems (5/1)		
	3.4 Emission Control Systems (3/1)		

Evaluation & Testing:
Minimum of one mid-term test during the 8 week term
Final exam at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Assignments related to theory and appropriate application skills

Reference Materials:
Workplace Safety and Insurance Act, 1997
Occupational Health and Safety Act, 1990
Employment Standards Act, 2000
Labour Relations Act, 1995
Employment Insurance Act, 1996
Ontario College of Trades and Apprenticeship Act, 2009
Apprenticeship and Certification Act, 1998
Canadian Standards Association (CSA)
Workplace Hazardous Materials Information System (WHMIS)
Canadian Coast Guard

Recommended Equipment List:
Approved storage and disposal containers
WHMIS materials
Approved fire extinguishers
Appropriate lifting, rigging and blocking equipment
Appropriate equipment and unit vehicles
Appropriate hand and power tools
Digital volt ohmmeters/multi-meters
Service information systems
Pressure gauges
Flow gauges
Vacuum gauges
Injector pop/spray testers
Compressed air supply equipment

Number:	S1439.1		
Title:	**Gasoline Fuel Systems**		
Duration:	Total Hours: 23	Theory: 11	Practical: 12
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6404.01 to 6404.04; 6405.01, 6405.03; 6385.01 to 6385.04, 6386.01, 6386.03			

General Learning Outcomes

Upon successful completion, the apprentice is able to test and maintain gasoline fuel systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

3.1.1 Describe the construction features and principles of operation of carbureted fuel systems. (5/0)

Variable venturi:
- chokes
- enrichment circuits
- priming circuits
- progression circuits
- idle circuits
- high speed circuits
- starting circuits
- compensating devices for various altitudes and temperatures

3.1.2 Inspect, test, troubleshoot and adjust carbureted fuel systems. (0/8)

Perform adjustments and overhaul procedures:
- idle speed, choke, idle mixture
- cleaning procedures
- replacement of components
- float adjustments
- checking machined surfaces
- gasket replacement
- choke adjustments
- throttle opening adjustments
- throttle position sensor adjustment

3.1.3 Explain the types, construction features and principles of operation for electronic fuel injection systems. (6/0)

Types:
- throttle body injection
- multi-point injection
- direct injection
- semi-direct injection

Components:
- sensors
- fuel tanks and lines
- filters and pumps
- throttle bodies
- injectors
- pressure regulators
- electronic control units
- fuel rails
- test ports

Compressors

3.1.4 Identify, inspect, test and diagnose fuel injection systems. (0/4)

Identify system components

Visual inspection of lines, filters

Introduction to on-board diagnostics

Perform fuel pump capacity, pressure and vacuum tests

Number:	S1439.2		
Title:	**Diesel Fuel Systems**		
Duration:	Total Hours: 12	Theory: 9	Practical: 3
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6404.05 to 6404.07, 6405.02; 6385.05 to 6385.07, 6386.02			

General Learning Outcomes

Upon successful completion, the apprentice is able to test and service diesel fuel systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

3.2.1 Define the fundamentals of diesel fuel injection systems. (2/0)

History, purpose, function, types, styles and application:
- principles of compression ignition
- fundamentals of fuel metering

Define the characteristics of diesel fuel including:
- chemical analysis
- calorific value
- octane rating
- volatility
- specific gravity
- pour and cloud point
- sulphur content
- chemical compatibility of water and diesel fuels

3.2.2 Describe the basic construction features of diesel fuel injection system components. (4/0)

Direct injection

Indirect injection

Fuel delivery pumps

Tanks, lines, filters

Water separators

Mechanical injectors

Injection inline pumps

Injection distributor pumps

Rotary pumps

Unit injectors

Injector nozzles

Starting aids

Governor systems

3.2.3 Explain the basic principles of operations of diesel fuel injection systems. (2/0)

Fuel delivery pumps

Distributor pumps, inline pumps

Water separators

Mechanical injectors

Starting aids

Electronic injectors

3.2.4 Inspect and test diesel fuel systems with the prescribed service tools and equipment. (1/2)

Visual inspection of tanks, lines, filters, fuel, delivery pumps and water separators

Pump timing

Cylinder load test

Perform fuel injector system testing

Pressure (pop) opening, spray pattern, leakage, leak-back, chatter

3.2.5 Describe manufacturers' system maintenance procedures of diesel fuel systems and perform assigned operations. (0/1)

Perform low pressure fuel priming procedures

Perform high pressure bleeding procedures

Perform replacement procedure for fuel filter

Number:	S1439.3		
Title:	**Intake and Exhaust Systems**		
Duration:	Total Hours: 6	Theory: 5	Practical: 1
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6402.02, 6402.03, 6404.01, 6404.02, 6405.01, 6405.02; 6383.02, 6383.03, 6385.01, 6385.02, 6386.01, 6386.02			

General Learning Outcomes

Upon successful completion, the apprentice is able inspect and test intake and exhaust systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

3.3.1 Define the fundamentals of intake and exhaust systems. (.5/0)

History, purpose, function, types, styles, and applications

Volumetric efficiency

Scavenging fundamentals

Manifold vacuum and exhaust back pressure

Ported vacuum

Properties of carbon monoxide, hydrocarbons, oxides of nitrogen and particulates

Thermal expansion and contraction

3.3.2 Describe the function, composition and construction of intake and exhaust systems. (3/0)

Intake and exhaust manifolds

Turbochargers, superchargers

Charged air coolers

Intercoolers/aftercoolers

3.3.3 Explain the operating principles of intake and exhaust systems. (1.5/0)

Intake and exhaust systems:
- intake and exhaust manifolds, pipes, resonators, mufflers, turbo chargers, superchargers/blowers

Charged air coolers

3.3.4 Inspect and test for intake and exhaust systems with the prescribed service tools and equipment. (0/1)

Demonstrate inspection procedures of intake and exhaust systems:
- restrictions
- noise
- leaks

Number:	S1439.4		
Title:	**Emission Control Systems**		
Duration:	Total Hours: 4	Theory: 3	Practical: 1
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6404.01, 6404.02, 6404.06, 6405.01, 6405.02; 6385.01, 6385.02, 6385.06, 6386.01, 6386.02			

General Learning Outcomes

Upon successful completion, the apprentice is able to inspect and test emission control systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

3.4.1 Define the fundamentals of emission control systems. (1/0)

Types and applications

Fundamentals:
- properties of carbon monoxide, hydrocarbons, oxides of nitrogen and particulates
- thermal expansion and contraction
- air/fuel ratios
- combustion of fuels
- photo-chemicals, smog, acid rain, greenhouse effect
- legal consequences of emission equipment tampering
- temperature of combustion
- legal requirements of exhaust emissions

3.4.2 Describe the construction features of emission control systems and components. (1/0)

Positive crankcase ventilation

Evaporative emissions systems

Catalytic converter

Sensors

3.4.3 Explain the principles of operation of emissions control systems. (1/0)

Positive crankcase ventilation

Evaporative emissions systems

Catalytic converter

Sensors

3.4.4 Inspect and test emission control systems with the prescribed service tools and equipment. (0/1)

Positive crankcase ventilation

Sensors

Catalytic converter

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
40%	30%	30%

Number:	S1440		
Title:	**Engine Systems**		
Duration:	Total Hours: 24	Theory: 11	Practical: 13
Prerequisites:	Level I, Reportable Subjects		
Content:	4.1 Engine Systems (11/13)		

Evaluation & Testing:
Minimum of one mid-term test during the 8 week term
Final exam at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Assignments related to theory and appropriate application skills

Reference Materials:
Workplace Safety and Insurance Act, 1997
Occupational Health and Safety Act, 1990
Employment Standards Act, 2000
Labour Relations Act, 1995
Employment Insurance Act, 1996
Ontario College of Trades and Apprenticeship Act, 2009
Apprenticeship and Certification Act, 1998
Canadian Standards Association (CSA)
Workplace Hazardous Materials Information System (WHMIS)
Canadian Coast Guard

Recommended Equipment List:
Approved storage and disposal containers
WHMIS materials
Approved fire extinguishers
Appropriate lifting, rigging and blocking equipment
Appropriate equipment and unit vehicles
Appropriate hand and power tools
Precision measuring tools
Digital volt ohmmeters/multi-meters
Service information systems
Pressure gauges
Vacuum gauges
Coolant pressure testers
PH testers
Cylinder ridge reamer
Cylinder hone
Valve and seat service equipment
Straight edge
Compressed air supply equipment

Number:	S1440.1		
Title:	**Engine Systems**		
Duration:	Total Hours: 24	Theory: 11	Practical: 13
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6406.01 to 6406.15; 6387.01 to 6387.15			

General Learning Outcomes

Upon successful completion, the apprentice is able to measure and assemble two and four stroke cycle engine assemblies in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

4.1.1 Review the fundamentals of major engine stationary and moving components of two and four stroke cycle engines. (2/0)

Heat transfer and expansion

Review the following engine terms:
- swept, clearance, total volume
- horsepower
- torque
- compression ratio
- valve timing
- thermal efficiency
- volumetric efficiency
- work
- camshaft timing

4.1.2 Define the failure analysis procedures for engine systems and components. (3/0)

Crankshafts

Camshafts

Bearings

Piston and connecting rod assemblies

Valve assemblies

Block and cylinder

4.1.3 Describe the repair procedures for engine repair practices. (6/0)

Cylinder heads and related components:
- head gasket surface distortion
- decarbonising of cylinder head
- valve guide repair
- refinishing valve seat
- setting valve seat width

Cylinder:
- significance of cross-hatch pattern
- wet and dry sleeves
- cleaning and re-installation of pistons
- piston diameter/clearance to cylinder

Connecting rod reconditioning practices:
- checking straightness
- checking twisting
- connecting rod thrust washer
  - bushings and bearings

Crankshaft reconditioning practices:
- 1-piece, plain bearing type
- bearing selection procedure
- crankshaft journal and crankpin bearing types
- interference fit of crank half sections
- alignment of crank axis to counterweight
- rebuilding crankshaft using press, aligning
- main crankshaft bearings and seals
- inspection, removal, sizing and installation
- installation of thrust washers

4.1.4 Select tools and perform repair or replacement procedures for engine components to meet the manufacturers' specifications. (0/9)

Cylinder blocks:
- resizing cylinders
- honing cylinders
- deglazing cylinders

Bearings

Camshaft

Pistons

Connecting rods and alignment

Valves, seats, and guides:
- replacement
- grinding
- cutting
- lapping Lubricant pumps

Seals

Gaskets

4.1.5 Reassemble engine components as established by manufacturers' specifications. (0/4)

Bearings

Crankshafts

Camshafts

Pistons

Cylinder heads

Valves

Seals and gaskets

Flywheels

Accessories

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
30%	40%	30%

Number:	S1441		
Title:	**Steering, Suspension and Brake Systems**		
Duration:	Total Hours: 42	Theory: 24	Practical: 18
Prerequisites:	Level I, Reportable Subjects		
Content:	5.1 Suspension System Fundamentals and Design (6/5)		
	5.2 Steering Systems (6/4)		
	5.3 Hydraulic Braking Systems (6/5)		
	5.4 Tires, Wheels, Tracks and Propellers (6/4)		

Evaluation & Testing:
Minimum of one mid-term test during the 8 week term
Final exam at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Assignments related to theory and appropriate application skills

Reference Materials:
Workplace Safety and Insurance Act, 1997
Occupational Health and Safety Act, 1990
Employment Standards Act, 2000
Labour Relations Act, 1995
Employment Insurance Act, 1996
Ontario College of Trades and Apprenticeship Act, 2009
Apprenticeship and Certification Act, 1998
Canadian Standards Association (CSA)
Workplace Hazardous Materials Information System (WHMIS)
Canadian Coast Guard

Recommended Equipment List:
Approved storage and disposal containers
WHMIS material
Approved fire extinguishers
Appropriate lifting, rigging and blocking equipment
Appropriate equipment and unit vehicles
Appropriate hand and power tools
Precision measuring tools
Digital volt ohmmeters/multi-meters
Service information systems
Vacuum gauge
Appropriate alignment equipment
Tire and wheel mounting equipment
Compressed air supply equipment

Number:	S1441.1		
Title:	**Suspension System Fundamentals and Design**		
Duration:	Total Hours: 11	Theory: 6	Practical: 5
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6407.01 to 6407.04; 6388.01 to 6388.04			

General Learning Outcomes

Upon successful completion, the apprentice is able to perform inspection and testing procedures of suspension systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

5.1.1 Describe the construction and principles of operation of suspension systems and components. (5/0)

Frames and chassis types

Axles:
- driving and non-driving

Wheel bearing assemblies

Suspension types and styles:
- solid
- independent
- semi-independent
- short/long arm
- center pivot
- struts
- carriage type
  - snowmobile

Stabilizers and radius rods

Ball joints

Shock absorbers:
- hydraulic
- gas

Springs:
- coil
- leaf

5.1.2 Inspect, test, service and maintain suspension systems, components and sub- assemblies. (1/5)

Suspension systems:
- inspect
  - wear
  - damage
- crack detection
  - leaks
  - misalignment
- test
  - ride height
  - action
- service
  - disassemble as required
  - repair or replace components
  - reassemble
  - adjust
- maintain
  - lubrication
  - adjust

Number:	S1441.2		
Title:	**Steering Systems**		
Duration:	Total Hours: 10	Theory: 6	Practical: 4
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6407.01, 6407.05 to 6407.07; 6388.01 to 6388.04			

General Learning Outcomes

Upon successful completion, the apprentice is able to perform inspection and testing procedures of steering systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

5.2.1 Define the fundamentals of steering systems. (3/0)

Parallelogram

Mechanical advantage

Ackerman's principles

Alignment angles:
- caster
- camber
- toe
- turning radius
- ride height
- thrust line
- center line
- steering torque
  - no-feedback systems

Alignment equipment:
- straight edge
- inclinometer
- tape measure
- alignment bars

5.2.2 Describe the construction features and principles of operation of steering systems and components. (3/0)

Cable steering

Direct steering

Manual steering gears:
- rack and pinion
- gear and quadrant
- rotary steering

Power-assist steering

Basic power steering systems

5.2.3 Inspect and test steering systems and components. (0/1)

Inspect:
- wear
- leakage
- damage

Test:
- binding
- alignment
- excessive play

5.2.4 Service, adjust and maintain steering systems. (0/3)

Identify replacement components

Remove and replace components as required

Reassemble steering system

Adjust steering system:
- perform alignment procedures
- perform toe adjustment

Maintain steering system:
- lubricate components as required

Number:	S1441.3		
Title:	**Hydraulic Braking Systems**		
Duration:	Total Hours: 11	Theory: 6	Practical: 5
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6409.01 to 6409.07			

General Learning Outcomes

Upon successful completion, the apprentice is able to describe the construction and operation of hydraulic braking systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

5.3.1 Define the fundamentals of hydraulic braking systems. (1/0)

Review mechanical fundamentals:
- mechanical leverage
- first, second and third class levers
- pivot points
- actuating arm
- pivoting mechanisms
- backing plates and stays

Review friction characteristics:
- co-efficient of friction
- temperature effects
- heat transfer
- static energy
- kinetic energy
- friction face materials
- lead transfer on braking

Review safety precautions:
- brake dust
- asbestos

Hydraulic fundamentals:
- Pascal's Law
- force and pressure factors
- sectional area
- formulae

5.3.2 Describe the construction features and principles of operation of brake systems and components. (3/0)

Master cylinders:
- reservoirs
  - remote
  - integral
- actuation devices
- spool valves
- seals

System delivery:
- lines
- hoses
- fittings
- pressure switches

Hydraulic drum brakes:
- wheel cylinders
- shoe design
  - leading
  - trailing
  - reaction of shoes
- heat dissipation characteristics

Hydraulic disc brakes:
- circuits
- calipers
  - single piston
  - multi piston
  - fixed piston
  - free-floating
- disc design

5.3.3 Inspect, test and repair brake systems. (1/4)

Hydraulic brake systems:
- identify system
- test operation
- inspect master cylinder
- inspect lines, hoses and fittings
- inspect wheel cylinders

- inspect calipers
- remove seized pistons
- renew seals, gaskets and bushings
- bleed air from system

Disc brake service:
- minimum thickness
- abnormal wear patterns
- wear tolerances
- heat checking
- mounting techniques
- disc mounting hardware
- lock types

Drum brake service:
- minimum shoe thickness
- abnormal wear patterns
- wear tolerances
- heat checking
- mounting techniques
- lock types
- out of round
- drum seal service

5.3.4 Perform the maintenance procedures for brake systems. (1/1)

Cleaning of brake dust

Identification of brake fluids

Brake fluid compatibility

Lubrication requirements

Regular adjustment procedures

High pressure fluid precautions

Safety precautions:
- back-up safety systems

Number:	S1441.4		
Title:	**Tires, Wheels, Tracks and Propellers**		
Duration:	Total Hours: 10	Theory: 6	Practical: 4
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6412.01 to 6412.04; 6390.01 to 6390.10			

General Learning Outcomes

Upon successful completion, the apprentice is able to perform testing and maintenance procedures of tires, wheels, tracks and propellers in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

5.4.1 Describe the purpose, types and application of tires, wheels, tracks, and propellers. (3/0)

Tires:
- terminology
- sizing
- load capacities
- construction
- tread design
- ratings
- balancing

Wheels:
- terminology
- sizing
- load capacities
- construction

Tracks:
- terminology
- sizing
- load capacities
- construction
- paddle design
- ratings

Propellers:
- terminology and fundamentals
- size, application and rotation
- load capacities
- construction
- balancing

5.4.2 Explain the principles of operation of tires, wheels, tracks and propellers. (3/0)

Tires

Wheels

Tracks

Propellers:
- impellers

5.4.3 Dismantle, inspect, test and install tires, wheels, tracks and propellers. (0/4)

Tires:
- size
- condition
  - tread
  - sidewall
  - run out
- repair procedures
  - tube repair
  - patches
  - plugs
- mounting procedures
- storage
- disposal

Wheels:
- damage
- fatigue
- corrosion

Tracks:

- condition
  - wear
  - clips
  - drive windows
  - studs
- repair procedures
- storage
- disposal

Propellers:

- wear
- damage
- hub inspection
- removal and installation

Impellers:

- wear
- damage
- wear ring inspection
- removal and installation

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
40%	30%	30%

Number:	S1442		
Title:	**Transmission and Auxiliary Drive Systems**		
Duration:	Total Hours: 48	Theory: 30	Practical: 18
Prerequisites:	Level I, Reportable Subjects		
Content:	6.1 Variable Ratio Belt Drive Systems (4/3)		
	6.2 Clutch Assemblies (4/4)		
	6.3 Hydraulic and Hydrostatic Drive Systems 12/5)		
	6.4 Basic Marine Drive Systems (10/6)		

Evaluation & Testing:
Minimum of one mid-term test during the 8 week term
Final exam at end of term
Periodic quizzes

Instructional and Delivery Strategies:
Assignments related to theory and appropriate application skills

Reference Materials:
Workplace Safety and Insurance Act, 1997
Occupational Health and Safety Act, 1990
Employment Standards Act, 2000
Labour Relations Act, 1995
Employment Insurance Act, 1996
Ontario College of Trades and Apprenticeship Act, 2009
Apprenticeship and Certification Act, 1998
Canadian Standards Association (CSA)
Workplace Hazardous Materials Information System (WHMIS)
Canadian Coast Guard

Recommended Equipment List:
Approved storage and disposal containers
WHMIS materials
Approved fire extinguishers
Appropriate lifting, rigging and blocking equipment
Appropriate equipment and unit vehicles
Appropriate hand and power tools
Precision measuring tools
Digital volt ohmmeters/multi-meters
Service information systems
Vacuum gauge
Hydraulic pressure gauge
Compressed air supply equipment

Number:	S1442.1		
Title:	**Variable Ratio Belt Drive Systems**		
Duration:	Total Hours: 7	Theory: 4	Practical: 3
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6408.01 to 6408.03			

General Learning Outcomes

Upon successful completion, the apprentice is able to test and maintain variable ratio belt drive systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

6.1.1 Define the fundamentals of variable ratio belt drive systems. (1/0)

Centrifugal force

Torque as applied to:
- inertia
- levers

Spring rate

Variable ratio belt drive:
- sheaves
  - primary
  - secondary
- torque feedback cams
- idlers
- belts
- springs
- weights
- spider assembly

6.1.2 Describe the construction features and principles of operations of variable ratio belt drive systems and components. (2/0)

Variable ratio belt drive:

- sheaves
  - primary
  - secondary
- torque feedback cams
- idlers
- belts
- springs

6.1.3 Dismantle, inspect, test and assemble variable ratio belt drives. (0/3)

Primary

Secondary

Belts

6.1.4 Describe manufacturers' maintenance procedures for variable ratio belt drives. (1/0)

Interpret maintenance schedules

Outline lubrication and adjustment requirements

Number:	S1442.2		
Title:	**Clutch Assemblies**		
Duration:	Total Hours: 8	Theory: 4	Practical: 4
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6408.01 to 6408.04			

General Learning Outcomes

Upon successful completion, the apprentice is able to test, diagnose and service clutch systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

6.2.1 Define the fundamentals of clutch systems. (1/0)

Centrifugal force

Torque as applied to:
- inertia
- levers

Friction

6.2.2 Describe the construction features and principles of operation of clutch systems and components. (3/0)

Multi-plate:
- wet
- dry
- clutch hub
- clutch housing
- pressure plate
- clutch springs
  - coil
  - diaphragm
  - wave washers
- clutch drive plates
  - design and materials
- clutch driven plates
  - design and materials

Clutch actuating devices:
- shift lever controlled actuation
- centrifugal mechanism
- adjustment devices
- ball and ramp system
- hydraulic actuation

6.2.3 Dismantle, inspect, repair, assemble and service clutch systems. (0/4)

Multi-plate type:
- measure drive plate thickness and claw width
- measure driven plates for distortion
- measure free length and tension of coil springs
- inspect condition of clutch housing
- inspect clutch hub
- inspect wave washer
- inspect clutch pressure plate for damage, wear and distortion

Fastening devices

Actuating devices:
- shift lever controlled actuation
- centrifugal mechanism
- adjustment devices
- ball and ramp system
- hydraulic actuation

Diagnose clutch problems:
- slippage
- drag
- chatter
- incorrect release
- incorrect release RPM (centrifugal type)
- incorrect engagement RPM (centrifugal type)

Identify a service schedule

Preventative maintenance:
- lubrication
- adjustments
- cleaning

Number:	S1442.3		
Title:	**Hydraulic and Hydrostatic Drive Systems**		
Duration:	Total Hours: 17	Theory: 12	Practical: 5
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6408.01, 6408.08 to 6408.10			

General Learning Outcomes

Upon successful completion, the apprentice is able to describe, inspect and maintain hydraulic and hydrostatic drive systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

6.3.1 Define the fundamentals of hydraulic and hydrostatic drive systems. (4/0)

Pascal's law

Boyle's law

Charles' law

Hydraulic mechanical advantage

Pressure, force and area

Flow and speed:
- measure of flow loss
- effects of viscosity

6.3.2 Describe the construction features and principles of operation of hydraulic and hydrostatic drive systems and components. (6/0)

Hydraulics as applied to:
- pumps (manual, gear, vane, piston, centrifugal diaphragm, positive and non-positive displacement)
- valves
- actuators
- reservoirs
- oil coolers
- filtration
- hydrostatic drive

Hydraulic fluids:
- types
- viscosity
- additives
- fire supportive
- fire resistant
- compatibility
- oxidation
- catalytic action
- rust and corrosion

Hydraulic system effects from:
- atmospheric pressure
- head pressure
- vacuum
- heat

Draw, read, and interpret hydraulic system graphs, symbols and schematic sketches

6.3.3 Inspect hydraulic systems, hydrostatic drives and components. (1/4)

Inspect lines, fittings, hoses:
- leakage
- routing
- mounting
- wear

Inspect pumps:
- wear
- leakage
- excessive clearances

Inspect motors:
- wear
- leakage
- excessive clearances

Inspect valves:
- wear
- leakage
- excessive clearances

Inspect actuators (cylinders and motors):
- wear
- leakage
- excessive clearances

Pressure test hydraulic systems

Inspect hydraulic fluids:
- types, viscosity and additives
- fire supporting
- fire resistive
- compatibility
- oxidization
- catalytic action
- rust and corrosion

6.3.4 Describe manufacturers' maintenance procedures for hydraulic and hydrostatic drive systems. (1/1)

Interpret a maintenance schedule

Preventative maintenance:
- fluid levels
- adjustments
- filters
- oil changes
- bleeding

Number:	S1442.4		
Title:	**Basic Marine Drive Systems**		
Duration:	Total Hours: 16	Theory: 10	Practical: 6
Prerequisites:	Level I, Reportable Subjects		
Cross Reference to Training Standard: 6390.01 to 6390.13, 6392.01 to 6392.04			

General Learning Outcomes

Upon successful completion, the apprentice is able to describe, inspect, maintain and repair basic marine drive systems in accordance with government safety regulations, manufacturers' recommendations and specifications and approved industry standards.

Learning Outcomes and Content

6.4.1 Describe the types and applications of portable outboard motors and personal watercraft drive systems. (3/0)

Direct drive

Direct horizontal

Rotation

Gear cases:
- ratcheting
- non-ratcheting
- shifting
- non-shifting

Lubrication:
- sealing

Engine cooling supply:
- low pressure/high volume
- high pressure/low volume

Vacuum type bilge draining

Exhaust types

Shaft sealing systems

6.4.2 Describe the construction features and principles of operation of portable outboard motors and personal watercraft drive systems. (6/0)

Portable outboard motors:

- gear cases
  - ratcheting
  - non-ratcheting
  - shifting
  - non-shifting
- bevel gears
- planetary gear sets
- drive shaft and housing
- propeller shaft
- bearing carriers
- engine cooling pumps
- lubrication
  - sealing

Personal watercraft:

- couplings
- shafts
- intake grate
- Venturi
- steering nozzle
- reverse gate
- controls
- impeller housing

6.4.3 Test, dismantle, inspect, repair and assemble portable outboard motors and personal watercraft drive systems. (0/6)

Portable outboard motors:

- vacuum pressure test gear case
- remove gear case from driveshaft housing
- inspect and replace water pump
- disassemble and inspect gear case and components
- repair gear case and components as required
- assemble, install and retest gear case
- lubricate as required

Personal watercraft:

- vacuum pressure test jet pump
- disassemble and inspect jet pump assembly
- assemble and retest jet pump
- lubricate as required

6.4.4 Describe maintenance procedures of portable outboard motors and personal watercraft drive systems. (1/0)

Preventative maintenance:

- fluid levels
- adjustments
- oil changes

Interpret a maintenance schedule

Evaluation Structure		
Theory Testing	Practical Application Testing	Final Assessment
45%	25%	30%

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