

# Red Seal Occupational Standard

## Heavy Duty Equipment Technician



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Title: Heavy Duty Equipment Technician

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# Foreword

***The Canadian Council of Directors of Apprenticeship (CCDA) recognizes this Red Seal Occupational Standard (RSOS) as the Red Seal standard for the Heavy Duty Equipment Technician trade.***

## **Background**

The first National Conference on Apprenticeship in Trades and Industries, held in Ottawa in 1952, recommended that the federal government be requested to cooperate with provincial and territorial apprenticeship committees and officials in preparing analyses of a number of skilled occupations. Employment and Social Development Canada (ESDC) funds the Red Seal Program, which, under the guidance of the CCDA, develops a national occupational standard for each of the Red Seal trades.

Standards have the following objectives:

- to describe and group the tasks performed by skilled workers;
- to identify which tasks are performed in every province and territory;
- to develop instruments for use in the preparation of Interprovincial Red Seal Examinations and assessment tools for apprenticeship and certification authorities;
- to develop common tools for apprenticeship on-the-job and technical training in Canada;
- to facilitate the mobility of apprentices and skilled workers in Canada;
- to supply employers, employees, associations, industries, training institutions and governments with occupational standards.

Any questions, comments, or suggestions for changes, corrections, or revisions to this standard or any of its related products may be forwarded to:

Trades and Apprenticeship Division  
Apprenticeship and Sectoral Initiatives Directorate  
Employment and Social Development Canada  
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This standard was prepared by the Apprenticeship and Sectoral Initiatives Directorate of ESDC. The coordinating, facilitating and processing of this standard were undertaken by employees of the standards development team of the Trades and Apprenticeship Division and of Prince Edward Island, the host jurisdiction for this trade.

# Structure of the Occupational Standard

This standard contains the following sections:

**Methodology:** an overview of the process for development, review, validation and weighting of the standard

**Description of the Heavy Duty Equipment Technician Trade:** an overview of the trade's duties, work environment, job requirements, similar occupations and career progression

**Trends in the Heavy Duty Equipment Technician Trade:** some of the trends identified by industry as being the most important for workers in this trade

**Skills for Success Summary:** an overview of how each of the skills for success (formerly called essential skills) is applied in this trade

**Roles and Opportunities for Skilled Trades in a Sustainable Future:** an overarching description of how in the context of climate change, skilled trades play a large role in implementing solutions and adjusting to changes in the world. In addition to highlighting the importance of this awareness, the standard may also contain more details on activities, skills and knowledge elements that are specific to the trade

**Industry Expected Performance:** description of the expectations regarding the level of performance of the tasks, including information related to specific codes, regulations and standards that must be observed

**Language Requirements:** description of the language requirements for working and studying in this trade in Canada

**Pie Chart of Red Seal Examination Weightings:** a graph which depicts the national percentages of exam questions assigned to the major work activities

**Task Matrix and Weightings:** a chart which outlines graphically the major work activities, tasks and sub-tasks of this standard and the national percentages of exam questions assigned to the major work activities and tasks

**Harmonization of Apprenticeship Training:** the aspects of apprenticeship training that participating provinces and territories have agreed upon to substantively align apprenticeship systems across Canada

**Major Work Activity (MWA):** the largest division within the standard that is comprised of a distinct set of trade activities

**Task:** distinct actions that describe the activities within a major work activity

**Task Descriptor:** a general description of the task

**Sub-task:** distinct actions that describe the activities within a task

**Skills:**

**Performance Criteria:** description of the activities that are done as the sub-task is performed

**Evidence of Attainment:** proof that the activities of the sub-task meet the expected performance of a tradesperson who has reached journeyperson level

**Range of Variables:** elements and examples (not all inclusive) that provide a more in-depth description of a term used in the performance criteria and evidence of attainment

**Knowledge:**

**Learning Outcomes:** describes what should be learned relating to a sub-task while participating in technical or in-school training

**Learning Objectives:** topics to be covered during technical or in-school training in order to meet the learning outcomes for the sub-task

**Range of Variables:** elements and examples (not all inclusive) that provide a more in-depth description of a term used in the learning outcomes and learning objectives

**Appendix A – Acronyms:** a list of acronyms used in the standard with their full name

**Appendix B – Tools and Equipment / Outils et équipement:** a bilingual non-exhaustive list of tools and equipment used in this trade

**Appendix C – Glossary / Glossaire:** bilingual definitions or explanations of selected technical terms used in the standard

# Methodology

## Development of the Standard

A draft standard is developed by a broad group of trade representatives, including tradespeople, instructors and employers at a National Workshop led by a team of facilitators. This draft standard breaks down all the tasks performed in the occupation and describes the knowledge and abilities required for a tradesperson to demonstrate competence in the trade.

## Harmonization of Apprenticeship Training

An analysis of all provinces' and territories' apprenticeship programs is performed and recommendations are made on harmonizing the name of the trade, the hours of training required and the number of levels of training. Provinces and territories consult with their respective industry stakeholders on these elements and revisions are discussed until consensus is reached. Following the development of the workshop draft of the RSOS, participants discuss and come to consensus on the sequence of training topics, as expressed in the new standard. Their sequencing recommendations are reviewed by stakeholders in participating provinces and territories and further discussions are convened to reach consensus and to identify any exceptions.

## Online Survey

Stakeholders are asked to review and validate the activities described in the new standard via an online survey. These stakeholders are invited to participate in this consultation through apprenticeship authorities, as well as national stakeholder groups.

## Draft Review

The RSOS development team forwards a copy of the standard to provincial and territorial authorities who consult with industry representatives to review it. Their recommendations are assessed and incorporated into the standard.

## Validation and Weighting

Participating provinces and territories also consult with industry to validate and weight the document for the purpose of planning the makeup of the Red Seal Interprovincial Examination for the trade. They validate and weight the major work activities (MWA), tasks and sub-tasks, of the standard as follows:

<b>MWA</b>	Each jurisdiction assigns a percentage of questions to each MWA for an examination that would cover the entire trade.
<b>Tasks</b>	Each jurisdiction assigns a percentage of exam questions to each task within a MWA.
<b>Sub-tasks</b>	Each jurisdiction indicates, with a "yes" or "no", whether or not each sub-task is performed by skilled workers within the occupation in its jurisdiction.

The results of this exercise are submitted to the RSOS development team who then analyzes the data and incorporates it into the document. The RSOS provides the individual jurisdictional validation results as well as the national averages of all responses. The national averages for MWA and task weighting guide the Interprovincial Red Seal Examination plan for the trade.

The validation of the RSOS is used to identify common core sub-tasks across Canada for the occupation. If at least 70% of the responding jurisdictions' industry performs a sub-task, it shall be considered common core. Interprovincial Red Seal Examination questions are limited to the common core sub-tasks identified through this validation process.



## Definitions for Validation and Weighting

<b>yes</b>	sub-task performed by qualified workers in the occupation in that province or territory
<b>no</b>	sub-task not performed by qualified workers in the occupation in that province or territory
<b>NV</b>	standard <u>N</u> ot <u>V</u> alidated by that province or territory
<b>ND</b>	trade <u>N</u> ot <u>D</u> esignated in a province or territory
<b>Not Common Core (NCC)</b>	sub-task, task or MWA performed less than 70% of responding jurisdictions; these will not be tested by the Interprovincial Red Seal Examination for the trade
<b>National Average %</b>	average percentage of questions assigned to each MWA and task in Interprovincial Red Seal Examination for the trade

## Provincial/Territorial Abbreviations

<b>NL</b>	Newfoundland and Labrador
<b>NS</b>	Nova Scotia
<b>PE</b>	Prince Edward Island
<b>NB</b>	New Brunswick
<b>QC</b>	Quebec
<b>ON</b>	Ontario
<b>MB</b>	Manitoba
<b>SK</b>	Saskatchewan
<b>AB</b>	Alberta
<b>BC</b>	British Columbia
<b>NT</b>	Northwest Territories
<b>YT</b>	Yukon Territory
<b>NU</b>	Nunavut

# Description of the Heavy Duty Equipment Technician trade

“Heavy Duty Equipment Technician” is this trade’s official Red Seal occupational title approved by the CCDA.

Heavy duty equipment technicians diagnose, repair, adjust, calibrate, rebuild, service, and test mobile and stationary heavy duty equipment.

Heavy duty equipment technicians are employed by companies in many sectors and services: heavy duty equipment dealerships, rental and service companies, construction contractors, road building, forestry companies, mining companies, railroads, landscaping companies, public recreational areas, and government departments that service and repair their own equipment. Many heavy duty equipment technicians have experience on a wide variety of equipment types and manufacturers.

Most heavy equipment in Canada is diesel-powered. However, heavy duty equipment technicians are increasingly working with alternative prime movers such as hybrid and electric-powered equipment.

Heavy duty equipment technicians work in a full range of environmental conditions: from shop environments to remote sites where inclement weather can affect the work. Heavy duty equipment technicians perform a lot of field service work, particularly in outdoor work environments. Good physical condition and agility are important because the work often requires considerable standing, bending, crawling, lifting, climbing, pulling and reaching.

Due to the size and complexity of the equipment, safety is of prime importance. Technicians must be conscious of the impact on people, equipment, work area and environment when performing their work. There is risk of injury when working with heavy equipment.

Some important attributes of a heavy duty equipment technician are: mechanical, mathematical and technical aptitude, effective communication, independence, teamwork, and the ability to plan and work sequentially. Heavy duty equipment technicians need to be able to organize multiple jobs at the same time and adapt to various workload and supply demands as well as changing priorities.

This standard recognizes similarities or overlaps in the work of other tradespersons, such as automotive service technicians, agricultural equipment technicians, truck and transport technicians, transport trailer technicians, parts technicians and industrial mechanics (millwrights).

# Trends in the Heavy Duty Equipment Technician Trade

## Technology

Technology continues to advance in sophistication and function. Satellite and wireless technology is becoming more widespread and improves a technicians' ability to diagnose, service and repair remotely. Satellite technology such as Telematics, Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) are used for various applications.

The use of remote control and autonomous and semi-autonomous equipment has been introduced, particularly in hazardous environments and in the mining industry.

There is also an increased role in network communications between individual components on equipment. This technology allows faster data transmission between control modules – this makes for more efficient and easier to operate equipment. For technicians, this has a significant effect on how they diagnose electronic components.

The heavy duty equipment market is moving towards a future of alternative powered equipment. Hybridization is making its way into many aspects of heavy duty equipment, including the powertrain system. Currently, some smaller equipment is fully electric, but this is not common in large heavy equipment. There is also research and development occurring in alternative power such as fuel cells and hydrogen fuels.

There are fewer and fewer mechanically controlled systems, which help reduce emissions and also facilitate operation of equipment.

There are a number of operator-assist technologies such as automatic guidance systems, cameras and radar to detect objects. Some equipment have operator monitoring systems to alert operators of drowsiness or lack of attention.

## Health and Safety

Safety awareness and practices continue to be forefront in the industry. Some examples include high-voltage safe work practices, pressurized hydraulic systems, ergonomic controls, lock-out and tag-out protocols, fall-arrest, equipment guards and live testing.

There are continuing advancements in the Workplace Hazardous Materials Information System (WHMIS) where there is now a Global Harmonized System (GHS).

## Tools and Equipment

Heavy duty equipment technicians are using more and more digital interfaces. Electronic devices such as smart phones, tablets and laptops are now essential tools. This in turn requires a higher level of training related to analytics for technicians with a stronger focus on advanced diagnostic tools (manufacturer-specific programs and apps). There is an increasing ability to track and repair problems before any failure happens. These advanced tools and equipment are used for diagnostics, troubleshooting, function calibration, programming, service and parts information.

New, ergonomic and safer tools and equipment are always being introduced in the trade. For example, there are more electric-power tools, lighter tools and flameless heaters.

**Products and Materials**

Products and materials are more modularized than previous equipment. The use of non-repairable electrical components and lighter weight materials continues to increase. Materials are also healthier, safer and more environmentally friendly, in their construction, as well as in their recyclability and reusability.

**Environmental, Legislative and Regulatory**

Environmental and emission control regulations continue to be important in the industry. There is always a risk for a large and expensive environmental disaster during a routine task in the trade. There is an increase in jurisdictional requirements for environmental awareness training and certification to ensure the proper handling and recycling of refrigerant and other waste materials.

# Skills for Success Summary

Skills for Success are needed in a quickly changing world for work, learning and life. They are foundational for building other skills and important for effective social interaction. Everyone benefits from having these skills as they help individuals get a job, progress at their current job and change jobs. They also help individuals become active members of their community and succeed in learning.

Through extensive research and consultations, the Government of Canada launched the new Skills for Success model renewing the previous Essential Skills framework to better reflect the needs of the current and future labour market.

The summary presented here is based on existing Essential Skills profiles and will be updated to align with the new [Skills for Success model](#) over time.

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## Reading

Heavy duty equipment technicians read many technical documents and specifications. Some examples of these technical documents are work orders, disassembly and assembly instructions, manufacturers' service bulletins, service manuals, recall information and product and material information. There are more and more online sources of information such as blogs and forums where technicians can find help with unusual problems or hard-to-find parts. The trade also has a significant amount of health and safety information and regulations.

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## Document Use

Heavy duty equipment technicians interpret drawings, schematics, digital readouts, troubleshooting graphs, diagrams and charts. They complete checklists, safety documentation, inspection certificates, work orders and service reports. They interpret labels, decals and icons on equipment. Heavy duty equipment technicians use electronic parts and equipment catalogues to order parts and obtain service information. Often, technicians must compile and process information from several sources to problem-solve and facilitate repairs.

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## Writing

Heavy duty equipment technicians write (handwritten and electronically) information for work orders, journals, logbooks, service reports, maintenance and inspection reports, and recommendations for service. These may be used to inform or request information from supervisors, colleagues, equipment manufacturers, different departments or customers.

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## Oral Communication

Heavy duty equipment technicians communicate with customers, operators, colleagues, manufacturers and supervisors to discuss and review job requirements. They participate in safety and toolbox meetings to discuss and learn about safety concerns, changes to operating procedures and projects.

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## Numeracy

Heavy duty equipment technicians take measurements. Some examples include lengths, dimensions, geometry and volumes. They calculate force, horsepower, weights and areas. They convert between measurement systems when calculating pressures, measuring torque and determining the capacity of cylinders and tanks. Heavy duty equipment technicians must analyze data by comparing readings and measurements.

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## **Thinking**

Heavy duty equipment technicians use problem solving skills to diagnose the source of the breakdowns. Decision-making and critical thinking skills are required for determining the type of equipment, parts, materials and procedures best suited for the job.

Heavy duty equipment technicians require job task planning skills to schedule work, determine task sequencing and prioritization of tasks. They organize their tools and the parts required at the beginning of each job.

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## **Working with Others**

Heavy duty equipment technicians mostly work alone but may assist other technicians with heavier or more complex repairs. They coordinate the use of tools and shop equipment with other technicians. They use co-workers, service managers and supervisors as resources in problem solving, diagnosing and laying out plans of actions.

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## **Digital Technology**

Heavy duty equipment technicians use electronic devices to complete work orders and other daily tasks. They communicate by email and text with co-workers, supervisors, suppliers and manufacturers. They use the Internet to access online manuals, training courses, seminars and articles by manufacturers, suppliers, employers, trades schools and technical institutes. They use calculators, mobile apps, and other electronic devices.

Heavy duty equipment technicians use diagnostic equipment that runs software applications and codes to determine operational data. Technicians use digital devices to connect to service information, diagnose faults, download software to program equipment, and communicate with technical support or remotely to a customer's piece of equipment.

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## **Continuous Learning**

Heavy duty equipment technicians are continuously learning to keep up with changes in the industry such as new technology and equipment. They may attend manufacturers' or suppliers' seminars to learn about new products, materials and technical training. They also need to stay up-to-date on industry standards and regulations.

# Roles and Opportunities for Skilled Trades in a Sustainable Future

Climate change affects all of us. Trades play a large role in implementing solutions and adjusting to changes in the world.

Throughout this standard, there may be specific references to tasks, skills and knowledge that clearly show this trade's role in a more sustainable future. Each trade has different roles to play and contributions to make in their own way.

For example:

- Construction tradespeople need to consider the materials they are using, building methods, and improvements to mechanical and electrical installations. There are important changes to codes and standards to help meet the climate change goals and commitments set for 2030 and 2050. Retrofits and new construction of low-energy buildings provide enormous opportunities for workers in this sector. Concepts, such as energy efficiency and regarding buildings as systems are foundational.
- Automotive and mechanical trades are seeing a shift towards the electrification of vehicles and equipment. As a result, new skills and knowledge will be required for tradespeople working in this sector. There are mandates for sales of new light-duty zero-emission vehicles (ZEV) in Canada, with the goal of achieving 100% ZEV sales by 2035. Due to this mandate, the demand for these vehicles is growing quickly among consumers and fleets. With this escalating demand, the need for skilled workers to maintain and repair these vehicles is also increasing.
- In industrial and resource sectors, there is pressure to move towards increased electrification of industrial processes. Many industrial and commercial facilities are also being upgraded to improve energy efficiency in areas such as lighting systems, and new production processes and technologies. There are also opportunities in carbon capture, utilization and storage (CCUS), as well as the production and export of low-carbon hydrogen.
- Trades in the service sector may also need to be aware of responsible sourcing, as well as efficient use of products and materials. New ways of working better are always a part of the job.

There are fast-moving changes in guidelines, codes, regulations and specifications. Many are being implemented for the purpose of energy efficiency and climate change. Those that affect specific trades may be mentioned within the standard. Examples of these guidelines and legislation include:

- The National Energy Code of Canada for Buildings (NECB).
- The Canadian Net-Zero Emissions Accountability Act (CNZEAA).
- programs that encourage sustainable building design and construction such as Leadership in Energy and Environmental Design (LEED) and the Zero Carbon Building (ZCB) standards.
- the Montreal Protocol for phasing out R22 refrigerants.
- energy efficiency programs such as ENERGY STAR.
- principles of the United Nations Declaration for the Rights of Indigenous Peoples pertaining to energy sector development.

Apprentices and tradespeople need to increase their climate literacy and reinforce their own understanding of energy issues and environmental practices. It is important for them to understand why these changes are happening and their effect on trades' work. While individual tradespeople and apprentices may not be able to choose certain elements like; the architectural design of buildings, building material selection, regulatory requirements, use of electric vehicles and technologies, they must understand the impact of using these elements in their work. Impacts include using environmentally friendly products and following requirements related to the disposal and recycling of materials.

In apprenticeship, as well as in ongoing professional development, employers and instructors should encourage learning about these concepts, why they are important, how they are implemented, and the overarching targets they are aiming to achieve.

All in all, it's about doing the work better and building a better world.



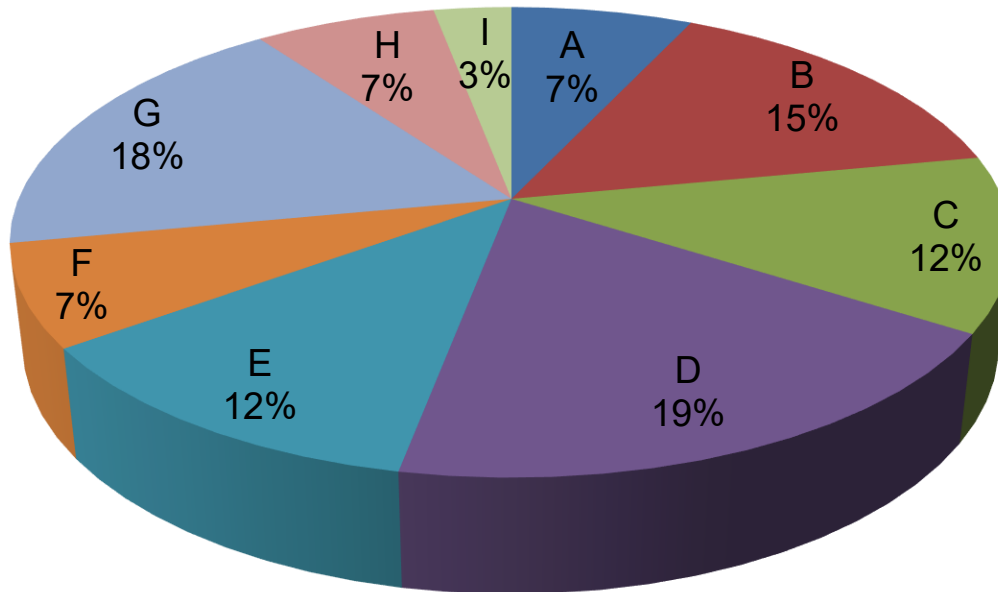
# Industry Expected Performance

All tasks must be performed according to the applicable jurisdictional codes and standards. All health and safety standards must be respected and observed. Work should be performed efficiently and to a high quality without material waste or environmental damage. All requirements of employers, engineers, designers, manufacturers, clients and quality control policies must be met. At a journey person level of performance, all tasks must be done with minimal direction and supervision. As a journey person progresses in their career there is an expectation they continue to upgrade their skills and knowledge to maintain pace with industry and promote continuous learning in their trade through mentoring of apprentices.

# Language Requirements

It is expected that journeypersons are able to understand and communicate in either English or French, which are Canada's official languages. English or French are the common languages of business as well as languages of instruction in apprenticeship programs.

# Pie Chart of Red Seal Examination Weightings



MWA A	Performs common occupational skills	7%
MWA B	Services, diagnoses and repairs engines and supporting systems	15%
MWA C	Services, diagnoses and repairs steering, suspension, brake and undercarriage systems, and wheel assemblies	12%
MWA D	Services, diagnoses and repairs electrical and electronic systems	19%
MWA E	Services, diagnoses and repairs drivetrain systems	12%
MWA F	Services, diagnoses and repairs environmental control systems	7%
MWA G	Services, diagnoses and repairs hydraulic, hydrostatic and pneumatic systems	18%
MWA H	Services, diagnoses and repairs structural components, operator stations, attachments and accessories	7%
MWA I	Services, diagnoses and repairs hybrid and all-electric equipment	3%

This pie chart represents a breakdown of the interprovincial Red Seal examination. Percentages are based on the collective input from workers from the trade from across Canada. The Task Matrix on the next pages indicates the breakdown of tasks and sub-tasks within each Major Work Activity and the breakdown of questions assigned to the Tasks. The Interprovincial examination for this trade has 135 questions.

# Heavy Duty Equipment Technician

## Task Matrix and Weightings

### A – Performs common occupational skills

7%

<b>Task A-1 Performs safety-related functions</b> <b>29%</b>	A-1.01 Performs hazard analysis	A-1.02 Maintains safe work environment	A-1.03 Uses personal protective equipment (PPE) and safety equipment
	A-1.04 Implements safety protocols for hybrid and all-electric equipment and attachments		
<b>Task A-2 Uses and maintains tools and equipment</b> <b>33%</b>	A-2.01 Uses hand, power, measuring, testing and diagnostic tools	A-2.02 Uses shop equipment	A-2.03 Uses access equipment
	A-2.04 Uses hoisting, rigging, lifting, cribbing and blocking equipment	A-2.05 Uses welding equipment	A-2.06 Uses heating and cutting equipment
	A-2.07 Uses electronic service tools and systems for diagnostics and programming		
<b>Task A-3 Performs routine work practices</b> <b>34%</b>	A-3.01 Uses documentation and reference materials	A-3.02 Prepares job action plan	A-3.03 Maintains fluids and lubricants
	A-3.04 Services hoses, tubing, piping and fittings	A-3.05 Services bearings and seals	A-3.06 Uses fasteners and sealing materials
	A-3.07 Services safety features	A-3.08 Performs operational check-out	

**Task A-4 Uses communication and mentoring techniques**  
**4%**

**A-4.01 Uses communication techniques**

**A-4.02 Uses mentoring techniques**

## **B – Services, diagnoses and repairs engines and supporting systems**

**15%**

**Task B-5 Services, diagnoses and repairs base engines**  
**14%**

**B-5.01 Services base engines**

**B-5.02 Diagnoses base engines**

**B-5.03 Repairs base engines**

**Task B-6 Services, diagnoses and repairs lubrication systems**  
**11%**

**B-6.01 Services lubrication systems**

**B-6.02 Diagnoses lubrication systems**

**B-6.03 Repairs lubrication systems**

**Task B-7 Services, diagnoses and repairs intake systems**  
**10%**

**B-7.01 Services intake systems**

**B-7.02 Diagnoses intake systems**

**B-7.03 Repairs intake systems**

**Task B-8 Services, diagnoses and repairs exhaust systems**  
**10%**

**B-8.01 Services exhaust systems**

**B-8.02 Diagnoses exhaust systems**

**B-8.03 Repairs exhaust systems**

**Task B-9 Services, diagnoses and repairs engine management systems**  
**16%**

**B-9.01 Services engine management systems**

**B-9.02 Diagnoses engine management systems**

**B-9.03 Repairs engine management systems**

**Task B-10 Services, diagnoses and repairs fuel delivery systems**  
**13%**

**B-10.01 Services fuel delivery systems**

**B-10.02 Diagnoses fuel delivery systems**

**B-10.03 Repairs fuel delivery systems**

**Task B-11 Services, diagnoses and repairs emission control systems**  
**17%**

**B-11.01 Services emission control systems**

**B-11.02 Diagnoses emission control systems**

**B-11.03 Repairs emission control systems**

**Task B-12 Services, diagnoses and repairs cooling systems**  
**9%**

**B-12.01 Services cooling systems**

**B-12.02 Diagnoses cooling systems**

**B-12.03 Repairs cooling systems**

**C – Services, diagnoses and repairs steering, suspension, brake and undercarriage systems, and wheel assemblies**

**12%**

**Task C-13 Services, diagnoses and repairs steering systems**  
**22%**

**C-13.01 Services steering systems**

**C-13.02 Diagnoses steering systems**

**C-13.03 Repairs steering systems**

**Task C-14 Services, diagnoses and repairs suspension systems**  
**17%**

**C-14.01 Services suspension systems**

**C-14.02 Diagnoses suspension systems**

**C-14.03 Repairs suspension systems**

**Task C-15 Services, diagnoses and repairs brake systems**  
**25%**

**C-15.01 Services brake systems**

**C-15.02 Diagnoses brake systems**

**C-15.03 Repairs brake systems**

**Task C-16 Services, diagnoses and repairs undercarriage systems**  
**21%**

**C-16.01 Services undercarriage systems**

**C-16.02 Diagnoses undercarriage systems**

**C-16.03 Repairs undercarriage systems**

**Task C-17 Services, diagnoses and repairs wheel assemblies**  
**15%**

**C-17.01 Services wheel assemblies**

**C-17.02 Diagnoses wheel assemblies**

**C-17.03 Repairs wheel assemblies**

## D – Services, diagnoses and repairs electrical and electronic systems

19%

<b>Task D-18 Services, diagnoses and repairs charging systems</b> <b>19%</b>	<b>D-18.01 Services charging systems</b>	<b>D-18.02 Diagnoses charging systems</b>	<b>D-18.03 Repairs charging systems</b>
<b>Task D-19 Services, diagnoses and repairs starting systems</b> <b>17%</b>	<b>D-19.01 Services starting systems</b>	<b>D-19.02 Diagnoses starting systems</b>	<b>D-19.03 Repairs starting systems</b>
<b>Task D-20 Services, diagnoses and repairs battery systems</b> <b>15%</b>	<b>D-20.01 Services battery systems</b>	<b>D-20.02 Diagnoses battery systems</b>	<b>D-20.03 Repairs battery systems</b>
<b>Task D-21 Services, diagnoses and repairs electrical components</b> <b>23%</b>	<b>D-21.01 Services electrical components</b>	<b>D-21.02 Diagnoses electrical components</b>	<b>D-21.03 Repairs electrical components</b>
<b>Task D-22 Services, diagnoses and repairs equipment management systems and electronic components</b> <b>26%</b>	<b>D-22.01 Services equipment management systems and electronic components</b>	<b>D-22.02 Diagnoses equipment management systems and electronic components</b>	<b>D-22.03 Repairs equipment management systems and electronic components</b>

## E – Services, diagnoses and repairs drivetrain systems

12%

<b>Task E-23 Services, diagnoses and repairs clutches</b> <b>9%</b>	<b>E-23.01 Services clutches</b>	<b>E-23.02 Diagnoses clutches</b>	<b>E-23.03 Repairs clutches</b>
<b>Task E-24 Services, diagnoses and repairs torque converters, fluid couplers and hydraulic retarders</b> <b>14%</b>	<b>E-24.01 Services torque converters, fluid couplers and hydraulic retarders</b>	<b>E-24.02 Diagnoses torque converters, fluid couplers and hydraulic retarders</b>	<b>E-24.03 Repairs torque converters, fluid couplers and hydraulic retarders</b>
<b>Task E-25 Services, diagnoses and repairs manual transmissions and transfer cases</b> <b>12%</b>	<b>E-25.01 Services manual transmissions and transfer cases</b>	<b>E-25.02 Diagnoses manual transmissions and transfer cases</b>	<b>E-25.03 Repairs manual transmissions and transfer cases</b>

<b>Task E-26 Services, diagnoses and repairs automatic and powershift transmissions</b> <b>21%</b>	<b>E-26.01 Services automatic and powershift transmissions</b>	<b>E-26.02 Diagnoses automatic and powershift transmissions</b>	<b>E-26.03 Repairs automatic and powershift transmissions</b>
<b>Task E-27 Services, diagnoses and repairs driveline systems</b> <b>12%</b>	<b>E-27.01 Services driveline systems</b>	<b>E-27.02 Diagnoses driveline systems</b>	<b>E-27.03 Repairs driveline systems</b>
<b>Task E-28 Services, diagnoses and repairs drive axles and differentials</b> <b>17%</b>	<b>E-28.01 Services drive axles and differentials</b>	<b>E-28.02 Diagnoses drive axles and differentials</b>	<b>E-28.03 Repairs drive axles and differentials</b>
<b>Task E-29 Services, diagnoses and repairs final drive systems</b> <b>15%</b>	<b>E-29.01 Services final drive systems</b>	<b>E-29.02 Diagnoses final drive systems</b>	<b>E-29.03 Repairs final drive systems</b>

## **F – Services, diagnoses and repairs environmental control systems** **7%**

<b>Task F-30 Services, diagnoses and repairs heating systems</b> <b>29%</b>	<b>F-30.01 Services heating systems</b>	<b>F-30.02 Diagnoses heating systems</b>	<b>F-30.03 Repairs heating systems</b>
<b>Task F-31 Services, diagnoses and repairs ventilation and filtration systems</b> <b>23%</b>	<b>F-31.01 Services ventilation and filtration systems</b>	<b>F-31.02 Diagnoses ventilation and filtration systems</b>	<b>F-31.03 Repairs ventilation and filtration systems</b>
<b>Task F-32 Services, diagnoses and repairs air conditioning systems</b> <b>37%</b>	<b>F-32.01 Services air conditioning systems</b>	<b>F-32.02 Diagnoses air conditioning systems</b>	<b>F-32.03 Repairs air conditioning systems</b>
<b>Task F-33 Services, diagnoses and repairs sound suppression systems</b> <b>11%</b>	<b>F-33.01 Services sound suppression systems</b>	<b>F-33.02 Diagnoses sound suppression systems</b>	<b>F-33.03 Repairs sound suppression systems</b>



## G – Services, diagnoses and repairs hydraulic, hydrostatic and pneumatic systems

18%

<b>Task G-34 Services, diagnoses and repairs hydraulic systems</b> <b>46%</b>	<b>G-34.01 Services hydraulic systems</b>	<b>G-34.02 Diagnoses hydraulic systems</b>	<b>G-34.03 Repairs hydraulic systems</b>
<b>Task G-35 Services, diagnoses and repairs hydrostatic systems</b> <b>34%</b>	<b>G-35.01 Services hydrostatic systems</b>	<b>G-35.02 Diagnoses hydrostatic systems</b>	<b>G-35.03 Repairs hydrostatic systems</b>
<b>Task G-36 Services, diagnoses and repairs pneumatic systems</b> <b>20%</b>	<b>G-36.01 Services pneumatic systems</b>	<b>G-36.02 Diagnoses pneumatic systems</b>	<b>G-36.03 Repairs pneumatic systems</b>

## H – Services, diagnoses and repairs structural components, operator stations, attachments and accessories

7%

<b>Task H-37 Services, diagnoses and repairs structural components</b> <b>27%</b>	<b>H-37.01 Services structural components</b>	<b>H-37.02 Diagnoses structural components</b>	<b>H-37.03 Performs mechanical repairs on structural components</b>
<b>Task H-38 Services, diagnoses and repairs operator station components</b> <b>35%</b>	<b>H-38.01 Services operator station components</b>	<b>H-38.02 Diagnoses operator station components</b>	<b>H-38.03 Repairs operator station components</b>
<b>Task H-39 Services, diagnoses and repairs attachments and accessories</b> <b>38%</b>	<b>H-39.01 Services attachments and accessories</b>	<b>H-39.02 Diagnoses attachments and accessories</b>	<b>H-39.03 Repairs attachments and accessories</b>
	<b>H-39.04 Installs attachments and accessories</b>		

# I – Services, diagnoses and repairs hybrid and all-electric equipment

**3%**

<b>Task I-40 Services, diagnoses and repairs hybrid equipment</b> <b>53%</b>	<b>I-40.01 Services hybrid equipment</b>	<b>I-40.02 Diagnoses hybrid equipment</b>	<b>I-40.03 Repairs hybrid equipment</b>
<b>Task I-41 Services, diagnoses and repairs all-electric equipment</b> <b>47%</b>	<b>I-41.01 Services all-electric equipment</b>	<b>I-41.02 Diagnoses all-electric equipment</b>	<b>I-41.03 Repairs all-electric equipment</b>

# Harmonization of Apprenticeship Training

Provincial and territorial apprenticeship authorities are each responsible for their respective apprenticeship programs. In the spirit of continual improvement, and to facilitate mobility among apprentices in Canada, participating authorities have agreed to work towards harmonizing certain aspects of their programs where possible. After consulting with their stakeholders in the trade, they have reached consensus on the following elements. Note that implementation of these elements may vary from jurisdiction to jurisdiction, depending on their own circumstances. For more information on the implementation in any province and territory, please contact that jurisdiction’s apprenticeship authority.

## 1. Trade name

The official Red Seal name for this trade is Heavy Duty Equipment Technician.

## 2. Number of Levels of Apprenticeship

The number of levels of technical training recommended for this trade is four (4).

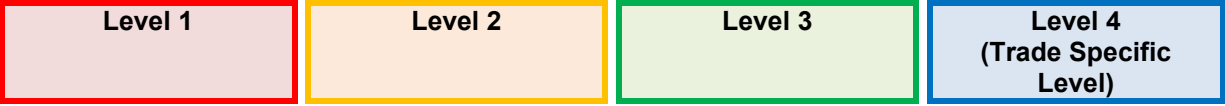
## 3. Total Training Hours

The total hours of training, including both on-the-job and in-school training for this trade is 7200.

## 4. Sequencing Topics and Related Sub-tasks

The topic titles in the table below are placed in a column for each apprenticeship level for technical training. Each topic is accompanied by the sub-tasks and their reference number. The topics in the grey shaded cells represent those that are covered “in context” with other training in the subsequent years.

Level 1	Level 2	Level 3	Level 4 (Trade Specific Level)
	Context	Context	Context
	Common Occupational Skills	Common Occupational Skills	Common Occupational Skills
	Tools and Equipment	Tools and Equipment	Tools and Equipment
	Routine Work Activities	Routine Work Activities	Routine Work Activities
	Operator Station Components	Operator Station Components	Operator Station Components
		Attachments and Accessories	Attachments and Accessories



**Common Occupational Skills**  
 1.01 Performs hazard analysis  
 1.02 Maintains safe work environment  
 1.03 Uses personal protective equipment (PPE) and safety equipment  
 1.04 Implements safety protocols for hybrid and all-electric equipment and attachments

**Tools and Equipment**  
 2.01 Uses hand, power, measuring, testing and diagnostic tools  
 2.02 Uses shop equipment  
 2.03 Uses access equipment  
 2.04 Uses hoisting, rigging, lifting, cribbing and blocking equipment  
 2.05 Uses welding equipment  
 2.06 Uses heating and cutting equipment  
 2.07 Uses electronic service tools and systems for diagnostics and programming

Level 1	Level 2	Level 3	Level 4 (Trade Specific Level)
<b>Routine Work Practices</b> 3.01 Uses documentation and reference materials 3.02 Prepares job action plan 3.03 Maintains fluids and lubricants 3.04 Services hoses, tubing, piping and fittings 3.05 Services bearings and seals 3.06 Uses fasteners and sealing materials 3.07 Services safety features 3.08 Performs operational check-out			
<b>Communication Techniques</b> 4.01 Uses communication techniques			<b>Mentoring Techniques</b> 4.02 Uses mentoring techniques
	<b>Base Engines</b> 5.01 Services base engines 5.02 Diagnoses base engines 5.03 Repairs base engines	<b>Base Engines</b> 5.02 Diagnoses base engines 5.03 Repairs base engines	
	<b>Lubrication Systems</b> 6.01 Services lubrication systems 6.02 Diagnoses lubrication systems 6.03 Repairs lubrication systems	<b>Lubrication Systems</b> 6.02 Diagnoses lubrication systems 6.03 Repairs lubrication systems	
	<b>Intake Systems</b> 7.01 Services intake systems 7.02 Diagnoses intake systems 7.03 Repairs intake systems	<b>Intake Systems</b> 7.02 Diagnoses intake systems 7.03 Repairs intake systems	

Level 1	Level 2	Level 3	Level 4 (Trade Specific Level)
	<b>Exhaust Systems</b> 8.01 Services exhaust systems 8.02 Diagnoses exhaust systems 8.03 Repairs exhaust systems	<b>Exhaust Systems</b> 8.02 Diagnoses exhaust systems 8.03 Repairs exhaust systems	
	<b>Engine Management Systems</b> 9.01 Services engine management systems 9.02 Diagnoses engine management systems 9.03 Repairs engine management systems	<b>Engine Management Systems</b> 9.01 Services engine management systems 9.02 Diagnoses engine management systems 9.03 Repairs engine management systems	
	<b>Fuel Delivery Systems</b> 10.01 Services fuel delivery systems 10.02 Diagnoses fuel delivery systems 10.03 Repairs fuel delivery systems	<b>Fuel Delivery Systems</b> 10.01 Services fuel delivery systems 10.02 Diagnoses fuel delivery systems 10.03 Repairs fuel delivery systems	
	<b>Emission Control Systems</b> 11.01 Services emission control systems 11.02 Diagnoses emission control systems 11.03 Repairs emission control systems	<b>Emission Control Systems</b> 11.01 Services emission control systems 11.02 Diagnoses emission control systems 11.03 Repairs emission control systems	
	<b>Cooling Systems</b> 12.01 Services cooling systems 12.02 Diagnoses cooling systems 12.03 Repairs cooling systems	<b>Cooling Systems</b> 12.02 Diagnoses cooling systems 12.03 Repairs cooling systems	

Level 1	Level 2	Level 3	Level 4 (Trade Specific Level)
<b>Steering Systems</b> 13.01 Services steering systems 13.02 Diagnoses steering systems 13.03 Repairs steering systems			<b>Steering Systems</b> 13.01 Services steering systems 13.02 Diagnoses steering systems 13.03 Repairs steering systems
<b>Suspension Systems</b> 14.01 Services suspension systems 14.02 Diagnoses suspension systems 14.03 Repairs suspension systems			<b>Suspension Systems</b> 14.01 Services suspension systems 14.02 Diagnoses suspension systems 14.03 Repairs suspension systems
<b>Brake Systems</b> 15.01 Services brake systems 15.02 Diagnoses brake systems 15.03 Repairs brake systems			<b>Brake Systems</b> 15.01 Services brake systems 15.02 Diagnoses brake systems 15.03 Repairs brake systems
<b>Undercarriage Systems</b> 16.01 Services undercarriage systems 16.02 Diagnoses undercarriage systems 16.03 Repairs undercarriage systems			<b>Undercarriage Systems</b> 16.02 Diagnoses undercarriage systems 16.03 Repairs undercarriage systems
<b>Wheel Assemblies</b> 17.01 Services wheel assemblies 17.02 Diagnoses wheel assemblies 17.03 Repairs wheel assemblies			<b>Wheel Assemblies</b> 17.02 Diagnoses wheel assemblies 17.03 Repairs wheel assemblies
<b>Charging Systems</b> 18.01 Services charging systems 18.02 Diagnoses charging systems 18.03 Repairs charging systems	<b>Charging Systems</b> 18.02 Diagnoses charging systems 18.03 Repairs charging systems		

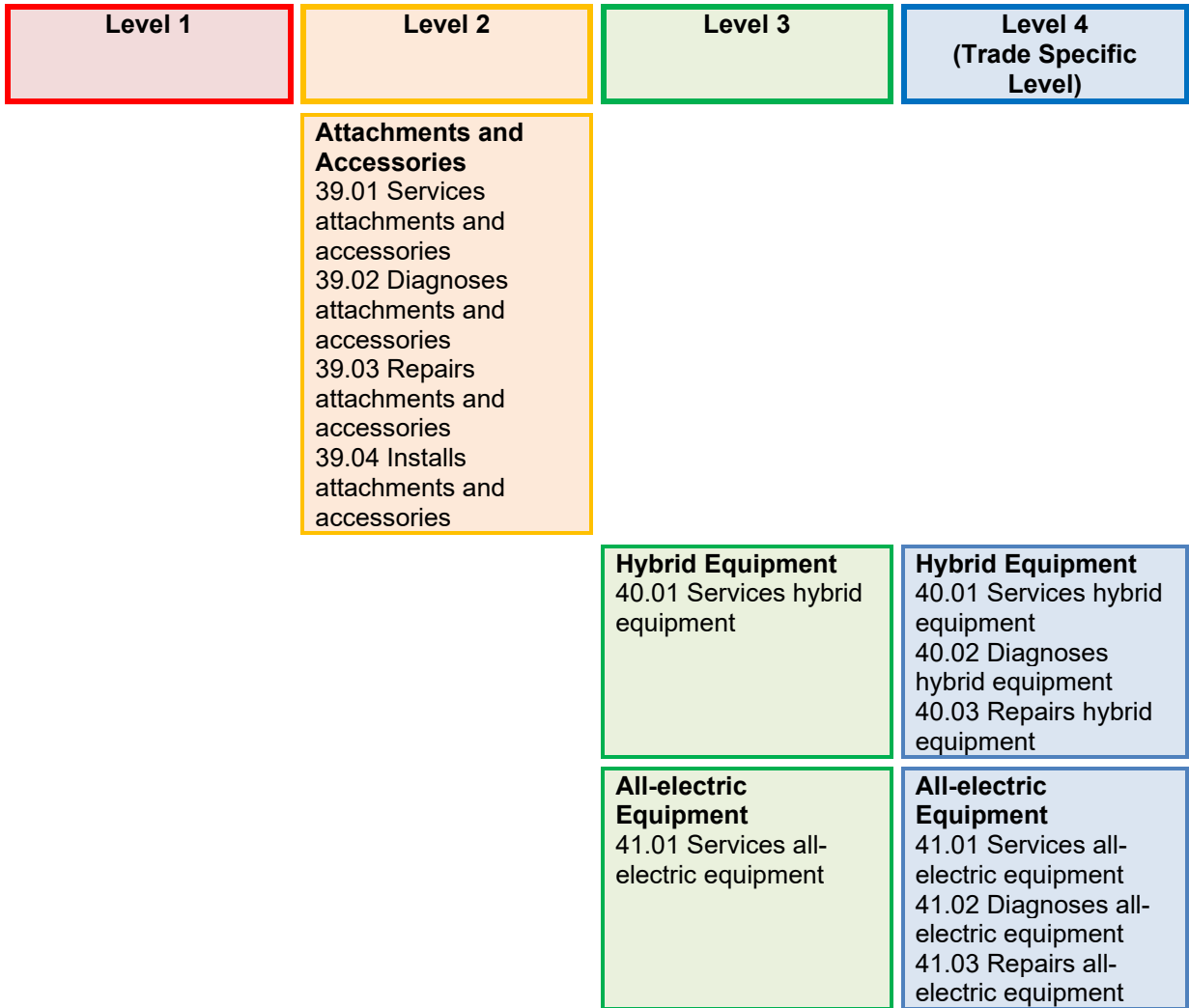
Level 1	Level 2	Level 3	Level 4 (Trade Specific Level)
<b>Starting Systems</b> 19.01 Services starting systems 19.02 Diagnoses starting systems 19.03 Repairs starting systems	<b>Starting Systems</b> 19.02 Diagnoses starting systems 19.03 Repairs starting systems		
<b>Battery Systems</b> 20.01 Services battery systems 20.02 Diagnoses battery systems 20.03 Repairs battery systems			
<b>Electrical Components</b> 21.01 Services electrical components	<b>Electrical Components</b> 21.01 Services electrical components 21.02 Diagnoses electrical components 21.03 Repairs electrical components		
		<b>Equipment Management Systems and Electronic Components</b> 22.01 Services equipment management systems and electronic components 22.03 Repairs equipment management systems and electronic components	<b>Equipment Management Systems and Electronic Components</b> 22.02 Diagnoses equipment management systems and electronic components
	<b>Clutches</b> 23.01 Services clutches 23.02 Diagnoses clutches 23.03 Repairs clutches	<b>Clutches</b> 23.02 Diagnoses clutches 23.03 Repairs clutches	



Level 1	Level 2	Level 3	Level 4 (Trade Specific Level)
	<p><b>Torque Converters, Fluid Couplers and Hydraulic Retarders</b></p> <p>24.01 Services torque converters, fluid couplers and hydraulic retarders</p> <p>24.02 Diagnoses torque converters, fluid couplers and hydraulic retarders</p> <p>24.03 Repairs torque converters, fluid couplers and hydraulic retarders</p>	<p><b>Torque Converters, Fluid Couplers and Hydraulic Retarders</b></p> <p>24.02 Diagnoses torque converters, fluid couplers and hydraulic retarders</p> <p>24.03 Repairs torque converters, fluid couplers and hydraulic retarders</p>	
	<p><b>Manual Transmission and Transfer Cases</b></p> <p>25.01 Services manual transmissions and transfer cases</p> <p>25.02 Diagnoses manual transmissions and transfer cases</p> <p>25.03 Repairs manual transmissions and transfer cases</p>	<p><b>Manual Transmission and Transfer Cases</b></p> <p>25.02 Diagnoses manual transmissions and transfer cases</p> <p>25.03 Repairs manual transmissions and transfer cases</p>	
	<p><b>Automatic and Powershift Transmissions</b></p> <p>26.01 Services automatic and powershift transmissions</p> <p>26.02 Diagnoses automatic and powershift transmissions</p> <p>26.03 Repairs automatic and powershift transmissions</p>	<p><b>Automatic and Powershift Transmissions</b></p> <p>26.02 Diagnoses automatic and powershift transmissions</p> <p>26.03 Repairs automatic and powershift transmissions</p>	
	<p><b>Driveline Systems</b></p> <p>27.01 Services driveline systems</p> <p>27.02 Diagnoses driveline systems</p> <p>27.03 Repairs driveline systems</p>	<p><b>Driveline Systems</b></p> <p>27.02 Diagnoses driveline systems</p> <p>27.03 Repairs driveline systems</p>	

Level 1	Level 2	Level 3	Level 4 (Trade Specific Level)
	<b>Drive Axles and Differentials</b> 28.01 Services drive axles and differentials 28.02 Diagnoses drive axles and differentials 28.03 Repairs drive axles and differentials	<b>Drive Axles and Differentials</b> 28.02 Diagnoses drive axles and differentials 28.03 Repairs drive axles and differentials	
	<b>Final Drive Systems</b> 29.01 Services final drive systems 29.02 Diagnoses final drive systems 29.03 Repairs final drive systems	<b>Final Drive systems</b> 29.02 Diagnoses final drive systems 29.03 Repairs final drive systems	
<b>Heating Systems</b> 30.01 Services heating systems 30.02 Diagnoses heating systems 30.03 Repairs heating systems		<b>Heating Systems</b> 30.02 Diagnoses heating systems 30.03 Repairs heating systems	
<b>Ventilation and Filtration Systems</b> 31.01 Services ventilation and filtration systems 31.02 Diagnoses ventilation and filtration systems 31.03 Repairs ventilation and filtration systems		<b>Ventilation and Filtration Systems</b> 31.02 Diagnoses ventilation and filtration systems 31.03 Repairs ventilation and filtration systems	
<b>Air Conditioning Systems</b> 32.01 Services air conditioning systems 32.02 Diagnoses air conditioning systems 32.03 Repairs air conditioning systems		<b>Air Conditioning Systems</b> 32.02 Diagnoses air conditioning systems 32.03 Repairs air conditioning systems	

Level 1	Level 2	Level 3	Level 4 (Trade Specific Level)
<b>Sound Suppression Systems</b> 33.01 Services sound suppression systems 33.02 Diagnoses sound suppression systems 33.03 Repairs sound suppression systems		<b>Sound Suppression Systems</b> 33.02 Diagnoses sound suppression systems 33.03 Repairs sound suppression systems	
<b>Hydraulic Systems</b> 34.01 Services hydraulic systems	<b>Hydraulic Systems</b> 34.03 Repairs hydraulic systems		<b>Hydraulic Systems</b> 34.02 Diagnoses hydraulic systems
	<b>Hydrostatic Systems</b> 35.01 Services hydrostatic systems	<b>Hydrostatic Systems</b> 35.03 Repairs hydrostatic systems	<b>Hydrostatic Systems</b> 35.02 Diagnoses hydrostatic systems
<b>Pneumatic Systems</b> 36.01 Services pneumatic systems 36.02 Diagnoses pneumatic systems 36.03 Repairs pneumatic systems			<b>Pneumatic Systems</b> 36.01 Services pneumatic systems 36.02 Diagnoses pneumatic systems 36.03 Repairs pneumatic systems
<b>Structural Components</b> 37.01 Services structural components	<b>Structural Components</b> 37.02 Diagnoses structural components 37.03 Performs mechanical repairs on structural components		
<b>Operator Station Components</b> 38.01 Services operator station components 38.02 Diagnoses operator station components 38.03 Repairs operator station components			



# Major Work Activity A

## Performs common occupational skills

### Task A-1 Performs safety-related functions

#### Task Descriptor

Heavy duty equipment technicians perform hazard analysis before starting any task. They create and maintain a safe work environment to ensure safety of personnel and equipment. They must wear personal protective equipment (PPE), use safety equipment, and follow manufacturers' service information when performing certain tasks.

Heavy duty equipment technicians are increasingly working on electric motors, inverters, converters, high-voltage batteries and associated support systems in hybrid and all-electric equipment and attachments. Safety is of paramount importance due to the risk of electrocution when working with high voltages.

#### **A-1.01** Performs hazard analysis

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
A-1.01.01P	perform safety inspection of equipment and surrounding work area	field-level hazard assessment is completed according to company policies and procedures, and <b>manufacturers' service information</b>
A-1.01.02P	identify <b>hazards</b>	<b>hazards</b> when working on equipment systems are identified according to <b>manufacturers' service information</b> , and by performing sensory inspection of equipment and worksite
A-1.01.03P	document <b>hazards</b>	<b>hazards</b> are documented according to company policies and procedures
A-1.01.04P	identify <b>hazardous materials</b>	<b>hazardous materials</b> are identified, labelled and documented according to <b>jurisdictional regulations</b>
A-1.01.05P	identify location of <b>workplace safety equipment</b> and emergency phone numbers	location of <b>workplace safety equipment</b> and emergency phone numbers are identified

A-1.01.06P	identify PPE and safety equipment required	PPE and safety equipment required for task is identified according to company policies and procedures, <b>manufacturers' service information</b> and jurisdictional regulations
A-1.01.07	report <b>hazards</b>	<b>hazards</b> are reported to supervisor according to company policies and procedures

## Range of Variables

**manufacturers' service information** includes: specifications, recommendations, procedures, standards

**hazards** include: air lines, light cords, broken equipment, fluids and gases under high pressure, ceiling heights, overhead wires, uneven surfaces, crush/pinch points, energized equipment, noise level, air quality, flammable and explosive materials

**hazardous materials** include: chemicals, refrigerants, high-pressure gases, fluids, fuels, lubricants, airborne contaminants, toxic gasses

**jurisdictional regulations** include: Occupational Health and Safety (OH&S), Workplace Hazardous Materials Information System (WHMIS) (labels, training, Safety Data Sheet [SDS]), Transportation of Dangerous Goods (TDG)

**workplace safety equipment** includes: safety stations, first-aid kits, eyewash stations, fire extinguishing equipment, anti-spill kits, PPE, automated external defibrillator (AED), ventilation equipment

## Knowledge

	Learning Outcomes	Learning Objectives
A-1.01.01L	demonstrate knowledge of hazard analysis procedures	describe procedures to perform hazard analysis
		identify potential <b>hazards</b> , and describe steps to mitigate risk
		identify <b>hazards</b> that require use of PPE and safety equipment
		identify <b>hazardous materials</b> , and describe their characteristics and applications
A-1.01.02L	demonstrate knowledge of certification and regulatory requirements pertaining to hazard analysis	identify and describe <b>jurisdictional regulations</b> related to hazard analysis

## Range of Variables

**hazards** include: air lines, light cords, broken equipment, fluids and gases under high pressure, ceiling heights, overhead wires, uneven surfaces, crush/pinch points, energized equipment, noise level, air quality, flammable and explosive materials

**jurisdictional regulations** include: Occupational Health and Safety (OH&S), Workplace Hazardous Materials Information System (WHMIS) (labels, training, Safety Data Sheet [SDS]), Transportation of Dangerous Goods (TDG)

**workplace safety equipment** includes: safety stations, first-aid kits, eyewash stations, fire extinguishing equipment, anti-spill kits, PPE, automated external defibrillator (AED), ventilation equipment

## A-1.02 Maintains safe work environment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-1.02.01P	handle, store, recycle and dispose of <b>hazardous materials</b>	<b>hazardous materials</b> are handled, stored, recycled and disposed of according to company policies and procedures, and <b>jurisdictional regulations</b>
A-1.02.02P	mitigate risks associated with hazards	hazards are mitigated according to company policy and procedures, industry best practices and <b>jurisdictional regulations</b>
A-1.02.03P	perform <b>housekeeping duties</b>	<b>housekeeping duties</b> are performed according to company policies and procedures
A-1.02.04P	use ventilation equipment to extract and contain fumes, smoke and dust	ventilation equipment is used according to safe work procedures to extract and contain fumes, smoke and dust
A-1.02.05P	identify location of <b>workplace safety equipment</b> and emergency phone numbers	location of <b>workplace safety equipment</b> and emergency phone numbers are identified
A-1.02.06P	apply lock-out and tag-out procedures	lock-out and tag-out procedures are applied according to company policies and procedures, and <b>manufacturers' service information</b> to prevent unwanted or unsafe operation of equipment
A-1.02.07P	use anti-spill kits and procedures	anti-spill kits and procedures are used according to <b>jurisdictional regulations</b>
A-1.02.08P	apply hazard analysis	hazard analysis is applied according to company policies and procedures, and <b>jurisdictional regulations</b>

### Range of Variables

**hazardous materials** include: chemicals, refrigerants, high-pressure gases, fluids, fuels, lubricants

**jurisdictional regulations** include: OH&S, WHMIS (labels, training, SDS), TDG

**housekeeping duties** include: maintain clean and dry floor, discarding of defective components, keeping area clear of obstacles

**workplace safety equipment** includes: safety stations, first-aid kits, eyewash stations, fire extinguishing equipment, anti-spill kits, PPE, AED, ventilation equipment

**manufacturers' service information** include: specifications, recommendations, procedures, standards

## Knowledge

Learning Outcomes	Learning Objectives
A-1.02.01L demonstrate knowledge of safe work practices	describe safe work practices and <b>housekeeping duties</b> to maintain a safe work environment
	identify <b>workplace safety equipment</b> , and describe their characteristics and applications
	describe procedures to lock out and tag out equipment
	describe procedures to use anti-spill kits
	describe hazard analysis characteristics and applications
A-1.02.02L demonstrate knowledge of certification and regulatory requirements pertaining to safety	identify <b>components of WHMIS</b> and associated certifications
	identify and describe <b>jurisdictional regulations</b> to maintain safe work environment
	identify and describe jurisdictional requirements for handling, recycling and disposing of <b>hazardous materials</b>

### Range of Variables

**housekeeping duties** include: maintain clean and dry floor, discarding of defective components, keeping area clear of obstacles

**workplace safety equipment** includes: safety stations, first-aid kits, eyewash stations, fire extinguishing equipment, anti-spill kits, PPE, AED, ventilation equipment

**components of WHMIS** include: labels, training, SDS

**jurisdictional regulations** include: OH&S, WHMIS (labels, training, SDS), TDG

**hazardous materials** (jurisdictional requirements for handling, recycling and disposing) include: battery fluid, diesel exhaust fluid (DEF), propane bottles, used fluids and lubricants, airborne contaminants, toxic gasses



**A-1.03****Uses personal protective equipment (PPE) and safety equipment**

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

**Skills**

	<b>Performance Criteria</b>	<b>Evidence of Attainment</b>
A-1.03.01P	select and use <b>PPE</b> and <b>safety equipment</b>	<b>PPE</b> and <b>safety equipment</b> are selected, fit and used according to hazard analysis, <b>work conditions and requirements</b> , company policies and procedures, <b>manufacturers' service information</b> and <b>jurisdictional regulations</b>
A-1.03.02P	store and maintain <b>PPE</b> and <b>safety equipment</b>	<b>PPE</b> and <b>safety equipment</b> are stored and maintained according to company policies and procedures, and <b>manufacturers' service information</b>
A-1.03.03P	repair or replace, and report worn damaged or defective <b>PPE</b> and <b>safety equipment</b>	worn, damaged or defective <b>PPE</b> and <b>safety equipment</b> are repaired or replaced, and reported according to company policies and procedures, and <b>jurisdictional regulations</b>

**Range of Variables**

**PPE** includes: hard hats, gloves, respirators, safety glasses, hearing protection, safety boots, protective clothing, face shields, high-visibility clothing

**safety equipment** includes: fall arrest, fall protection, guarding, shielding, jack, support stands, wheel chocks, lock-out, tag-out, dust mask, respirator, breathing equipment

**work conditions and requirements** include: wearing rubber gloves when handling hazardous or carcinogenic materials; wearing eye and hearing protection when hammering and grinding metals; wearing masks and breathing protection when working around hazardous airborne and liquid substances; protective aprons, gloves and face shield when working with batteries; working in confined spaces

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**jurisdictional regulations** include: OH&S, WHMIS (labels, training, SDS), TDG, occupational safety standards

## Knowledge

Learning Outcomes	Learning Objectives
A-1.03.01L	demonstrate knowledge of <b>PPE</b> and <b>safety equipment</b> , their characteristics, applications and procedures for use
	identify types of <b>PPE</b> and <b>safety equipment</b> , and describe their characteristics, applications and procedures for use
	describe procedures to handle, store and maintain <b>PPE</b> and <b>safety equipment</b>
	interpret information pertaining to <b>PPE</b> and <b>safety equipment</b> found in company policies and procedures, and <b>manufacturers' service information</b>
A-1.03.02L	demonstrate knowledge of training and certification for <b>PPE</b> and <b>safety equipment</b>
	identify training and certification requirements pertaining to <b>PPE</b> and <b>safety equipment</b>
A-1.03.03L	demonstrate knowledge of regulatory requirements pertaining to <b>PPE</b> and <b>safety equipment</b>
	identify <b>standards and regulations</b> and <b>jurisdictional regulations</b> , and describe their applications

### Range of Variables

**PPE** includes: hard hats, gloves, respirators, safety glasses, hearing protection, safety boots, protective clothing, face shields, high-visibility clothing

**safety equipment** includes: fall arrest, fall protection, guarding, shielding, jack, support stands, wheel chocks, lock-out, tag-out, dust mask, respirator, breathing equipment

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**standards and regulations** include: Canadian Standards Association (CSA), OH&S, site specific (company or client)

**jurisdictional regulations** include: OH&S, WHMIS (labels, training, SDS), TDG, occupational safety standards

**A-1.04****Implements safety protocols for hybrid and all-electric equipment and attachments**

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	yes	yes	yes	yes	yes	no	no	yes	NV	NV	NV

**Skills**

	<b>Performance Criteria</b>	<b>Evidence of Attainment</b>
A-1.04.01P	select and use <b>PPE and safety equipment</b>	<b>PPE and safety equipment</b> specific to hybrid and all-electric equipment systems is selected and used according to <b>manufacturers' service information</b>
A-1.04.02P	select and use tools and equipment to complete safety preparation	tools and equipment to complete safety preparation are selected and used according to <b>manufacturers' service information</b>
A-1.04.03P	identify <b>safety hazards</b>	<b>safety hazards</b> specific to working on hybrid and all-electric equipment systems are identified
A-1.04.04P	ensure <b>safety protocols</b> for hybrid and all-electric equipment systems have been implemented	<b>safety protocols</b> for hybrid and all-electric equipment systems have been implemented according to <b>manufacturers' service information</b>

**Range of Variables**

**PPE and safety equipment** include: insulated gloves, pylons, high-voltage specific tools, safety hook, lock-out devices, tag-out devices, arc flash suits, high-voltage signage

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**safety hazards** include: electrocution, burns, arc flash

**safety protocols** include: safe work procedures for high voltage, manufacturers' safety procedures, maintenance facility requirements, maintain zero energy state when working on all-electric equipment and attachments

## Knowledge

	Learning Outcomes	Learning Objectives
A-1.04.01L	demonstrate knowledge of <b>PPE and safety equipment</b> specific to hybrid and all-electric equipment systems, their characteristics, applications and procedures for use	identify types of <b>PPE and safety equipment</b> specific to hybrid and all-electric equipment systems, and describe their characteristics, applications and procedures for use
A-1.04.02L	demonstrate knowledge of <b>safety protocols</b> for hybrid and all-electric equipment systems	describe <b>safety protocols</b> pertaining to hybrid and all-electric equipment systems
		identify <b>safety hazards</b> specific to working on hybrid equipment and all-electric equipment systems and safe work practices
		interpret information pertaining to hybrid and all-electric equipment systems found in company policies and procedures, and <b>manufacturers' service information</b>
A-1.04.03L	demonstrate knowledge of regulatory requirements pertaining to hybrid and all-electric equipment systems	identify and interpret <b>standards and regulations</b> pertaining to hybrid and all-electric equipment systems

### Range of Variables

**PPE and safety equipment** include: insulated gloves, pylons, high-voltage specific tools, safety hook, lock-out devices, tag-out devices, arc flash suits, high-voltage signage

**safety protocols** include: safe work procedures for high voltage, manufacturers' safety procedures, maintenance facility requirements, maintain zero energy state when working on all-electric equipment and attachments

**safety hazards** include: electrocution, burns, arc flash

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**standards and regulations** include: CSA (Z462), jurisdictional regulations

# Task A-2 Uses and maintains tools and equipment

## Task Descriptor

Heavy duty equipment technicians use tools and equipment to perform all tasks in their trade in a safe and efficient manner. They maintain these tools and equipment to ensure longevity and safe operation.

### A-2.01 Uses hand, power, measuring, testing and diagnostic tools

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

Skills		
	Performance Criteria	Evidence of Attainment
A-2.01.01P	select and use hand, power, measuring, testing and diagnostic tools	hand, power, measuring, testing and diagnostic tools are selected and used according to task and <b>manufacturers' service information</b>
A-2.01.02P	identify potential <b>hazards</b> and implement measures to minimize risk	potential <b>hazards</b> are identified and measures are implemented to minimize risk
A-2.01.03P	clean hand, power, measuring, testing and diagnostic tools	hand, power, measuring, testing and diagnostic tools are cleaned according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.01.04P	inspect hand, power, measuring, testing and diagnostic tools	hand, power, measuring, testing and diagnostic tools are inspected for <b>conditions</b> according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.01.05P	repair or replace worn, damaged and faulty hand, power, measuring, testing and diagnostic tools	worn, damaged and faulty hand, power, measuring, testing and diagnostic tools are repaired or replaced according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.01.06P	lubricate power tools	power tools are lubricated according to <b>manufacturers' service information</b>
A-2.01.07P	calibrate measuring tools	measuring tools are calibrated according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.01.08P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>

A-2.01.09P	sharpen tools	tools are sharpened according to company policies and procedures, and type of material being used
A-2.01.10P	document maintenance information	maintenance information is documented according to company policies and procedures, and manufacturers' requirements for warranty, and for future reference and tracking
A-2.01.11P	store hand, power, measuring, testing and diagnostic tools	hand, power, measuring, testing and diagnostic tools are stored according to company policies and procedures, and <b>manufacturers' service information</b>

### Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: environment, crush/pinch points, flying debris, flammables, high torque application, poorly or undressed tools

**conditions** include: wear, damage, defects, failure

Knowledge		
	Learning Outcomes	Learning Objectives
A-2.01.01L	demonstrate knowledge of hand, power, measuring, testing and diagnostic tools, their characteristics and applications	identify types of hand, power, measuring, testing and diagnostic tools, and describe their characteristics and applications
A-2.01.02L	demonstrate knowledge of procedures to use and maintain hand, power, measuring, testing and diagnostic tools	identify hazards and describe safe work practices to use hand, power, measuring, testing and diagnostic tools
		describe procedures to inspect hand, power, measuring, testing and diagnostic tools
		describe procedures to lubricate and clean hand, power, measuring, testing and diagnostic tools
		describe fundamentals of alignment using <b>alignment tools</b>
		describe procedures to dress tools
		describe procedures to sharpen hand tools

describe procedures to repair hand, power, measuring, testing and diagnostic tools

describe procedures to store hand, power, measuring, testing and diagnostic tools

describe procedures to destroy and dispose of damaged and defective hand, power, measuring, testing and diagnostic tools

## Range of Variables

**alignment tools** include: plumb bobs, laser levels, measuring tape, tram bar

### A-2.02 Uses shop equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
A-2.02.01P	select and use shop equipment	shop equipment is selected and used according to task, company policies and procedures, and <b>manufacturers' service information</b>
A-2.02.02P	identify potential hazards and implement measures to minimize risk	potential hazards are identified and measures are implemented to minimize risk
A-2.02.03P	clean shop equipment	shop equipment is cleaned according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.02.04P	inspect shop equipment	shop equipment is visually inspected for inspection tags, <b>conditions</b> and are removed from service and reported according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.02.05P	repair or replace worn, damaged and faulty shop equipment	worn, damaged and faulty shop equipment is repaired or replaced according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.02.06P	lubricate shop equipment	shop equipment is lubricated according to company policies and procedures, and <b>manufacturers' service information</b>

A-2.02.07P	maintain solvent washers and biological parts washers	solvent washers and biological parts washers are maintained according to <b>manufacturers' service information</b>
A-2.02.08P	verify certification dates	certification dates are verified to ensure they are current according to jurisdictional regulations
A-2.02.09P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
A-2.02.10P	document maintenance information	maintenance information is documented according to company policies and procedures, and manufacturers' requirements for warranty, and for future reference and tracking
A-2.02.11P	store shop equipment	shop equipment is stored according to company policies and procedures, and <b>manufacturers' service information</b>

### Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, leaks

Knowledge		
	Learning Outcomes	Learning Objectives
A-2.02.01L	demonstrate knowledge of shop equipment, their characteristics and applications	identify types of shop equipment and describe their characteristics and applications
		identify load limitations of shop equipment
		interpret information pertaining to shop equipment found in <b>manufacturers' service information</b> and rating tags on shop equipment
A-2.02.02L	demonstrate knowledge of procedures to use, maintain and store shop equipment	identify hazards and describe safe work practices to use shop equipment
		describe procedures to inspect shop equipment
		describe procedures to lubricate and clean shop equipment
		describe procedures to document and report damaged and defective shop equipment
		describe importance of valid inspection certification dates on shop equipment
		describe procedures to store shop equipment



A-2.02.03L	demonstrate knowledge of training and certification requirements to use shop equipment	identify training and certification requirements to use shop equipment
A-2.02.04L	demonstrate knowledge of regulatory requirements to maintain shop equipment	identify and interpret standards and jurisdictional regulations to maintain shop equipment

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

## A-2.03 Uses access equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-2.03.01P	select and use or operate <b>access equipment</b>	<b>access equipment</b> is selected and used or operated according to task, equipment limitations, company policies and procedures, jurisdictional regulations and <b>manufacturers' service information</b>
A-2.03.02P	identify potential <b>hazards</b> and implement measures to minimize risk	potential <b>hazards</b> are identified and measures are implemented to minimize risk
A-2.03.03P	determine <b>access equipment</b> maximum capacities	<b>access equipment</b> maximum capacities are determined by referring to tags and specifications
A-2.03.04P	obtain clearances and licenses for use of <b>access equipment</b>	clearances and licenses for use of <b>access equipment</b> are obtained
A-2.03.05P	implement <b>safety practices</b>	<b>safety practices</b> are implemented according to jurisdictional regulations, company policies and procedures, and <b>manufacturers' service information</b>
A-2.03.06P	communicate with others	others are informed of actions through hand signals or radio communication
A-2.03.07P	position and connect <b>access equipment</b>	<b>access equipment</b> is positioned and connected according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.03.08P	secure <b>access equipment</b>	<b>access equipment</b> is secured to prevent movement according to company policies and procedures, and <b>manufacturers' service information</b>

A-2.03.09P	clean <b>access equipment</b>	<b>access equipment</b> is cleaned according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.03.10P	inspect <b>access equipment</b>	<b>access equipment</b> is inspected for <b>conditions</b> according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.03.11P	repair, replace and report worn, damaged and defective components on <b>access equipment</b>	worn, damaged and defective components on <b>access equipment</b> are repaired or replaced, and reported according to company policies and procedures
A-2.03.12P	document maintenance information	maintenance information is documented according to company policies and procedures, and manufacturers' requirements for warranty, and for future reference and tracking
A-2.03.13P	store <b>access equipment</b>	<b>access equipment</b> is stored according to company policies and procedures, and <b>manufacturers' service information</b>

## Range of Variables

**access equipment** includes: aerial work platforms, scissor lifts, scaffolding, mobile steps, ladders

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: uneven ground, overhead hazards, slips and falls, working at heights, load limitations, inclement weather (lightning), soft ground

**safety practices** include: fall protection, pre-operational tests, environmental checks

**conditions** include: wear, damage, defects, failure, leaks, safety decals in place

Knowledge		
	Learning Outcomes	Learning Objectives
A-2.03.01L	demonstrate knowledge of <b>access equipment</b> , their components, characteristics and applications	identify types of <b>access equipment</b> and their components, and describe their characteristics and applications
		identify capacity and limitations of <b>access equipment</b>
A-2.03.02L	demonstrate knowledge of procedures to use or operate and maintain <b>access equipment</b>	identify <b>factors to consider</b> when selecting <b>access equipment</b>
		identify <b>hazards</b> and describe safe work practices to use <b>access equipment</b>
		describe procedures to use or operate <b>access equipment</b>
		describe procedures to position and connect <b>access equipment</b>
		describe procedures to inspect <b>access equipment</b>

		describe procedures to repair or replace <b>access equipment</b>
		describe procedures to document and report damaged and defective <b>access equipment</b>
		describe procedures to store <b>access equipment</b>
A-2.03.03L	demonstrate knowledge of training and certification requirements to operate <b>access equipment</b>	describe training and certification requirements to operate <b>access equipment</b>
A-2.03.04L	demonstrate knowledge of regulatory requirements to operate <b>access equipment</b>	locate, identify and interpret regulations to operate <b>access equipment</b>

### Range of Variables

**access equipment** includes: aerial work platforms, scissor lifts, scaffolding, mobile steps, ladders

**factors to consider** include: capacity, height, environmental, space

**hazards** include: uneven ground, overhead hazards, slips and falls, working at heights, load limitations, inclement weather (lightning), soft ground

## A-2.04 Uses hoisting, rigging, lifting, cribbing and blocking equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-2.04.01P	select and use or operate <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	<b>hoisting, rigging, lifting, cribbing and blocking equipment</b> are selected and used or operated according to task, equipment limitations, company policies and procedures, and <b>manufacturers' service information</b>
A-2.04.02P	identify potential <b>hazards</b> and implement measures to minimize risk	potential <b>hazards</b> are identified and measures are implemented to minimize risk
A-2.04.03P	locate component weights and lift points	component weights and lift points are located
A-2.04.04P	determine <b>hoisting, rigging, lifting, cribbing and blocking equipment</b> maximum capacities	<b>hoisting, rigging, lifting, cribbing and blocking equipment</b> maximum capacities are determined by referring to tags and specifications

A-2.04.05P	obtain certificates and licenses for use of <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	clearances and licenses for use of <b>hoisting, rigging, lifting, cribbing and blocking equipment</b> are obtained according to jurisdictional regulations
A-2.04.06P	implement <b>safety practices</b>	<b>safety practices</b> are implemented according to jurisdictional regulations, company policies and procedures, and <b>manufacturers' service information</b>
A-2.04.07P	communicate lift	lift is communicated through hand signals or radio communication
A-2.04.08P	prepare lift plan	lift plan is prepared according to <b>manufacturers' service information</b>
A-2.04.09P	position and connect <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	<b>hoisting, rigging, lifting, cribbing and blocking equipment</b> are positioned and connected according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.04.10P	secure <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	<b>hoisting, rigging, lifting, cribbing and blocking equipment</b> are secured to prevent movement according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.04.11P	clean <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	<b>hoisting, rigging, lifting, cribbing and blocking equipment</b> are cleaned according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.04.12P	inspect <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	<b>hoisting, rigging, lifting, cribbing and blocking equipment</b> are inspected for <b>conditions</b> according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.04.13P	repair, replace and report worn, damaged and defective components on <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	worn, damaged and defective components on <b>hoisting, rigging, lifting, cribbing and blocking equipment</b> are repaired or replaced, and reported according to company policies and procedures
A-2.04.14P	document maintenance information	maintenance information is documented according to company policies and procedures, and manufacturers' requirements for warranty, and for future reference and tracking
A-2.04.15P	store <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	<b>hoisting, rigging, lifting, cribbing and blocking equipment</b> are stored according to company policies and procedures, and <b>manufacturers' service information</b>

## Range of Variables

**hoisting and lifting equipment** includes: overhead crane, chain hoist, cable hoist, mobile crane, hardware

**rigging equipment** includes: slings, spreader bars, load levellers

**cribbing and blocking equipment** includes: jack stands, composite and wood blocking

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: ceiling heights, overhead hazards, uneven surfaces, placement of cribbing and blocking equipment, power lines, unstable ground, environmental conditions, crush/pinch points

**safety practices** include: securing lift area, using spotters supervision of lifts, securing work area, communication, being aware of lifting capacities, knowing weight of object to lift

Knowledge		
	Learning Outcomes	Learning Objectives
A-2.04.01L	demonstrate knowledge of <b>hoisting, rigging, lifting, cribbing and blocking equipment</b> , their components, characteristics and applications	identify types of <b>hoisting, rigging, lifting, cribbing and blocking equipment</b> and their components, and describe their characteristics and applications
		identify differences between imperial and metric measuring systems
		identify capacity and limitations of lifting equipment
		identify elements in a lift plan, and describe procedures to communicate lift
A-2.04.02L	demonstrate knowledge of procedures to use, operate and maintain <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	identify <b>factors to consider</b> when selecting <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>
		identify <b>hazards</b> and describe <b>safety practices</b> to use <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>
		describe procedures to use or operate <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>
		describe procedures to position and connect <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>
		describe procedures to inspect <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>
		describe procedures to repair or replace <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>

		describe procedures to document and report damaged and defective <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>
		describe procedures to store <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>
A-2.04.03L	demonstrate knowledge of training and certification requirements to operate <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	describe training and certification requirements to operate <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>
A-2.04.04L	demonstrate knowledge of regulatory requirements to operate <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>	locate, identify and interpret regulations to operate <b>hoisting, rigging, lifting, cribbing and blocking equipment</b>

## Range of Variables

**hoisting and lifting equipment** includes: overhead crane, chain hoist, cable hoist, mobile crane, hardware

**rigging equipment** includes: slings, spreader bars, load levellers

**cribbing and blocking equipment** includes: jack stands, composite and wood blocking

**factors to consider** include: load characteristics, environment, safety factors, anchor points, sling angles

**hazards** include: ceiling heights, overhead hazards, uneven surfaces, placement of cribbing and blocking equipment, power lines, unstable ground, environmental conditions, crush/pinch points

**safety practices** include: securing lift area, using spotters supervision of lifts, securing work area, communication, being aware of lifting capacities, knowing weight of object to lift

## A-2.05 Uses welding equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-2.05.01P	select and use welding equipment	welding equipment is selected and used according to task, company policies and procedures, and <b>manufacturers' service information</b>
A-2.05.02P	determine when repairs should be completed by a certified welder	repairs to be completed by a certified welder are determined
A-2.05.03P	identify potential <b>hazards</b> and implement measures to minimize risk	potential <b>hazards</b> are identified and measures are implemented to minimize risk

A-2.05.04P	determine and select equipment and <b>consumables</b>	equipment and <b>consumables</b> are determined and selected according to materials being worked on
A-2.05.05P	transport welding equipment	welding equipment is transported according to jurisdictional regulations and TDG
A-2.05.06P	set up welding equipment	welding equipment is set up by adjusting controls for task being performed
A-2.05.07P	prepare equipment for welding	equipment is prepared for welding according to <b>manufacturers' service information</b> to prevent damage to equipment and electronic components
A-2.05.08P	<b>prepare</b> work area for welding	work area is <b>prepared</b> for welding according to task, and company policies and procedures
A-2.05.09P	perform <b>basic welding</b>	<b>basic welding</b> is performed according to jurisdictional regulations
A-2.05.10P	assess flow and penetration during welding	flow and penetration are assessed during welding according to sensory inspection
A-2.05.11P	shut down welding equipment	welding equipment is shut down according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.05.12P	clean welding tips	welding tips are cleaned according to <b>manufacturers' service information</b>
A-2.05.13P	inspect welding equipment	welding equipment is inspected for <b>conditions</b> , and findings are reported to supervisor according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.05.14P	remove worn, damaged and defective welding equipment from service	worn, damaged and defective welding equipment is removed from service according to company policies and procedures
A-2.05.15P	document maintenance information	maintenance information is documented according to company policies and procedures, and manufacturers' requirements for warranty, and for future reference and tracking
A-2.05.16P	store and secure welding equipment	welding equipment is stored and secured according to company policies and procedures, <b>manufacturers' service information</b> and jurisdictional regulations

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: electrocution, fire, arc flash, metal poisoning, burns, ultra-violet lights

**consumables** include: filler rod or wire, tips, covered and coiled wire electrodes, shielding gases

**prepare** includes: removing combustibles, placing flash curtains, verifying ventilation

**basic welding** includes: non-structural, non-pressure, oxy-fuel, arc welding

**conditions** include: worn or damaged cables; damaged plugs; rusted, cracked leaking or contaminated equipment; damaged gauges

Knowledge		
	Learning Outcomes	Learning Objectives
A-2.05.01L	demonstrate knowledge of welding equipment, its characteristics and applications	identify types of welding equipment, and describe their characteristics and applications
		identify welding <b>consumables</b> , and describe their characteristics and applications
A-2.05.02L	demonstrate knowledge of procedures to use and maintain welding equipment	describe procedures to use welding equipment
		identify <b>hazards</b> and describe safe work practices to use welding equipment
		identify welding principles and considerations
		identify <b>basic welding</b> procedures
		describe procedures to inspect welding equipment
		describe procedures to store welding equipment
A-2.05.03L	demonstrate knowledge of training and certification requirements to use welding equipment	describe procedures to transport welding equipment
		describe procedures to transport welding equipment
A-2.05.04L	demonstrate knowledge of regulatory requirements to transport and store welding equipment	identify and interpret standards and regulations to transport and store welding equipment

## Range of Variables

**consumables** include: filler rod or wire, tips, covered and coiled wire electrodes, shielding gases

**hazards** include: electrocution, fire, arc flash, metal poisoning, burns, ultra-violet lights

**basic welding** includes: non-structural, non-pressure, oxy-fuel, arc welding



## A-2.06 Uses heating and cutting equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-2.06.01P	select and use heating and cutting equipment	heating and cutting equipment are selected and used according to task, company policies and procedures, and <b>manufacturers' service information</b>
A-2.06.02P	identify potential <b>hazards</b> and implement measures to minimize risk	potential <b>hazards</b> are identified and measures are implemented to minimize risk
A-2.06.03P	determine and select equipment and <b>consumables</b>	equipment and <b>consumables</b> are determined and selected according to task
A-2.06.04P	transport heating and cutting equipment	heating and cutting equipment is transported according to jurisdictional regulations and TDG
A-2.06.05P	set up heating and cutting equipment	heating and cutting equipment is set up by adjusting controls for task being performed
A-2.06.06P	prepare equipment for heating and cutting	equipment is prepared for heating and cutting according to <b>manufacturers' service information</b> to prevent damage to equipment and electronic components
A-2.06.07P	<b>prepare</b> work area for heating and cutting	work area is <b>prepared</b> for heating and cutting according to task and company policies and procedures
A-2.06.08P	perform basic heating and cutting procedures	basic heating and cutting procedures are performed
A-2.06.09P	use <b>heating methods</b>	<b>heating methods</b> are used according to material of component
A-2.06.10P	use <b>cooling methods</b>	<b>cooling methods</b> are used according to material of component
A-2.06.11P	measure temperature of metals	temperature of metals is measured using <b>measuring methods</b> to achieve desired temperature
A-2.06.12P	shut down heating equipment	heating equipment is shut down according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.06.13P	clean heating and cutting tips	heating and cutting tips are cleaned according to <b>manufacturers' service information</b>

A-2.06.14P	inspect heating and cutting equipment	heating and cutting equipment is inspected for <b>conditions</b> , and findings are reported to supervisor according to company policies and procedures, and <b>manufacturers' service information</b>
A-2.06.15P	remove worn, damaged and defective heating and cutting equipment from service	worn, damaged and defective heating and cutting equipment is removed from service according to company policies and procedures
A-2.06.16P	document maintenance information	maintenance information is documented according to company policies and procedures, and manufacturers' requirements for warranty, and for future reference and tracking
A-2.06.17P	store and secure heating and cutting equipment	heating and cutting equipment is stored and secured according to company policies and procedures, <b>manufacturers' service information</b> and jurisdictional regulations

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: fire, metal poisoning, burns, flashback, pressurized gas bottles becoming projectiles, acetone withdrawal from torch

**consumables** include: lancing rods, gouging rods, gases, torch tips, plasma tips

**prepare** includes: removing combustibles, placing flash curtains, verifying ventilation

**heating methods** include: using induction heaters, ovens and heat lamps

**cooling methods** include: using carbon dioxide (CO<sup>2</sup>) and liquid nitrogen

**measuring methods** include: using a heat stick, using infrared temperature gun and measuring with temperature probe

**conditions** include: leaking hoses, flashback, operational gauges and regulators, defective tips and torch

## Knowledge

	Learning Outcomes	Learning Objectives
A-2.06.01L	demonstrate knowledge of heating and cutting equipment, their characteristics and applications	identify types of heating and cutting equipment, and describe their characteristics and applications
		identify heating and cutting <b>consumables</b> , and describe their characteristics and applications
		identify required temperature of heating and cooling of materials

A-2.06.02L	demonstrate knowledge of procedures to use and maintain heating and cutting equipment	Describe procedures to use and maintain heating and cutting equipment
		identify <b>hazards</b> and describe safe work practices to use heating and cutting equipment
		identify heating and cutting principles and considerations
		identify heating and cutting basic procedures
		describe procedures to inspect heating and cutting equipment
		describe procedures to transport heating and cutting equipment
		describe procedures to store heating and cutting equipment
A-2.06.03L	demonstrate knowledge of training and certification requirements to use heating and cutting equipment	identify training and certification requirements to use heating and cutting equipment
A-2.06.04L	demonstrate knowledge of regulatory requirements to transport and store heating and cutting equipment	identify and interpret standards and regulations to transport and store heating and cutting equipment

## Range of Variables

**consumables** include: lancing rods, gouging rods, gases, torch tips, plasma tips

**hazards** include: fire, metal poisoning, burns, flashback, pressurized gas bottles becoming projectiles, acetone withdrawal from torch

## A-2.07 Uses electronic service tools and systems for diagnostics and programming

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-2.07.01P	select and use <b>electronic service tools</b>	<b>electronic service tools</b> are selected and used according to task and <b>manufacturers' service information</b>
A-2.07.02P	use <b>software applications</b>	<b>software applications</b> are used according to <b>manufacturers' service information</b>

A-2.07.03P	verify software version, download from manufacturer and upload to controllers	software version is verified, downloaded from manufacturer and uploaded to controllers
A-2.07.04P	download and document reports from equipment controller	reports from equipment controller are downloaded and documented and forwarded to original equipment manufacturer (OEM) or customer
A-2.07.05P	monitor <b>data</b> and <b>parameters</b>	<b>data</b> and <b>parameters</b> are monitored for operational status according to <b>manufacturers' service information</b>
A-2.07.06P	adjust <b>parameters</b>	<b>parameters</b> are adjusted according to customer request and <b>manufacturers' service information</b>
A-2.07.07P	interpret diagnostic results and reports	diagnostic results and reports are interpreted to determine failure and required repair
A-2.07.08P	document information	information is documented according to company policies and procedures, and manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**electronic service tools** include: laptops, smart phones, tablets, communication interface adapters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**software applications** include: OEM diagnostic and operating software, Internet-based technical support, remote monitoring systems

**data** includes: temperatures, speeds, pressure, switch states

**parameters** include: speeds, temperatures, pressures, anti-lock braking system (ABS), roll stability, software versions, application-specific configurations

Knowledge		
	Learning Outcomes	Learning Objectives
A-2.07.01L	demonstrate knowledge of using <b>electronic service tools</b> for diagnostics and programming	identify types of <b>electronic service tools</b> used in diagnostics and programming, and describe their characteristics, applications and procedures for use
		identify <b>software applications</b> used in diagnostics and programming, and describe their applications
		describe manufacturers' programming and monitoring procedures
		describe elements of diagnostic results and reports
A-2.07.02L	demonstrate knowledge of training available to use <b>electronic service tools</b> for diagnostics and programming	describe training available to use <b>electronic service tools</b> for diagnostics and programming

## Range of Variables

**electronic service tools** include: laptops, smart phones, tablets, communication interface adapters

**software applications** include: OEM diagnostic and operating software, Internet-based technical support, remote monitoring systems

## Task A-3 Performs routine work practices

### Task Descriptor

Heavy duty equipment technicians reference different sources of documentation to prepare job action plans, and diagnose, service and repair systems.

They service hoses, tubing, piping, fittings and safety features. They must have knowledge of materials and hardware such as fluids and lubricants, fasteners, bearings, sealing devices and their applications.

### A-3.01 Uses documentation and reference materials

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
A-3.01.01P	locate <b>information on equipment</b>	<b>information on equipment</b> is located
A-3.01.02P	locate and reference most recent <b>technical information</b>	most recent <b>technical information</b> is located and referenced for diagnostic, servicing and repair procedures
A-3.01.03P	interpret and apply <b>technical information</b> to task	<b>technical information</b> is interpreted and applied to task
A-3.01.04P	document <b>service history</b>	<b>service history</b> is documented according to company policies and procedures, manufacturers' requirements and jurisdictional regulations
A-3.01.05P	create list of parts needed	list of parts needed is created according to repair required, company policies and procedures, and <b>manufacturers' service information</b>
A-3.01.06P	match replacement part to original part	replacement part is matched to original part
A-3.01.07P	document <b>work-related information</b>	<b>work-related information</b> is documented according to company policies and procedures, and manufacturers' requirements
A-3.01.08P	complete <b>safety-related documents</b>	<b>safety-related documents</b> are completed according to jurisdictional regulations, and company policies and procedures

A-3.01.09P	report completion of documentation to supervisor	completion of documentation is reported to supervisor according to company policies and procedures
A-3.01.10P	follow confidentiality guidelines	confidentiality guidelines are followed according to company policies and procedures

## Range of Variables

**information on equipment** includes: vehicle identification (VIN) and serial numbers, arrangement numbers, safety placards and decals, information labels, part numbers

**technical information** includes: shop service and parts manuals, troubleshooting trees, flow charts, schematics, technical drawings, specifications, test results, parameters, service bulletins, warranty claims, service records, preventative maintenance records, online resources

**service history** includes: inspection or work order history, warranty forms, preventive maintenance documents, failure analysis using photographs

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**work-related information** includes: technician hours worked, machine hours, VIN, parts used, task descriptions, failure analysis, measurements

**safety-related documents** include: accident reports, injury reports, safety inspection reports, workplace hazard reports including hazard analysis

Knowledge		
	Learning Outcomes	Learning Objectives
A-3.01.01L	demonstrate knowledge of trade-related documentation, their characteristics and applications	identify types of trade-related documentation and describe their characteristics and applications
A-3.01.02L	demonstrate knowledge of procedures to use and complete trade-related documentation	describe procedures to use and complete trade-related documentation
A-3.01.03L	demonstrate knowledge of confidentiality guidelines	identify elements of confidentiality guidelines, and describe their characteristics and applications
A-3.01.04L	demonstrate knowledge of regulatory requirements pertaining to use and completion of trade-related documentation	identify and interpret regulations pertaining to use and completion of trade-related documentation

## A-3.02 Prepares job action plan

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-3.02.01P	conduct pre-inspection of equipment to determine safety hazards and initial status of equipment	pre-inspection is conducted prior to starting the job action plan according to company policies and procedures
A-3.02.02P	determine tasks required	tasks required are determined prior to disassembly
A-3.02.03P	refer to <b>manufacturers' service information</b>	<b>manufacturers' service information</b> is referred to for an overview of service or repair procedures
A-3.02.04P	determine tools and equipment requirements	tools and equipment are determined according to task and <b>manufacturers' service information</b>
A-3.02.05P	use <b>procedures for recording</b> disassembly of equipment	<b>procedures for recording</b> disassembly of equipment are used to assist in reassembly
A-3.02.06P	plan space for all <b>operations</b>	space for all <b>operations</b> is planned according to task
A-3.02.07P	determine parts required and availability	parts required and availability is determined
A-3.02.08P	plan order of <b>service and repair procedures</b>	order of <b>service and repair procedures</b> are planned according to company policies and procedures, and <b>manufacturers' service information</b>
A-3.02.09P	consult with experienced technicians and <b>other trades</b>	experienced technicians and <b>other trades</b> are consulted with to coordinate job action plan
A-3.02.10P	estimate repair or service times and finish dates	repair or service times and finish dates are estimated
A-3.02.11P	organize travel schedule	travel schedule is organized in order to make most effective use of time

### Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**procedures for recording** include: taking pictures, tagging, marking

**operations** include: hoisting requirements, housekeeping, component storage

**service and repair procedures** include: disassembly, assembly, repair, rebuild, replace

**other trades** include: machinists, welders, electricians

## Knowledge

	Learning Outcomes	Learning Objectives
A-3.02.01L	demonstrate knowledge of elements of a job action plan	identify tools and equipment used for service, diagnosis and repair, and describe their procedures for use
		identify steps and describe importance of <b>procedures for recording</b> equipment disassembly
		describe procedures to determine availability of parts
		describe <b>service and repair procedures</b>
		interpret information found in <b>manufacturers' service information</b>

### Range of Variables

**procedures for recording** include: taking pictures, tagging, marking

**service and repair procedures** include: disassembly, assembly, repair, rebuild, replace

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

## A-3.03 Maintains fluids and lubricants

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

## Skills

	Performance Criteria	Evidence of Attainment
A-3.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
A-3.03.02P	identify safe handling procedures for <b>fluids</b> and <b>lubricants</b>	safe handling procedures for <b>fluids</b> and <b>lubricants</b> are identified according to WHMIS
A-3.03.03P	Verify and adjust <b>fluid</b> levels	<b>fluid</b> levels are verified and adjusted according to <b>manufacturers' service information</b>
A-3.03.04P	identify and select types and grades of <b>fluids</b> and <b>lubricants</b>	types and grades of <b>fluids</b> and <b>lubricants</b> are identified and selected according to application, environmental conditions and <b>manufacturers' service information</b>
A-3.03.05P	identify and select types of glycols and their additives	types of glycols and their additives are identified and selected according to <b>manufacturers' service information</b>



A-3.03.06P	verify coolant has been mixed properly	coolant is verified using tools and equipment to ensure it has been mixed properly
A-3.03.07P	store, recycle and dispose of <b>fluids</b> and <b>lubricants</b>	<b>fluids</b> and <b>lubricants</b> are stored, recycled and disposed of according to jurisdictional regulations
A-3.03.08P	test <b>fluid properties</b>	<b>fluid properties</b> are tested using diagnostic equipment according to <b>manufacturers' service information</b>
A-3.03.09P	select and use <b>additives</b>	<b>additives</b> are selected and used according to <b>manufacturers' service information</b>
A-3.03.10P	take <b>fluid</b> samples	<b>fluid</b> samples are taken according <b>manufacturers' service information</b>
A-3.03.11P	interpret <b>fluid</b> sample results	<b>fluid</b> sample results are interpreted to indicate <b>issues</b>
A-3.03.12P	document service and repair	service and repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: dip sticks, sight glass, refractometers, test strips

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fluids** include: oils (hydraulic, engine, transmission, drive axle), washer fluids, fuels, lubricants, coolants, brake, diesel exhaust

**lubricants** include: oils and greases (synthetic, semi-synthetic, non-synthetic)

**fluid properties** include: coolant strength, oil viscosity

**additives** include: supplemental coolant additive (SCA), diesel fuel conditioners, limited slip additives

**issues** include: contamination, abnormal wear, signs of premature failure

## Knowledge

	Learning Outcomes	Learning Objectives
A-3.03.01L	demonstrate knowledge of <b>fluids</b> and <b>lubricants</b> , their characteristics and applications	identify types and grades of <b>fluids</b> and <b>lubricants</b> , and describe their characteristics and applications
		describe consequences of mixing different types of <b>fluids</b> and <b>lubricants</b>
		interpret information pertaining to <b>fluids</b> and <b>lubricants</b> found in <b>manufacturers' service information</b>

A-3.03.02L	demonstrate knowledge of procedures to maintain <b>fluids</b> and <b>lubricants</b>	identify <b>tools and equipment</b> used to maintain <b>fluids</b> and <b>lubricants</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to maintain <b>fluids</b> and <b>lubricants</b>
		describe procedures to maintain level of <b>fluids</b> and <b>lubricants</b>
		describe procedures to collect <b>fluid</b> samples
		describe procedures to dispose of and recycle oil, coolant, air conditioning refrigerant, contaminated fuels and filters
		identify practices that reduce material waste
A-3.03.03L	demonstrate knowledge of regulatory requirements to recycle and dispose of oil, coolant, air conditioning refrigerant, contaminated fuels and filters	identify and interpret standards and regulations to recycle and dispose of oil, coolant, air conditioning refrigerant, contaminated fuels and filters
A-3.03.04L	demonstrate knowledge of emerging technologies and practices related to extending service intervals	identify reusable filters, and describe their characteristics and applications

### Range of Variables

**fluids** include: oils (hydraulic, engine, transmission, drive axle), washer fluids, fuels, lubricants, coolants, brake, diesel exhaust

**lubricants** include: oils and greases (synthetic, semi-synthetic, non-synthetic)

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: dip sticks, sight glass, refractometers, test strips

**hazards** include: caustic, respiratory, carcinogenic, poisoning

**A-3.04****Services hoses, tubing, piping and fittings**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

**Skills**

	<b>Performance Criteria</b>	<b>Evidence of Attainment</b>
A-3.04.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
A-3.04.02P	drain fluid and relieve pressure from air and fluid systems	fluid is drained and pressure is relieved from air and fluid systems before disconnecting hoses, tubing and fittings according to service conditions and <b>manufacturers' service information</b>
A-3.04.03P	identify and document <b>conditions</b>	<b>conditions</b> are identified and documented according to sensory inspection of hoses, tubing and fittings
A-3.04.04P	route and secure hoses, tubing and fittings	hoses, tubing and fittings are routed and secured using <b>methods</b> to avoid chafing, crush/pinch points or interference with other components
A-3.04.05P	identify and replace hoses and tubing	hoses and tubing are identified and replaced according to <b>application</b> and <b>manufacturers' service information</b>
A-3.04.06P	identify and replace <b>fittings</b> and clamping devices	<b>fittings</b> and clamping devices are identified and replaced according to thread, fitting size, compatibility and <b>manufacturers' service information</b>
A-3.04.07P	install ferrules, nuts and inserts	ferrules, nuts and inserts are installed according to design and application
A-3.04.08P	construct hose and tubing assemblies	hose and tubing assemblies are constructed using <b>tools and equipment</b>
A-3.04.09P	crimp and press fittings	fittings are crimped and pressed using crimping tools, presses and dies
A-3.04.10P	fabricate hoses, tubing and piping	hoses, tubing and piping are fabricated according to manufacturers' specifications
A-3.04.11P	bend and flare tubing and piping	tubing and piping are bent and flared using <b>tools and equipment</b>
A-3.04.12P	document service	service is documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: crimping tools, tube flaring tools, hose presses, specialized tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: holes, cracks, breakage, chafing, leaks, bubbling

**methods** include: using clamps, springs, separators and ties

**application** includes: size, pressure limits, fluid type

**fittings** include: metric, imperial

Knowledge		
	Learning Outcomes	Learning Objectives
A-3.04.01L	demonstrate knowledge of hoses, tubing and fittings, their characteristics, applications and operation	identify <b>types of hoses, tubing and fittings</b> , and describe their characteristics and applications
		describe operating principles of hoses, tubing and fittings
		interpret information pertaining to hoses, tubing and fittings found in <b>manufacturers' service information</b>
		identify ratings and applications of hoses, tubing, piping and fittings
		identify <b>types of fittings</b> , and describe their characteristics and applications
A-3.04.02L	demonstrate knowledge of procedures to remove and install hoses, tubing and fittings	describe compatibility of hoses, tubing and fittings with non OEM materials
		identify tools and equipment used to remove and install hoses, tubing and fittings, and describe their applications and procedures for use
		identify hazards and describe safe work practices to service hoses, tubing and fittings
		describe procedures to inspect hoses, tubing and fittings
A-3.04.03L	demonstrate knowledge of regulatory requirements pertaining to hoses, tubing and fittings	describe procedures to remove and install hoses, tubing and fittings
		identify and interpret standards and regulations pertaining to hoses, tubing and fittings

## Range of Variables

**types of hoses, tubing and fittings** include: plastic, rubber, neoprene, steel

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of fittings** include: reusable, crimp, press type

## A-3.05 Services bearings and seals

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-3.05.01P	select and use tools and equipment	tools and equipment are selected and used according to task and <b>manufacturers' service information</b>
A-3.05.02P	inspect <b>bearings</b> for <b>conditions</b>	<b>bearings</b> are inspected for <b>conditions</b>
A-3.05.03P	inspect <b>seals</b> for <b>conditions</b> during installation	<b>seals</b> are inspected for <b>conditions</b> during installation
A-3.05.04P	inspect <b>seals</b> and sealing surfaces for damage after installation	<b>seals</b> and sealing surfaces are inspected for damage after installation
A-3.05.05P	lubricate and install <b>bearings</b> and bushings	<b>bearings</b> and bushings are lubricated and installed according to <b>manufacturers' service information</b>
A-3.05.06P	install <b>seals</b>	<b>seals</b> are installed according to <b>manufacturers' service information</b>
A-3.05.07P	adjust <b>bearings</b>	<b>bearings</b> are adjusted according to <b>manufacturers' service information</b>
A-3.05.08P	heat or cool <b>bearings</b>	<b>bearings</b> are heated or cooled according to <b>manufacturers' service information</b>
A-3.05.09P	measure temperature of metals	temperature of metals is measured using <b>measuring methods</b>

### Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**bearings** include: friction, non-friction

**conditions** (bearings) include: pitting, scoring, discolouration, excessive wear, cracks, breakage, distortions

**seals** include: static, dynamic

**conditions** (seals) include: distortion, warped sealing surface, installation damage, brittleness, cracks, breakage

**measuring methods** include: using a heat stick, using infrared temperature gun and measuring with temperature probe

## Knowledge

Learning Outcomes	Learning Objectives
A-3.05.01L demonstrate knowledge of <b>bearings</b> and <b>seals</b> , their characteristics, applications and operation	identify types of <b>bearings</b> and <b>seals</b> , and describe their characteristics and applications
	describe operating principles of <b>bearings</b> and <b>seals</b>
	interpret information pertaining to <b>bearings</b> and <b>seals</b> found in <b>manufacturers' service information</b>
A-3.05.02L demonstrate knowledge of procedures to service <b>bearings</b> and <b>seals</b>	identify required temperature of heating and cooling of materials
	identify tools and equipment used to service <b>bearings</b> and <b>seals</b> , and describe their applications and procedures for use
	identify <b>hazards</b> and describe safe work practices to service <b>bearings</b> and <b>seals</b>
	describe procedures to inspect <b>bearings</b> , <b>seals</b> and sealing surfaces
	describe procedures to service <b>bearings</b> and <b>seals</b>
	describe procedures to remove and install <b>bearings</b> and <b>seals</b>
	describe procedures to <b>repair surfaces</b> for <b>bearings</b> and <b>seals</b> installations

### Range of Variables

**bearings** include: friction, non-friction

**seals** include: static, dynamic

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: removal process, flying shards

**repair surfaces** include: installing wear sleeves, re-machining of shaft, line boring

## A-3.06 Uses fasteners and sealing materials

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-3.06.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
A-3.06.02P	select and install fasteners	fasteners are selected and installed according to <b>factors</b> and <b>manufacturers' service information</b>
A-3.06.03P	tighten fasteners	fasteners are tightened according to <b>manufacturers' service information</b>
A-3.06.04P	select and apply <b>sealing materials</b>	<b>sealing materials</b> are selected and applied according to application, environmental conditions and <b>manufacturers' service information</b>
A-3.06.05P	verify quality of fasteners and <b>sealing materials</b>	fasteners and <b>sealing materials</b> are verified according to <b>manufacturers' service information</b>
A-3.06.06P	remove broken fasteners	broken fasteners are removed while minimizing damage to threads
A-3.06.07P	repair threads	threads are repaired using <b>tools</b>
A-3.06.08P	remove <b>sealing materials</b>	<b>sealing materials</b> are removed while minimizing damage to sealing surface
A-3.06.09P	fabricate and install <b>sealing materials</b>	<b>sealing materials</b> are fabricated and installed according to application and <b>manufacturers' service information</b>

### Range of Variables

**tools and equipment** include: rivet guns, impact guns, glue guns, torque wrenches, crimpers, air hammers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**factors** include: application, type, grade, thread pitch, size

**sealing materials** include: weatherstripping, window channel, aerobic and anaerobic sealants, O-rings, compound gaskets, paper gaskets, head gaskets

**tools** (to repair threads) include: taps, dies, chasers, thread inserts

## Knowledge

Learning Outcomes	Learning Objectives	
A-3.06.01L	demonstrate knowledge of fasteners, their characteristics, applications and operation	identify types, grades and torque specifications of fasteners, and describe their characteristics and applications
		describe operating principles of fasteners
		interpret information pertaining to fasteners found in <b>manufacturers' service information</b>
A-3.06.02L	demonstrate knowledge of <b>sealing materials</b> , their characteristics, applications and operation	identify types of <b>sealing materials</b> , and describe their characteristics and applications
		describe operating principles of <b>sealing materials</b>
		interpret information pertaining to <b>sealing materials</b> found in <b>manufacturers' service information</b>
A-3.06.03L	demonstrate knowledge of procedures to apply, remove and install fasteners and <b>sealing materials</b>	identify <b>tools and equipment</b> used with fasteners and <b>sealing materials</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to use fasteners and <b>sealing materials</b>
		identify <b>tools</b> used to repair threads, and describe their procedures for use
		describe procedures used to repair threads
		describe procedures to remove and install fasteners and <b>sealing materials</b>
		describe procedures to apply <b>sealing materials</b>
		describe torque sequence and associated <b>procedures</b>
		identify aerobic and anaerobic materials, and describe their characteristics and applications
A-3.06.04L	demonstrate knowledge of regulatory requirements pertaining to <b>sealing materials</b> and adhesives	identify ventilation requirements when using sealants and adhesives
		identify and interpret standards and regulations pertaining to handling, storing and disposing of <b>sealing materials</b>



## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**sealing materials** include: weatherstripping, window channel, aerobic and anaerobic sealants, O-rings, compound gaskets, paper gaskets, head gaskets

**tools and equipment** include: rivet guns, impact guns, glue guns, torque wrenches, crimpers, air hammers

**hazards** include: seal failure, fastener failure, irritants

**tools** (to repair threads) include: taps, dies, chasers, thread inserts

**procedures** (torque) include: torque stages, torque to yield, torque turn, torque pattern

### A-3.07 Services safety features

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
A-3.07.01P	perform function test and maintenance of <b>safety features</b>	function test and maintenance of <b>safety features</b> are performed according to <b>manufacturers' service information</b>
A-3.07.02P	report <b>conditions</b> of <b>safety features</b>	<b>conditions</b> of <b>safety features</b> are reported to supervisor to ensure defects are corrected
A-3.07.03P	<b>determine</b> criteria for repair or replacement of <b>safety features</b>	criteria for repair or replacement of <b>safety features</b> are determined according to <b>manufacturers' service information</b>
A-3.07.04P	repair <b>safety features</b>	<b>safety features</b> are repaired according to <b>manufacturers' service information</b> and jurisdictional regulations
A-3.07.05P	remove and replace <b>safety features</b>	<b>safety features</b> are removed and replaced according to <b>manufacturers' service information</b> and jurisdictional regulations
A-3.07.06P	adjust <b>safety features</b>	<b>safety features</b> are adjusted according to <b>manufacturers' service information</b> and jurisdictional regulations

## Range of Variables

**safety features** include: restraints, warning devices, limit devices

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, leaks

## Knowledge

Learning Outcomes	Learning Objectives	
A-3.07.01L	demonstrate knowledge of <b>safety features</b> , their characteristics, applications and operation	identify <b>safety features</b> and describe their characteristics and applications
		describe operating principles of <b>safety features</b>
		interpret information pertaining to <b>safety features</b> found in <b>manufacturers' service information</b>
A-3.07.02L	demonstrate knowledge of procedures to service <b>safety features</b>	identify tools and equipment used to service <b>safety features</b> , and describe their applications and procedures for use
		identify hazards and describe safe work practices to service <b>safety features</b>
		describe procedures to inspect <b>safety features</b>
		describe procedures to service <b>safety features</b>
		describe procedures to dispose of and recycle <b>safety features</b>
A-3.07.03L	demonstrate knowledge of regulatory requirements to recycle and dispose of <b>safety features</b>	identify practices that reduce <b>safety features</b> waste
		identify and interpret standards and regulations to recycle and dispose of <b>safety features</b>
A-3.07.04L	demonstrate knowledge of emerging technologies and practices related to <b>safety features</b>	identify emerging technologies pertaining to <b>safety features</b>

### Range of Variables

**safety features** include: restraints, warning devices, limit devices

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

## A-3.08 Performs operational check-out

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-3.08.01P	perform walk-around inspection and start-up procedures	walk-around inspection and start-up procedures are performed according to <b>manufacturers' service information</b>
A-3.08.02P	verify working condition of operating equipment	working condition of operating equipment is verified according to <b>manufacturers' service information</b>
A-3.08.03P	perform equipment shut-down procedures	equipment shut-down procedures are performed according to <b>manufacturers' service information</b>
A-3.08.04P	document and report findings from operational check-out	findings from operational check-out are documented and reported to supervisor according to company policies and procedures

### Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

### Knowledge

	Learning Outcomes	Learning Objectives
A-3.08.01L	demonstrate knowledge of operational check-outs	identify safety lockout devices, and describe their characteristics and applications
		interpret information pertaining to operational check-outs found in <b>manufacturers' service information</b>
A-3.08.02L	demonstrate knowledge of procedures to perform operational check-out	describe procedures to perform walk-around inspection and start-up procedures
		describe procedures to perform equipment shut-down

### Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

## Task A-4 Uses communication and mentoring techniques

### Task Descriptor

Learning in the trades is done primarily in the workplace with tradespeople passing on their skills and knowledge to apprentices, as well as sharing knowledge among themselves. Apprenticeship is, and always has been about mentoring – learning workplace skills and passing them on. Because of the importance of this to the trade, this task covers the activities related to communication in the workplace and mentoring skills.

#### A-4.01 Uses communication techniques

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
A-4.01.01P	demonstrate communication practices with individuals or in a group	instructions and messages are interpreted by all parties involved in communication
A-4.01.02P	listen using <b>active listening</b> practices	<b>active listening</b> practices are used
A-4.01.03P	speak clearly using correct industry terminology to ensure understanding	understanding of message is confirmed by both parties
A-4.01.04P	receive and respond to instructions	response to instructions indicates understanding
A-4.01.05P	receive and respond to feedback on work completed or performed	response to feedback indicates understanding and corrective measures are taken
A-4.01.06P	explain and provide feedback	explanation and feedback are provided and task is carried out as directed
A-4.01.07P	use questions to improve communication	questions enhance understanding, on-the-job training and goal setting
A-4.01.08P	participate in safety and information meetings	meetings are attended, information is relayed to workforce and is applied
A-4.01.09P	send and receive <b>electronic messages</b>	<b>electronic messages</b> are sent and received using professionalism, plain language and clear expressions according to company policy

### Range of Variables

**active listening** includes: hearing, interpreting, reflecting, responding, paraphrasing

**electronic messages** include: e-mail, text messages

## Knowledge

	Learning Outcomes	Learning Objectives
A-4.01.01L	demonstrate knowledge of trade terminology	define terminology used in trade
A-4.01.02L	demonstrate knowledge of effective communication practices	describe importance of using effective verbal and non-verbal communication with <b>people in the workplace</b>
		identify <b>sources of information</b> to effectively communicate
		identify communication and <b>learning styles</b>
		describe effective listening and speaking skills
		describe how to receive and give instructions effectively
		identify <b>personal responsibilities and attitudes</b> that contribute to on-the-job success
		identify value of equity, diversity and inclusion in workplace
		identify communication that constitutes bullying, <b>harassment</b> and <b>discrimination</b>
		identify communication styles appropriate to different systems and applications of <b>electronic messages</b>

### Range of Variables

**people in the workplace** include: other tradespeople, colleagues, apprentices, supervisors, clients, jurisdictional representatives, manufacturers

**sources of information** include: regulations, codes, occupational health and safety requirements, jurisdictional requirements, prints, drawings, specifications, company and client documentation

**learning styles** include: visual, auditory, reading, writing, kinesthetic

**personal responsibilities and attitudes** include: asking questions, working safely, accepting constructive feedback, time management and punctuality, respect for authority, good stewardship of materials, tools and property, efficient work practice

**harassment:** as defined by the Canadian and jurisdictional Human Rights Commissions, workplace policies

**discrimination:** as defined by the Canadian Human Rights Act and jurisdictional human rights laws, workplace policies

**electronic messages** include: e-mail, text messages

## A-4.02 Uses mentoring techniques

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
A-4.02.01P	identify and communicate learning objective and point of lesson	apprentice or learner can explain objective and point of lesson
A-4.02.02P	link lesson to other lessons and project	lesson order and unplanned learning opportunities are defined
A-4.02.03P	demonstrate performance of a skill to an apprentice or learner	<b>steps required to demonstrate a skill</b> are performed
A-4.02.04P	set up conditions required for apprentice or learner to practice a skill	<b>practice conditions</b> are set up so that skill can be practiced safely by apprentice or learner
A-4.02.05P	assess apprentice or learner's ability to perform tasks with increasing independence	skills of apprentice or learner improves with practice to a point where skill can be performed with little supervision
A-4.02.06P	give supportive and corrective feedback	apprentice or learner adopts best practice after having been given supportive or corrective feedback
A-4.02.07P	support apprentices or learners in pursuing technical training opportunities	technical training is completed within timeframe prescribed by apprenticeship authority
A-4.02.08P	support anti- <b>harassment</b> and anti- <b>discrimination</b> practices in workplace	workplace is <b>harassment-</b> and <b>discrimination-free</b>
A-4.02.09P	assess apprentice or learner suitability to trade during probationary period	apprentice or learner is given constructive feedback that helps them identify their own strengths and weaknesses and suitability for the trade

### Range of Variables

**steps required to demonstrate a skill** include: understanding who, what, where, when, why, and how, explaining, showing, giving encouragement, following up to ensure skill is performed correctly

**practice conditions** means: guided, limited independence, full independence

**harassment:** as defined by the Canadian and jurisdictional Human Rights Commissions, workplace policies

**discrimination:** as defined by the Canadian Human Rights Act and jurisdictional human rights laws, workplace policies

## Knowledge

Learning Outcomes	Learning Objectives
A-4.02.01L demonstrate knowledge of strategies for learning skills in workplace	describe importance of individual experience
	describe shared responsibilities for workplace learning
	determine one's own learning preferences and explain how these relate to learning new skills
	describe importance of different types of skills in workplace
	describe importance of <b>essential skills</b> in workplace
	identify different <b>learning styles</b>
	identify different <b>learning needs</b> and strategies to meet them
	identify <b>strategies to assist in learning a skill</b>
	A-4.02.02L demonstrate knowledge of strategies for teaching workplace skills
describe teaching skills	
explain importance of identifying point of lesson	
identify how to choose a good time to present lesson	
explain importance of linking lessons	
identify context for learning skills	
describe considerations in setting up opportunities for skill practice	
explain importance of providing feedback	
identify techniques for giving effective feedback	
describe a skills assessment	
identify methods of assessing progress	
explain how to adjust lesson to different situations	

### Range of Variables

**essential skills** are: reading, document use, writing, oral communication, numeracy, thinking, working with others, digital technology, continuous learning

**learning styles** include: visual, auditory, reading, writing, kinesthetic

**learning needs** include: learning disabilities, learning preferences, language proficiency

**strategies to assist in learning a skill** include: understanding the basic principles of instruction, developing coaching skills, being mature and patient, providing feedback

# Major Work Activity B

## Services, diagnoses and repairs engines and supporting systems

### Task B-5 Services, diagnoses and repairs base engines

#### Task Descriptor

Heavy duty equipment technicians must diagnose and service the base engine and its components to ensure proper engine function and reduce down time. A base engine is the assembled block and head including internal components and gear trains (long block). Servicing includes the adjustment of components as well as their routine maintenance. Diagnosing is required to locate failures to effectively perform repairs on the engine, which may include replacement or rebuilding of components.

#### **B-5.01** Services base engines

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
B-5.01.01P	select and use tools and equipment	tools and equipment are selected and used according to task and <b>manufacturers' service information</b>
B-5.01.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-5.01.03P	collect oil sample	oil sample is collected according to sample kit instructions, visually inspected for residual contaminants, then sent for analysis according to company policies and customer request
B-5.01.04P	perform sensory inspection of base engine <b>components</b>	sensory inspection of base engine <b>components</b> is performed to identify <b>conditions</b>
B-5.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>



B-5.01.06P	adjust clearance of valve train components	clearance of valve train components is adjusted according to <b>manufacturers' service information</b>
B-5.01.07P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: heads, block, pistons, connecting rods, crankshaft, wrist pins, bearings, camshaft, harmonic balancers, gears, lifters, covers, gaskets, seals, push rods, valves, rockers, springs, flywheel housing, flywheel, liners

**conditions** include: noise, leaks, wear, damage, defects, smoke, fumes, odours

**measurements** include: valve lash, engine compression brake, top set, revolutions per minute (RPM) (engine speed)

Knowledge		
	Learning Outcomes	Learning Objectives
B-5.01.01L	demonstrate knowledge of base engines, their <b>components</b> , characteristics, applications and operation	identify types of base engines and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of base engines
		interpret information pertaining to base engines found in <b>manufacturers' service information</b>
B-5.01.02L	demonstrate knowledge of procedures to service base engines and their <b>components</b>	identify tools and equipment used to service base engines and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service base engines
		describe procedures to inspect base engines and their <b>components</b>
		describe procedures to clean <b>components</b>
		describe procedures to service base engines and their <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to remove, replace, recycle and dispose of consumables

		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-5.01.03L	demonstrate knowledge of regulatory requirements pertaining to base engines	identify codes, standards and regulations pertaining to base engines
B-5.01.04L	demonstrate knowledge of emerging technologies and practices related to base engines	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technological improvements to base engine materials and design

## Range of Variables

**components** include: heads, block, pistons, connecting rods, crankshaft, wrist pins, bearings, camshaft, harmonic balancers, gears, lifters, covers, gaskets, seals, push rods, valves, rockers, springs, flywheel housing, flywheel, liners

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: sharp edges, weight, size, heat, moving parts, noise

## B-5.02 Diagnoses base engines

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-5.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
B-5.02.02P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
B-5.02.03P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-5.02.04P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
B-5.02.05P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>

B-5.02.06P	inspect valve timing and adjustment	valve timing and adjustment is inspected according to <b>manufacturers' service information</b>
B-5.02.07P	verify complaint and expected performance	complaint and expected performance are verified by comparing equipment operation to <b>manufacturers' service information</b>
B-5.02.08P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
B-5.02.09P	interpret oil sample analysis results	oil sample analysis results are interpreted to determine specific <b>component</b> wear
B-5.02.10P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
B-5.02.11P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-5.02.12P	perform failure analysis	failure analysis is performed to determine root cause of failure
B-5.02.13P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
B-5.02.14P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: abnormal vibration, leaks, noise, no start, hard start, low power, low oil pressure

**sensory inspections** include: feeling for vibrations, listening for abnormal sounds, smelling for burning oil

**conditions** include: leaks, wear, damage, defects, failure

**tools and equipment** include: temperature measuring devices, compression testers, measuring instruments, pressure measuring devices, dynamometers, fluid analysis sampling devices, electronic service tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: heads, block, pistons, connecting rods, crankshaft, wrist pins, bearings, camshaft, harmonic balancers, gears, lifters, covers, gaskets, seals, push rods, valves, rockers, springs, flywheel housing, flywheel, liners

**tests** include: compression tests, cylinder leakage, oil pressure, dynamometer checks, fluid sampling for analysis, injector cut-out, vacuum, crack testing, non-destructive

**measurements** include: bore alignment, warpage, protrusion, run out, pressures, bearing clearances, straightness, taper, out-of-round, crankshaft end play, gear lash

**next steps** include: repairs, component replacement, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
B-5.02.01L	demonstrate knowledge of base engines, their <b>components</b> , characteristics, applications and operation	identify types of base engines and their <b>components</b> , and describe their characteristics and applications describe operating principles of base engines interpret information pertaining to base engines found in <b>manufacturers' service information</b> identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
B-5.02.02L	demonstrate knowledge of procedures to diagnose base engines and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose base engines and their <b>components</b> , and describe their applications and procedures for use identify <b>hazards</b> and describe safe work practices to diagnose base engines describe common causes and <b>symptoms of problems</b> describe procedures to inspect base engines and their <b>components</b> describe procedures to <b>test</b> base engines and their <b>components</b> describe procedures to diagnose base engines and their <b>components</b> describe procedures to clean base engines and their <b>components</b> identify steps for failure analysis identify materials that can be reconditioned, reused or recycled

### Range of Variables

**components** include: heads, block, pistons, connecting rods, crankshaft, wrist pins, bearings, camshaft, harmonic balancers, gears, lifters, covers, gaskets, seals, push rods, valves, rockers, springs, flywheel housing, flywheel, liners

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: temperature measuring devices, compression testers, measuring instruments, pressure measuring devices, dynamometers, fluid analysis sampling devices, electronic service tools

**hazards** include: sharp edges, weight, size, heat, moving parts

**symptoms of problems** include: abnormal vibration, leaks, noise, no start, hard start, low power, low oil pressure

**tests** include: compression tests, cylinder leakage, oil pressure, dynamometer checks, fluid sampling for analysis, injector cut-out, vacuum, crack testing, non-destructive

**B-5.03****Repairs base engines**

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

<b>Skills</b>		
<b>Performance Criteria</b>	<b>Evidence of Attainment</b>	
B-5.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-5.03.02P	prepare equipment for engine repair, removal and reinstallation procedures	equipment is prepared for engine repair, removal and reinstallation procedures by performing <b>functions</b>
B-5.03.03P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-5.03.04P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
B-5.03.05P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
B-5.03.06P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
B-5.03.07P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
B-5.03.08P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
B-5.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
B-5.03.10P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
B-5.03.11P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
B-5.03.12P	perform mechanical engine timing procedures	mechanical engine timing procedures are performed according to <b>manufacturers' service information</b>
B-5.03.13P	perform pre-lubrication procedures	pre-lubrication procedures are performed according to <b>manufacturers' service information</b>

B-5.03.14P	perform updates	updates are performed according to <b>manufacturers' service information</b>
B-5.03.15P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
B-5.03.16P	document repairs performed	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: torque wrenches, dial indicators, measuring instruments, lifting devices, engine rotator, torque angle gauge, feeler gauges, dynamometer, hand tools, plastigauge, straight edge, micrometer

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**functions** include: disconnecting electrical connections, draining fluids, steam cleaning engine

**components** include: heads, block, pistons, connecting rods, crankshaft, wrist pins, bearings, camshaft, harmonic balancers, gears, lifters, covers, gaskets, seals, push rods, valves, rockers, springs, flywheel housing, flywheel, liners

**conditions** include: wear, damage, defects, failure, leaks

**parts and materials** include: gaskets, sealants, fastening devices

**methods** (to verify repairs) include: operational testing, dynamometer testing, electronic diagnostic testing

## Knowledge

	Learning Outcomes	Learning Objectives
B-5.03.01L	demonstrate knowledge of base engines, their <b>components</b> , characteristics, applications and operation	identify types of base engines and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of base engines
		interpret information pertaining to base engines found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		identify potential environmental and health impacts of repair, and describe associated prevention measures

B-5.03.02L	demonstrate knowledge of procedures to repair base engines and their <b>components</b>	identify <b>tools and equipment</b> used to repair base engines and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair base engines
		describe procedures to remove, disassemble, inspect and assemble <b>components</b>
		describe procedures to replace, rebuild or repair <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-5.03.03L	demonstrate knowledge of emerging technologies and practices related to base engines	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technological improvements to base engine materials and design

## Range of Variables

**components** include: heads, block, pistons, connecting rods, crankshaft, wrist pins, bearings, camshaft, harmonic balancers, gears, lifters, covers, gaskets, seals, push rods, valves, rockers, springs, flywheel housing, flywheel, liners

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: torque wrenches, dial indicators, measuring instruments, lifting devices, engine rotator, torque angle gauge, feeler gauges, dynamometer, hand tools, plastigauge, straight edge, micrometer

**hazards** include: sharp edges, weight, size, heat, moving parts, noise

**methods** (to verify repairs) include: operational testing, dynamometer testing, electronic diagnostic testing

# Task B-6 Services, diagnoses and repairs lubrication systems

## Task Descriptor

Heavy duty equipment technicians must service, diagnose and repair the lubrication system to ensure proper protection of the engine and its components.

Servicing includes the replacement of consumables as well as the routine maintenance of the system. Diagnosing is required to determine the root cause of failures to effectively perform repairs on lubrication systems.

### B-6.01 Services lubrication systems

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-6.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-6.01.02P	clean lubrication system <b>components</b>	lubrication system <b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-6.01.03P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify worn, damaged and defective <b>components</b>
B-6.01.04P	measure oil pressure, temperature and level	oil pressure, temperature and level are measured to determine if they meet <b>manufacturers' service information</b>
B-6.01.05P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
B-6.01.06P	recycle or dispose of <b>consumables</b>	<b>consumables</b> are recycled or disposed of according to jurisdictional regulations
B-6.01.07P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking



## Range of Variables

**tools and equipment** include: hand tools, power tools, sample pump, pressure gauge

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: oil pumps, oil coolers, pressure regulator valves, bypass valves, inlet strainers, oil filters, lubricants, oil lines, oil sumps, gears, seals, gaskets, pressure relief valves

**sensory inspections** include: looking for leaks, smelling for burnt oil, checking magnetic drain plug for contamination

**consumables** include: oil filters, oil, gaskets, sealants

Knowledge		
	Learning Outcomes	Learning Objectives
B-6.01.01L	demonstrate knowledge of lubrication systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of lubrication systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of lubrication systems
		interpret information pertaining to lubrication systems found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		describe functions and characteristics of engine oil
B-6.01.02L	demonstrate knowledge of procedures to service lubrication systems and their <b>components</b>	identify <b>fluid classifications</b>
		identify <b>tools and equipment</b> used to service lubrication systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service lubrication systems
		describe procedures to inspect lubrication systems and their <b>components</b>
		describe procedures to service lubrication systems and their <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		identify materials that can be reconditioned, reused or recycled
identify practices that reduce material waste		

B-6.01.03L	demonstrate knowledge of regulatory requirements pertaining to lubrication systems	identify and interpret standards and regulations pertaining to lubrication systems
B-6.01.04L	demonstrate knowledge of emerging technologies and practices related to lubrication systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: oil pumps, oil coolers, pressure regulator valves, bypass valves, inlet strainers, oil filters, lubricants, oil lines, oil sumps, gears, seals, gaskets, pressure relief valves

**consumables** include: oil filters, oil, gaskets, sealants

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fluid classifications** include: OEM, American Petroleum Institute (API), Society of Automotive Engineers (SAE)

**tools and equipment** include: hand tools, power tools, sample pump, pressure gauge

**hazards** include: high temperatures, skin irritation, splashing, dripping oil, fire

## B-6.02 Diagnoses lubrication systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-6.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
B-6.02.02P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
B-6.02.03P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-6.02.04P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
B-6.02.05P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>

B-6.02.06P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
B-6.02.07P	determine type of <b>lubricant</b> to be used	type of <b>lubricant</b> to be used is determined according to <b>manufacturers' service information</b> and operating conditions
B-6.02.08P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
B-6.02.09P	perform oil sampling	oil sample is taken, and results are interpreted using <b>sensory inspection</b> , lab results for failure analysis according to <b>manufacturers' service information</b>
B-6.02.10P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
B-6.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
B-6.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
B-6.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: low or high fluid level, low or high oil pressure, internal or external oil leaks, oil dilution, cross-contaminated oil, high oil temperature, worn components

**sensory inspections** include: listening for engine knock, smelling oil, looking for leaks, visual inspection of levels

**conditions** include: blockages, leakages, wear, damage, defects, failure

**tools and equipment** include: pressure gauges, infrared or direct contact thermometers, dyes, fluid analysis sampling devices, temperature gauges, onboard diagnostic tools, filter cutter

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: oil pump, oil cooler, pressure regulator valves, bypass valves, inlet strainers, oil filters, lubricants, oil lines, oil sump, gears, seals, gaskets, pressure relief valve

**lubricants** include: oils and greases (synthetic, semi-synthetic, non-synthetic)

**tests** include: oil pressure and temperature, contamination, system pressure, inspect contamination in filter media

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

Learning Outcomes	Learning Objectives	
B-6.02.01L	demonstrate knowledge of lubrication systems, their <b>components</b> , characteristics, applications and operation	identify types of lubrication systems and their <b>components</b> , and describe their characteristics, applications and operation
		describe operating principles of lubrication systems
		interpret information pertaining to lubrication systems found in <b>manufacturers' service information</b>
		describe functions and characteristics of engine oil
		identify <b>fluid classifications</b>
B-6.02.02L	demonstrate knowledge of procedures to diagnose lubrication systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose lubrication systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose lubrication systems
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect lubrication systems and their <b>components</b>
		describe procedures to <b>test</b> lubrication systems and their <b>components</b>
		describe procedures to diagnose lubrication systems and their <b>components</b>
		identify steps for failure analysis
		identify practices that reduce material waste
	identify materials that can be reconditioned, reused or recycled	
B-6.02.03L	demonstrate knowledge of regulatory requirements pertaining to lubrication systems	identify and interpret standards and regulations pertaining to lubrication systems

B-6.02.04L	demonstrate knowledge of emerging technologies and practices related to lubrication systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: oil pump, oil cooler, pressure regulator valves, bypass valves, inlet strainers, oil filters, lubricants, oil lines, oil sump, gears, seals, gaskets, pressure relief valve

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fluid classifications** include: OEM, API, SAE

**lubricants** include: oils and greases (synthetic, semi-synthetic, non-synthetic)

**tools and equipment** include: pressure gauges, infrared or direct contact thermometers, dyes, fluid analysis sampling devices, temperature gauges, onboard diagnostic tools, filter cutter

**hazards** include: high temperatures, high pressures, skin irritation, splashing, dripping oil, fire

**symptoms of problems** include: low or high fluid level, low or high oil pressure, internal or external oil leaks, oil dilution, cross-contaminated oil, high oil temperature, worn components

## B-6.03 Repairs lubrication systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-6.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-6.03.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-6.03.03P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-6.03.04P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
B-6.03.05P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>

B-6.03.06P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
B-6.03.07P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
B-6.03.08P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
B-6.03.09P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
B-6.03.10P	adjust <b>components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
B-6.03.11P	identify and select specified lubricants	specified lubricants are identified and selected according to <b>manufacturers' service information</b>
B-6.03.12P	perform priming and pre-lubrication of oil pressure system	priming and pre-lubrication of oil pressure system are performed according to <b>manufacturers' service information</b>
B-6.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
B-6.03.14P	document repairs performed	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: feeler gauges, oil pressure gauges, measuring tools, hand tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: oil pump, oil cooler, pressure regulator valves, bypass valves, inlet strainers, oil filters, lubricants, oil lines, oil sump, gears, seals, gaskets, pressure relief valve

**conditions** include: wear, failure, damage, defect

**parts and materials** include: gaskets, O-rings, sealants, fastening devices

**methods** include: checking oil pressure and oil levels

Knowledge		
	Learning Outcomes	Learning Objectives
B-6.03.01L	demonstrate knowledge of lubrication systems, their <b>components</b> , characteristics, applications and operation	identify types of lubrication systems, their <b>components</b> , and describe their characteristics, applications and operation
		describe operating principles of lubrication systems
		interpret information pertaining to lubrication systems found in <b>manufacturers' service information</b>

		describe functions and characteristics of engine oil
		identify <b>fluid classifications</b>
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
B-6.03.02L	demonstrate knowledge of procedures to repair lubrication systems and their <b>components</b>	identify tools and equipment used to repair lubrication systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair lubrication systems
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair, replace or recondition <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-6.03.03L	demonstrate knowledge of regulatory requirements pertaining to lubrication system waste disposal	identify and interpret standards and regulations pertaining to lubrication system waste disposal
B-6.03.04L	demonstrate knowledge of emerging technologies and practices related to lubrication systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: oil pump, oil cooler, pressure regulator valves, bypass valves, inlet strainers, oil filters, lubricants, oil lines, oil sump, gears, seals, gaskets, pressure relief valve

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fluid classifications** include: OEM, API, SAE

**hazards** include: high temperatures, skin irritation, splashing, dripping oil, fire, carcinogens

**methods** include: checking oil pressure and oil levels

## Task B-7 Services, diagnoses and repairs intake systems

### Task Descriptor

Heavy duty equipment technicians must service, diagnose and repair intake systems to ensure proper operation and performance of the engine.

Servicing includes the replacement of consumables and components as well as their routine maintenance. Diagnosing is required to determine root cause of failures to effectively perform repairs on intake systems.

### B-7.01 Services intake systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-7.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-7.01.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-7.01.03P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify worn, damaged and defective <b>components</b>
B-7.01.04P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-7.01.05P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>



B-7.01.06P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
B-7.01.07P	adjust <b>components</b>	<b>components</b> are adjusted according to <b>manufacturers' service information</b>
B-7.01.08P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, feeler gauges, torque wrench, dial indicator, spring compressor

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: turbochargers (variable geometry turbochargers [VGT] and compound), superchargers, piping, manifolds, filter housing, pressure and temperature sensors, intake throttle valve, tubing, air cleaner, coolers, pre-cleaners, restriction indicators, ether injection, positive air shut offs

**sensory inspections** include: listening for air escaping, looking for incorrect fit or installation of piping, checking gauges

**measurements** include: valve clearance, vacuum, boost pressure, leak down

**consumables** include: gaskets, filters, sealants, clamps

Knowledge		
	Learning Outcomes	Learning Objectives
B-7.01.01L	demonstrate knowledge of intake systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	<p>identify types of intake systems, their <b>components</b> and <b>consumables</b>, and describe their characteristics and applications</p> <p>describe operating principles of intake systems</p> <p>interpret information pertaining to intake systems found in <b>manufacturers' service information</b></p> <p>identify types of <b>starting aids</b> and describe their characteristics, applications and safe use</p>
B-7.01.02L	demonstrate knowledge of procedures to service intake systems, their <b>components</b> and <b>consumables</b>	<p>identify <b>tools and equipment</b> used to service intake systems, their <b>components</b> and <b>consumables</b>, and describe their applications and procedures for use</p> <p>identify <b>hazards</b> and describe safe work practices to service intake systems</p> <p>describe procedures to inspect intake systems, and their <b>components</b> and <b>consumables</b></p>

		describe procedures to clean intake systems, and their <b>components</b> and <b>consumables</b>
		describe procedures to service intake systems, and their <b>components</b> and <b>consumables</b>
		describe procedures to adjust <b>components</b>
		describe procedures to remove, replace, recycle and dispose of intake system <b>consumables</b>
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-7.01.03L	demonstrate knowledge of emerging technologies and practices related to intake systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: turbochargers (variable geometry turbochargers [VGT] and compound), superchargers, piping, manifolds, filter housing, pressure and temperature sensors, intake throttle valve, tubing, air cleaner, coolers, pre-cleaners, restriction indicators, ether injection, positive air shut offs

**consumables** include: gaskets, filters, sealants, clamps

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**starting aids** include: intake heaters, ether injection, glow plugs

**tools and equipment** include: hand tools, feeler gauges, torque wrench, dial indicator, spring compressor

**hazards** include: running engine in confined spaces, dangers surrounding air inlets, moving parts, noise, toxicity

**B-7.02****Diagnoses intake systems**

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

**Skills**

	<b>Performance Criteria</b>	<b>Evidence of Attainment</b>
B-7.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
B-7.02.02P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
B-7.02.03P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-7.02.04P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
B-7.02.05P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-7.02.06P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
B-7.02.07P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
B-7.02.08P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
B-7.02.09P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
B-7.02.10P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-7.02.11P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-7.02.12P	perform failure analysis	failure analysis is performed to determine root cause of failure

B-7.02.13P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
B-7.02.14P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>
B-7.02.15P	inspect and test <b>starting aids</b>	<b>starting aids</b> are inspected and tested according to <b>manufacturers' service information</b>

## Range of Variables

**symptoms of problems** include: excessive noise, excessive heat, visible exhaust smoke, low power, no start, low boost

**sensory inspections** include: listening for air escaping, looking for incorrect fit or installation of piping, checking gauges

**conditions** include: wear, damage, defect, failure, leaks (air, oil)

**tools and equipment** include: pressure gauges, infrared temperature gun, electronic service tools, pressure test kits, manometers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: turbochargers (VGT and compound), superchargers, piping, manifolds, filter housing, pressure and temperature sensors, intake throttle valve, tubing, air cleaner, coolers, pre-cleaners, restriction indicators, ether injection

**tests** include: turbo boost, engine performance, intake pressure

**measurements** include: vacuum, boost pressure, after cooler leak down

**next steps** include: repairs, component replacement or adjustment, further diagnosis

**starting aids** include: intake heaters, ether injection, glow plugs

## Knowledge

	Learning Outcomes	Learning Objectives
B-7.02.01L	demonstrate knowledge of intake systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of intake systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of intake systems
		interpret information pertaining to intake systems found on <b>manufacturers' service information</b>
		identify types of <b>starting aids</b> and describe their characteristics, applications and safe use
		identify <b>intake system contamination</b>
		identify <b>emergency shutdown devices</b>

B-7.02.02L	demonstrate knowledge of procedures to diagnose intake systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose intake systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose intake systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect intake systems and their <b>components</b>
		describe procedures to test intake systems and their <b>components</b>
		describe procedures to diagnose intake systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing intake systems and their <b>components</b>
		identify steps for failure analysis
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
B-7.02.03L	demonstrate knowledge of emerging technologies and practices related to intake systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: turbochargers (VGT and compound), superchargers, piping, manifolds, filter housing, pressure and temperature sensors, intake throttle valve, tubing, air cleaner, coolers, pre-cleaners, restriction indicators, ether injection

**consumables** include: gaskets, filters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**starting aids** include: intake heaters, ether injection, glow plugs

**intake system contamination** includes: dust, oil, antifreeze, soot

**emergency shutdown devices** include: positive air shut downs

**tools and equipment** include: pressure gauges, infrared temperature gun, electronic service tools, pressure test kits, manometers

**hazards** include: running engine in confined spaces, dangers surrounding air inlets

**symptoms of problems** include: excessive noise, excessive heat, visible exhaust smoke, low power, no start, low boost

**conditions** include: wear, damage, defect, failure, leaks (air, oil)

**B-7.03****Repairs intake systems**

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

**Skills**

	<b>Performance Criteria</b>	<b>Evidence of Attainment</b>
B-7.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-7.03.02P	remove, disassemble and inspect <b>components for conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-7.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-7.03.04P	select <b>components</b>	<b>components</b> are selected according to repair requirements and <b>manufacturers' service information</b>
B-7.03.05P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
B-7.03.06P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
B-7.03.07P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
B-7.03.08P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
B-7.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
B-7.03.10P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
B-7.03.11P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
B-7.03.12P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
B-7.03.13P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: pressure gauges, infrared temperature gun, electronic service tools, pressure test kits, manometers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: turbochargers (VGT and compound), superchargers, piping, manifolds, filter housing, pressure and temperature sensors, intake throttle valve, tubing, air cleaner, coolers, pre-cleaners, restriction indicators, ether injection

**conditions** include: wear, damage, defect, failure, leaks (air, oil)

**components** (to be adjusted and calibrated) include: intake throttle valves, electronic waste gate, VGT actuators

**methods** include: pressure testing intake system, performing sensory observations of intake system, load testing

Knowledge		
	Learning Outcomes	Learning Objectives
B-7.03.01L	demonstrate knowledge of intake systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of intake systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of intake systems
		interpret information pertaining to intake systems found in <b>manufacturers' service information</b>
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
B-7.03.02L	demonstrate knowledge of procedures to repair intake systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair intake systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair intake systems and their <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace and repair <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled

		identify practices that reduce material waste
B-7.03.05L	demonstrate knowledge of emerging technologies and practices related to intake systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: turbochargers (VGT and compound), superchargers, piping, manifolds, filter housing, pressure and temperature sensors, intake throttle valve, tubing, air cleaner, coolers, pre-cleaners, restriction indicators, ether injection

**consumables** include: gaskets, filters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, infrared temperature gun, electronic service tools, pressure test kits, manometers

**hazards** include: running engine in confined spaces, dangers surrounding air inlets, toxicity

**methods** include: pressure testing intake system, performing sensory observations of intake system, load testing



# Task B-8 Services, diagnoses and repairs exhaust systems

## Task Descriptor

Heavy duty equipment technicians must service and diagnose the exhaust systems to ensure proper operation and performance of the engine systems.

Servicing includes the replacement of consumables and components as well as their routine maintenance. Diagnosing is required to determine root cause of failures to effectively perform repairs on exhaust systems.

### B-8.01 Services exhaust systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-8.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-8.01.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-8.01.03P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify worn, damaged and defective <b>components</b>
B-8.01.04P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-8.01.05P	remove and replace <b>components</b> and <b>consumables</b>	<b>components</b> and <b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
B-8.01.06P	recycle and dispose of <b>components</b> and <b>consumables</b>	<b>components</b> and <b>consumables</b> are recycled and disposed of according to jurisdictional regulations
B-8.01.07P	adjust <b>components</b>	<b>components</b> are adjusted according to <b>manufacturers' service information</b>
B-8.01.08P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: electronic service tools, temperature and pressure measuring devices, feeler gauges

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: muffler, piping, turbo, waste gates, manifolds, exhaust brake, exhaust diverter valve

**sensory inspections** include: looking for leaks, looking for visible exhaust smoke, listening for leaks (noise)

**measurements** include: waste gate travel, temperature, pressure

**consumables** include: gaskets, clamps, sealants

Knowledge		
	Learning Outcomes	Learning Objectives
B-8.01.01L	demonstrate knowledge of exhaust systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of exhaust systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of exhaust systems
		interpret information pertaining to exhaust systems found in <b>manufacturers' service information</b>
B-8.01.02L	demonstrate knowledge of procedures to service exhaust systems, their <b>components</b> and <b>consumables</b>	identify <b>tools and equipment</b> used to service exhaust systems, their <b>components</b> and <b>consumables</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service exhaust systems
		describe procedures to inspect exhaust systems and their <b>components</b>
		describe procedures to clean <b>components</b>
		describe procedures to service exhaust systems and their <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		describe procedures to perform software updates
		identify practices that reduce material waste

B-8.01.03L	demonstrate knowledge of exhaust brakes and components	describe procedures to adjust, diagnose and repair exhaust brakes and components
B-8.01.04L	demonstrate knowledge of regulatory requirements pertaining to exhaust systems	identify and interpret standards and regulations pertaining to exhaust systems
B-8.01.05L	demonstrate knowledge of emerging technologies and practices related to exhaust systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: muffler, piping, turbo, waste gates, manifolds, exhaust brake, exhaust diverter valve

**consumables** include: gaskets, clamps, sealants

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: electronic service tools, temperature and pressure measuring devices, feeler gauges

**hazards** include: skin and eye irritation, high temperatures, hazardous fumes, poor ventilation, toxicity

## B-8.02 Diagnoses exhaust systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-8.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
B-8.02.02P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
B-8.02.03P	diagnose exhaust brakes	exhaust brakes are diagnosed using <b>methods</b> and <b>manufacturers' service information</b>
B-8.02.04P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-8.02.05P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem

B-8.02.06P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-8.02.07P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
B-8.02.08P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
B-8.02.09P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
B-8.02.10P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
B-8.02.11P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-8.02.12P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-8.02.13P	perform failure analysis	failure analysis is performed to determine root cause of failure
B-8.02.14P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
B-8.02.15P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: excessive noise, damaged components, excessive heat, leaks, low power, visible exhaust smoke, warning lights, fault codes

**sensory inspections** include: looking for leaks, looking for visible exhaust smoke, listening for leaks (noise)

**conditions** include: wear, damage, defect, failure

**methods** (exhaust brakes) include: noise, effectiveness, load, setting

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, infrared temperature guns, electronic service tools, temperature and pressure measuring devices, feeler gauges, dial indicators

**components** include: muffler, piping, turbo, waste gates, manifolds, exhaust brake, exhaust diverter valve

**tests** include: turbo boost, engine performance, temperature and pressure

**measurements** include: waste gate travel, temperature, pressure

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

Learning Outcomes	Learning Objectives
B-8.02.01L demonstrate knowledge of exhaust systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of exhaust systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
	describe operating principles of exhaust systems
	interpret information pertaining to exhaust systems found in <b>manufacturers' service information</b>
B-8.02.02L demonstrate knowledge of procedures to diagnose exhaust brakes	describe procedures to test exhaust brakes
B-8.02.03L demonstrate knowledge of procedures to diagnose exhaust systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose exhaust systems and their <b>components</b> , and describe their applications and procedures for use
	identify <b>hazards</b> and describe safe work practices to diagnose exhaust systems and their <b>components</b>
	describe common causes and <b>symptoms of problems</b>
	describe procedures to inspect exhaust systems and their <b>components</b>
	describe procedures to test exhaust systems and their <b>components</b>
	describe procedures to diagnose exhaust systems and their <b>components</b>
	identify <b>conditions</b> found while diagnosing exhaust systems and their <b>components</b>
	identify steps for failure analysis
	identify practices that reduce material waste
	identify materials that can be reconditioned, reused or recycled
B-8.02.04L demonstrate knowledge of regulatory requirements pertaining to exhaust systems	identify and interpret standards and regulations pertaining to exhaust systems
B-8.02.05L demonstrate knowledge of emerging technologies and practices related to exhaust systems	identify technologies that reduce environmental impacts
	describe strategies and practices that reduce the carbon footprint
	identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: muffler, piping, turbo, waste gates, manifolds, exhaust brake, exhaust diverter valve

**consumables** include: gaskets, clamps, sealants

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, infrared temperature guns, electronic service tools, temperature and pressure measuring devices, feeler gauges, dial indicators

**hazards** include: skin and eye irritation, high temperatures, hazardous fumes, poor ventilation, noise

**symptoms of problems** include: excessive noise, damaged components, excessive heat, leaks, low power, visible exhaust smoke, warning lights, fault codes

**conditions** include: wear, damage, defect, failure

### B-8.03 Repairs exhaust systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
B-8.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-8.03.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-8.03.03P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-8.03.04P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
B-8.03.05P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
B-8.03.06P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
B-8.03.07P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
B-8.03.08P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
B-8.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>

B-8.03.10P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
B-8.03.11P	adjust <b>components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
B-8.03.12P	repair exhaust brake <b>components</b>	exhaust brake <b>components</b> are repaired according to <b>manufacturers' service information</b>
B-8.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
B-8.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: pressure gauges, infrared temperature guns, electronic service tools, temperature and pressure measuring devices, dial indicators, hand tools, heating tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: muffler, piping, turbo, waste gates, manifolds, gaskets

**conditions** include: wear, damage, defect, failure

**parts and materials** include: gaskets, sealants, fastening devices

**components** (exhaust brakes) include: solenoids, set screws, harness

**methods** include: operation, load test, temperature test

## Knowledge

	Learning Outcomes	Learning Objectives
B-8.03.01L	demonstrate knowledge of exhaust systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of exhaust systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of exhaust systems
		interpret information pertaining to exhaust systems found on <b>manufacturers' service information</b>
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures

B-8.03.02L	demonstrate knowledge of procedures to repair exhaust systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair exhaust systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair exhaust systems and their <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild or repair <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe procedures to repair exhaust brake <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-8.03.03L	demonstrate knowledge of regulatory requirements pertaining to exhaust systems	identify and interpret standards and regulations pertaining to exhaust systems
B-8.03.04L	demonstrate knowledge of emerging technologies and practices related to exhaust systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: muffler, piping, turbo, waste gates, manifolds, gaskets

**consumables** include: filter, gasket, sealant

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, infrared temperature guns, electronic service tools, temperature and pressure measuring devices, dial indicators, hand tools, heating tools

**components** (exhaust brakes) include: solenoids, set screws, harness

**hazards** include: skin and eye irritation, high temperatures, hazardous fumes, poor ventilation, noise, toxicity

**methods** include: operation, load test, temperature test



## Task B-9 Services, diagnoses and repairs engine management systems

### Task Descriptor

Heavy duty equipment technicians must service and diagnose the engine management system to ensure proper operation of integrated systems.

Servicing is primarily a matter of updating software to meet both manufacturer programming and fleet/owner requirements. Diagnosing is required to determine root cause of failures in order to effectively perform repairs on engine management systems.

### B-9.01 Services engine management systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-9.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-9.01.02P	set electronic control module ( <b>ECM parameters</b> )	<b>ECM parameters</b> are set according to <b>manufacturers' service information</b> and fleet/owner requirements
B-9.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-9.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify leaks and worn, damaged and defective <b>components</b>
B-9.01.05P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
B-9.01.06P	perform software updates	engine management system software updates are performed according to <b>manufacturers' service information</b>
B-9.01.07P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: electronic service tools, multimeters, break-out harnesses, back probes

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**ECM parameters** include: shutdowns, speed controls, fan controls, fixed and variable settings

**components** include: harnesses, ECMs, switches, sensors, actuators

**sensory inspections** include: visual, tactile, smell

Knowledge		
	Learning Outcomes	Learning Objectives
B-9.01.01L	demonstrate knowledge of engine management systems, their <b>components</b> , characteristics, applications and operation	identify engine management systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of engine management systems
		interpret information pertaining to engine management systems found in <b>manufacturers' service information</b>
		describe effect of static electricity and external voltage induction on delicate electronic components
		describe elements of manufacturers' engine ratings
B-9.01.02L	demonstrate knowledge of procedures to service engine management systems and their <b>components</b>	identify <b>tools and equipment</b> used to service engine management systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service engine management systems and their <b>components</b>
		describe procedures to service engine management systems and their <b>components</b>
		describe procedures to inspect engine management systems and their <b>components</b>
		describe procedures to clean <b>components</b>
B-9.01.03L	demonstrate knowledge of regulatory requirements pertaining to engine management systems	describe procedures to perform software updates
		identify codes, standards and regulations pertaining to engine management systems

B-9.01.04L	demonstrate knowledge of emerging technologies and practices related to engine management systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: harnesses, ECMs, switches, sensors, actuators

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: electronic service tools, multimeters, break-out harnesses, back probes

**hazards** include: noise, sharp edges, electrocution, crush/pinch points

## B-9.02 Diagnoses engine management systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-9.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
B-9.02.02P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
B-9.02.03P	isolate static electricity	static electricity is isolated through grounding process
B-9.02.04P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-9.02.05P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
B-9.02.06P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
B-9.02.07P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
B-9.02.08P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values

B-9.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-9.02.10P	analyze <b>ECM diagnostic information</b>	<b>ECM diagnostic information</b> is reviewed for <b>next steps</b>
B-9.02.11P	perform <b>engine control system diagnosis</b>	<b>engine control system diagnosis</b> is performed according to <b>manufacturers' service information</b>
B-9.02.12P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
B-9.02.13P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-9.02.14P	perform <b>failure</b> analysis	<b>failure</b> analysis is performed to determine root cause of failure
B-9.02.15P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
B-9.02.16P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: misfires, gauges with readings outside expected range, engine shutdowns, no start, derated power, fault codes, warning lights, throttle linkage wear, linkage binding

**sensory inspections** include: visual, tactile, smell

**conditions** include: wear, damage, defects, failure

**tools and equipment** include: electronic service tools, multimeters, pin-out equipment, break-out harnesses, back probes, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: harnesses, switches, sensors, actuators, ECMs, software, wiring, coils, spark plugs, solenoids, sensors, linkages, pedals, cables, potentiometer, engine protection devices

**tests** (spark ignition system) include: coil resistance test, spark plug gap

**ECM diagnostic information** include: fault codes, parameters, software version

**next steps** include: repairs, component replacement or adjustment, further diagnosis

**engine control system diagnosis** include: solenoid test, calibration test, injector cut-out test

**measurements** include: resistance, voltage outputs, voltage inputs, reference voltage, frequency, sensor set-ups, proximity

**failures** include: poor connections, chafed or corroded harnesses, faulty components

## Knowledge

Learning Outcomes	Learning Objectives	
B-9.02.01L	demonstrate knowledge of engine management systems, their <b>components</b> , characteristics, applications and operation	identify engine management systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of engine management systems
		interpret information pertaining to engine management systems found on <b>manufacturers' service information</b>
		describe effect of static electricity and external voltage induction on delicate electronic components
		identify <b>types of specialized connectors and harnesses</b>
B-9.02.02L	demonstrate knowledge of procedures to diagnose engine management systems and their <b>components</b>	describe elements of manufacturers' engine ratings
		identify <b>tools and equipment</b> used to diagnose engine management systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose engine management systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b> and <b>failures</b>
		describe procedures to inspect engine management systems and their <b>components</b>
		describe procedures to test engine management systems and their <b>components</b>
		describe procedures to diagnose engine management systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing engine management systems and their <b>components</b>
B-9.02.03L	demonstrate knowledge of regulatory requirements pertaining to engine management systems	identify steps for failure analysis
		identify codes, standards and regulations pertaining to engine management systems

B-9.02.04L	demonstrate knowledge of emerging technologies and practices related to engine management systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: harnesses, switches, sensors, actuators, ECMs, software, wiring, coils, spark plugs, solenoids, sensors, linkages, pedals, cables, potentiometer, engine protection devices

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of specialized connectors and harnesses** include: sensor connections, injector harnesses, ECM connectors

**tools and equipment** include: electronic service tools, multimeters, pin-out equipment, break-out harnesses, back probes, laptop

**hazards** include: high-voltage outputs, hot surfaces, sharp edges, crush/pinch points, moving parts

**symptoms of problems** include: misfires, gauges with readings outside expected range, engine shutdowns, no start, derated power, fault codes, warning lights, throttle linkage wear, linkage binding

**failures** include: poor connections, chafed or corroded harnesses, faulty components

**conditions** include: wear, damage, defects, failure

## B-9.03 Repairs engine management systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-9.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-9.03.02P	isolate static electricity	static electricity is isolated through grounding process
B-9.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-9.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-9.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>

B-9.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
B-9.03.07P	perform updates and recalls	updates and recalls are performed according to <b>manufacturers' service information</b>
B-9.03.08P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
B-9.03.09P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
B-9.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
B-9.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
B-9.03.12P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
B-9.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
B-9.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: electronic service tools, multimeters, pin-out equipment, break-out harnesses, hand tools, crimpers, back probes, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: ECMs, harnesses, sensors, actuators, resistors, switches

**conditions** include: wear, damage, defect, failure

**parts and materials** include: terminals including pins and sockets, bulk wire, heat shrink, solder, frame clamps

**components** (to be repaired) include: harnesses, connectors, terminals

**components** (to be adjusted and calibrated) include: injectors, turbochargers, speed control sensors, exhaust gas recirculation (EGR) valves, intake throttle valves, exhaust sensors, controllers

**methods** include: clearing codes, resetting virtual breaker, verifying that fault codes remain inactive, performing operational tests

## Knowledge

	Learning Outcomes	Learning Objectives
B-9.03.01L	demonstrate knowledge of engine management systems, their <b>components</b> , characteristics, applications and operation	identify engine management systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of engine management systems

		interpret information pertaining to engine management systems found in <b>manufacturers' service information</b>
		describe elements of manufacturers' engine ratings
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
B-9.03.02L	demonstrate knowledge of procedures to repair engine management systems and their <b>components</b>	identify tools and equipment used to repair engine management systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair engine management systems and their <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair or replace <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		identify materials that can be reused or recycled
		identify practices that reduce material waste
B-9.03.03L	demonstrate knowledge of regulatory requirements pertaining to engine management systems	identify codes, standards and regulations pertaining to engine management systems
B-9.03.04L	demonstrate knowledge of emerging technologies and practices related to engine management systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: ECMs, harnesses, sensors, actuators, resistors, switches

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: high-voltage outputs, hot surfaces, sharp edges, crush/pinch points, moving parts

**components** (to be repaired) include: harnesses, connectors, terminals

**components** (to be adjusted and calibrated) include: injectors, turbochargers, speed control sensors, exhaust gas recirculation (EGR) valves, intake throttle valves, exhaust sensors, controllers



# Task B-10 Services, diagnoses and repairs fuel delivery systems

## Task Descriptor

Heavy duty equipment technicians must service, diagnose and repair the fuel delivery system to ensure proper engine operation and minimize downtime.

### B-10.01 Services fuel delivery systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
B-10.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-10.01.02P	release or isolate stored energy	stored energy is released or isolated according to <b>manufacturers' service information</b>
B-10.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-10.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify worn, damaged and defective <b>components</b>
B-10.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-10.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
B-10.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
B-10.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
B-10.01.09P	prime fuel delivery system for operation	fuel delivery system is primed for operation
B-10.01.10P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
B-10.01.11P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: pressure gauges, vacuum gauges, hand tools, power tools, electronic service tools, laptops, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: fuels, fuel filters, regulators, tanks, lines, lift pumps, mechanical and electronic injectors, pumps, fuel injector pumps, hoses, tubes, water separators, governors, timing and spark advance, seals, gaskets, sensors, solenoids, harness, carburetor

**sensory inspections** include: smelling or looking for fuel leaks, looking for excessive exhaust smoke, listening for engine miss

**measurements** include: pressure, vacuum, flow, temperature, spray patterns, torquing, engine speed

**consumables** include: fuels, filters, fuel-water separators, fuel additives

Knowledge		
	Learning Outcomes	Learning Objectives
B-10.01.01L	demonstrate knowledge of fuel delivery systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of fuel delivery systems</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of fuel delivery systems
		interpret information pertaining to fuel delivery systems found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		identify grade, condition and <b>types of fuels</b> , and describe their characteristics and applications
		identify <b>types of fuel additives</b> and describe their characteristics, applications and effects
B-10.01.02L	demonstrate knowledge of procedures to service fuel delivery systems, their <b>components</b> and <b>consumables</b>	identify <b>tools and equipment</b> used to service fuel delivery systems, their <b>components</b> and <b>consumables</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service fuel delivery systems
		describe procedures to release or isolate stored energy
		describe procedures to inspect fuel delivery systems and their <b>components</b>
		describe procedures to clean <b>components</b>
		describe procedures to service fuel delivery systems and their <b>components</b>

		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to remove, replace recycle and dispose of fuel delivery system <b>consumables</b>
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-10.01.03L	demonstrate knowledge of regulatory requirements pertaining to fuel delivery systems	identify and interpret regulations pertaining to fuel delivery systems
B-10.01.04L	demonstrate knowledge of emerging technologies and practices related to fuel delivery systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: fuels, fuel filters, regulators, tanks, lines, lift pumps, mechanical and electronic injectors, pumps, fuel injector pumps, hoses, tubes, water separators, governors, timing and spark advance, seals, gaskets, sensors, solenoids, harness, carburetor

**consumables** include: fuels, filters, fuel-water separators, fuel additives

**types of fuel delivery systems** include: mechanical, electronic, hydraulic, carburation

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of fuels** include: winter and summer diesel fuels, natural gas, biodiesel, gasoline, biofuels, compressed natural gas (CNG), liquefied propane gas (LPG)

**types of fuel additives** include: antigel, antiwax, fuel conditioner

**hazards** include: extreme high pressure, flammable and explosive materials, environmental irritant, noxious fumes, noise, freeze hazard (LPG)

## B-10.02 Diagnoses fuel delivery systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-10.02.01P	identify <b><i>symptoms of problems</i></b>	<b><i>symptoms of problems</i></b> are identified by consulting with customer or operator
B-10.02.02P	perform <b><i>sensory inspections</i></b>	<b><i>sensory inspections</i></b> are performed to identify <b><i>conditions</i></b>
B-10.02.03P	release or isolate stored energy	stored energy is released or isolated according to <b><i>manufacturers' service information</i></b>
B-10.02.04P	select and use <b><i>tools and equipment</i></b>	<b><i>tools and equipment</i></b> are selected and used according to task and <b><i>manufacturers' service information</i></b>
B-10.02.05P	remove and disassemble <b><i>components</i></b> to identify problem	<b><i>components</i></b> are removed and disassembled to identify problem
B-10.02.06P	inspect <b><i>components</i></b> for <b><i>conditions</i></b>	<b><i>components</i></b> are inspected for <b><i>conditions</i></b> according to <b><i>manufacturers' service information</i></b>
B-10.02.07P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b><i>manufacturers' service information</i></b>
B-10.02.08P	perform diagnostic procedures and <b><i>tests</i></b>	diagnostic procedures and <b><i>tests</i></b> are performed according to <b><i>manufacturers' service information</i></b>
B-10.02.09P	verify diagnosis	diagnosis is verified by interpreting <b><i>test</i></b> results and comparing them to <b><i>manufacturers' service information</i></b> or expected values
B-10.02.10P	perform <b><i>measurements</i></b>	<b><i>measurements</i></b> are performed and compared with <b><i>manufacturers' service information</i></b>
B-10.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
B-10.02.12P	document <b><i>test</i></b> results and inspection findings	<b><i>test</i></b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
B-10.02.13P	interpret diagnostic results to determine <b><i>next steps</i></b>	diagnostic results are interpreted to determine <b><i>next steps</i></b>

## Range of Variables

**symptoms of problems** include: rough running engine, poor engine performance, no start, fuel leaks, aeration, abnormal exhaust smoke

**sensory inspections** include: smelling and looking for leaks, listening for engine misfires and vibrations, looking for excessive exhaust smoke

**conditions** include: wear, defects, damage, failure

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, vacuum gauges, flow meters, dynamometers, electronic service tools, injector testers, multimeter, laptop

**components** include: fuels, fuel filter, regulators, tank, lines, lift pump, mechanical and electronic injectors, pumps, fuel injector pumps, hoses, tubes, water separator, governors, timing and spark advance, seals, gaskets, sensors, solenoids, harness

**tests** include: injector cut-out, injector performance, transfer pump pressure, return volume, filter restriction, injector leakage, engine performance, fuel pressure

**measurements** include: pressure, vacuum, flow, temperature, torquing, engine speed

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
B-10.02.01L	demonstrate knowledge of fuel delivery systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of fuel delivery systems</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of fuel delivery systems
		interpret information pertaining to fuel delivery systems found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		identify grade, condition and <b>types of fuels</b> , and describe their characteristics and applications
		identify <b>types of fuel additives</b> and describe their characteristics and applications
B-10.02.02L	demonstrate knowledge of procedures to diagnose fuel delivery systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose fuel delivery systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose fuel delivery systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>

		describe procedures to inspect fuel delivery systems and their <b>components</b>
		describe procedures to test fuel delivery systems and their <b>components</b>
		describe procedures to diagnose fuel delivery systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing fuel delivery systems and their <b>components</b>
		identify steps for failure analysis
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-10.02.03L	demonstrate knowledge of regulatory requirements pertaining to fuel delivery systems	identify and interpret regulations pertaining to fuel delivery systems
B-10.02.04L	demonstrate knowledge of emerging technologies and practices related to fuel delivery systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: fuels, fuel filter, regulators, tank, lines, lift pump, mechanical and electronic injectors, pumps, fuel injector pumps, hoses, tubes, water separator, governors, timing and spark advance, seals, gaskets, sensors, solenoids, harness

**consumables** include: fuels, filters, fuel-water separators

**types of fuel delivery systems** include: mechanical, electronic

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of fuels** include: winter and summer diesel fuels, natural gas, biodiesel, gasoline, biofuels, CNG, LPG

**types of fuel additives** include: antigel, antiwax, fuel conditioners

**tools and equipment** include: pressure gauges, vacuum gauges, flow meters, dynamometers, electronic service tools, injector testers, multimeter, laptop

**hazards** include: extreme high pressure, flammable and explosive materials, environmental irritant, noxious fumes, freeze hazard (LPG)

**symptoms of problems** include: rough running engine, poor engine performance, no start, fuel leaks, aeration, abnormal exhaust smoke

**conditions** include: wear, defects, damage, failure

## B-10.03 Repairs fuel delivery systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-10.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-10.03.02P	release or isolate stored energy	stored energy is released or isolated according to <b>manufacturers' service information</b>
B-10.03.03P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-10.03.04P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-10.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
B-10.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
B-10.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
B-10.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
B-10.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
B-10.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
B-10.03.11P	reassemble <b>components</b> and perform <b>measurements</b>	<b>components</b> are reassembled and <b>measurements</b> are performed according to <b>manufacturers' service information</b>
B-10.03.12P	<b>adjust and calibrate components</b> and parts	<b>components</b> and parts are <b>adjusted and calibrated</b> according to <b>manufacturers' service information</b>
B-10.03.13P	perform updates and recalls	updates and recalls are performed according to <b>manufacturers' service information</b>
B-10.03.14P	prime fuel system for operation	fuel system is primed for operation
B-10.03.15P	torque components	components are torqued according to sequence and specifications
B-10.03.16P	pressurize and bleed system	system is pressurized and bled according to <b>manufacturers' service information</b>

B-10.03.17P	perform fuel system timing procedures	fuel system timing procedures are performed according to <b>manufacturers' service information</b>
B-10.03.18P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
B-10.03.19P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: torque wrenches, manufacturers' specialty tools, pullers, dial indicators, electronic service tools, fuel pressure gauges, hand tools, fuel transfer, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: fuels, fuel filter, regulators, tank, lines, lift pump, mechanical and electronic injectors, pumps, fuel injector pumps, hoses, tubes, water separator, governors, timing and spark advance, sensors, solenoids

**conditions** include: wear, damage, defect, failure

**parts and materials** include: gaskets, sealants, fastening devices, O-rings

**measurements** include: pressure, vacuum, flow, temperature, torquing, engine speed

**adjust and calibrate** includes: entering calibration values for electronic injectors, setting injector pre-load, confirming high and low throttle (mechanical injection systems), adjusting throttle linkages, setting injector height, setting pump timing

**methods** include: running equipment at operating condition, performing manufacturers' test procedures

## Knowledge

	Learning Outcomes	Learning Objectives
B-10.03.01L	demonstrate knowledge of fuel delivery systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of fuel delivery systems</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of fuel delivery systems
		interpret information pertaining to fuel delivery systems found in <b>manufacturers' service information</b>
		identify grade, condition and <b>types of fuels</b> , and describe their characteristics and applications
		identify <b>types of fuel additives</b> and describe their characteristics and applications
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures



		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
B-10.03.02L	demonstrate knowledge of procedures to repair fuel delivery systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair fuel delivery systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair fuel delivery systems
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe procedures to replace, rebuild or repair <b>components</b>
		describe <b>methods</b> to verify repairs
		identify practices that reduce material waste
B-10.03.03L	demonstrate knowledge of regulatory requirements pertaining to fuel delivery systems	identify and interpret regulations pertaining to fuel delivery systems
B-10.03.04L	demonstrate knowledge of emerging technologies and practices related to fuel delivery systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: fuels, fuel filter, regulators, tank, lines, lift pump, mechanical and electronic injectors, pumps, fuel injector pumps, hoses, tubes, water separator, governors, timing and spark advance, sensors, solenoids

**consumables** include: filters, O-rings, injector tubes, high pressure common rail injector lines

**types of fuel delivery systems** include: mechanical, electronic

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of fuels** include: winter and summer diesel fuels, natural gas, propane, biodiesel, gasoline, biofuels, CNG, LPG

**types of fuel additives** include: antigel, antiwax, fuel conditioners

**tools and equipment** include: torque wrenches, manufacturers' specialty tools, pullers, dial indicators, electronic service tools, fuel pressure gauges, hand tools, fuel transfer, laptop

**hazards** include: extreme high pressure, flammable and explosive materials, environmental irritant, noxious fumes, freeze hazard (LPG)

## Task B-11 Services, diagnoses and repairs emission control systems

### Task Descriptor

The emission control system controls and reduces harmful waste from the tailpipe. Some of these emissions include nitrous oxides (NOx), aldehydes, carbon monoxide, ammonia, and particulate matter. Heavy duty equipment technicians must service, diagnose and repair the emission control system to ensure proper operation and minimize downtime.

### B-11.01 Services emission control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-11.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-11.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
B-11.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-11.01.04P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>

B-11.01.05P	perform <b>measurements and readings</b>	<b>measurements and readings</b> are performed and compared with <b>manufacturers' service information</b>
B-11.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
B-11.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
B-11.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
B-11.01.09P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
B-11.01.10P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
B-11.01.11P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
B-11.01.12P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: electronic service tools, multimeters, emissions analyzers, manufacturer-specific equipment, refractometers, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: catalytic converters, scrubber, EGR components, positive crankcase ventilation (PCV) valves, exhaust gas coolers, sensors, diesel particulate filter (DPF), diesel oxidation catalyst (DOC), selective catalytic reduction (SCR), injectors, actuators, pumps, ammonia oxidation catalyst (AOC)

**measurements and readings** include: flow rate, DPF load capacity, pressures, duty cycles

**consumables** include: filters, DEF, coolant, gaskets, seals

Knowledge		
	Learning Outcomes	Learning Objectives
B-11.01.01L	demonstrate knowledge of emission control systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	<p>identify <b>types of emission control systems</b>, their <b>components</b> and <b>consumables</b>, and describe their characteristics and applications</p> <p>describe operating principles of emission control systems</p> <p>interpret information pertaining to emission control systems found in <b>manufacturers' service information</b></p>

		identify quality of DEF, and describe its characteristics and applications
B-11.01.02L	demonstrate knowledge of procedures to service emission control systems, their <b>components</b> and <b>consumables</b>	identify <b>tools and equipment</b> used to service emission control systems, their <b>components</b> and <b>consumables</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service emission control systems
		describe procedures to release and isolate stored energy
		describe procedures to inspect emission control systems and their <b>components</b>
		describe procedures to clean <b>components</b>
		describe procedures to service emission control systems and their <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to remove, replace recycle and dispose of emission control system <b>consumables</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned or reused
		identify practices that reduce material waste
B-11.01.03L	demonstrate knowledge of regulatory requirements pertaining to emission control systems	identify and interpret regulations pertaining to emission control systems
B-11.01.04L	demonstrate knowledge of emerging technologies and practices related to emission control systems	describe how emission control systems contribute to reduction of harmful emissions and pollution
		describe impact of hybrid and electric equipment on emission control systems and reduction in carbon footprint

## Range of Variables

**components** include: catalytic converters, scrubber, EGR components, positive crankcase ventilation (PCV) valves, exhaust gas coolers, sensors, diesel particulate filter (DPF), diesel oxidation catalyst (DOC), selective catalytic reduction (SCR), injectors, actuators, pumps, ammonia oxidation catalyst (AOC)

**consumables** include: filters, DEF, coolant, gaskets, seals

**types of emission control systems** include: tier 1, tier 2, tier 3, tier 4 interim, tier 4 final, tier 5

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: electronic service tools, multimeters, emissions analyzers, manufacturer-specific equipment, refractometers, laptop

**hazards** include: high pressure, high temperatures, flammable and explosive materials, airborne contaminants, noxious fumes, skin irritation, toxic materials, spills, noise

### B-11.02 Diagnoses emission control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

Performance Criteria		Evidence of Attainment
B-11.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
B-11.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-11.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
B-11.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
B-11.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
B-11.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
B-11.02.07P	interpret fuel system flow schematics	fuel system flow schematics are interpreted according to <b>manufacturers' service information</b>
B-11.02.08P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>

B-11.02.09P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
B-11.02.10P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-11.02.11P	perform <b>measurements and readings</b>	<b>measurements and readings</b> are performed and compared with <b>manufacturers' service information</b>
B-11.02.12P	perform failure analysis	failure analysis is performed to determine root cause of failure
B-11.02.13P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
B-11.02.14P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: exhaust smoke, rough running engine, poor engine performance, no start, fuel leaks, excessive smoke, damaged components, fault codes, exhaust leaks

**tools and equipment** include: pressure gauges, vacuum gauges, flow meters, dynamometers, electronic service tools, injector testers, gas analyzer, computer, multimeters, temperature measuring tools, refractometer, manufacturer-specific equipment, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, leaks

**tests** include: regeneration, pressure, DEF system integrity, exhaust after treatment fuel injector flow, DEF injector flow, emission system functionality, EGR

**components** include: catalytic converters, scrubber, EGR components, PCV valves, exhaust gas coolers, sensors, DPF, DOC, SCR, injectors, actuators, pumps, AOC

**measurements and readings** include: flow rate, DPF load capacity, pressures, duty cycles, temperatures

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
B-11.02.01L	demonstrate knowledge of emission control systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of emission control systems</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of emission control systems
		interpret information pertaining to emission control systems found in <b>manufacturers' service information</b>
		identify quality of DEF, and describe its characteristics and applications

B-11.02.02L	demonstrate knowledge of procedures to diagnose emission control systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose emission control systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose emission control systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect emission control systems and their <b>components</b>
		describe procedures to <b>test</b> emission control systems and their <b>components</b>
		describe procedures to diagnose emission control systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing emission control systems and their <b>components</b>
		identify steps for failure analysis
		identify materials that can be reconditioned or reused
		identify practices that reduce material waste
B-11.02.03L	demonstrate knowledge of regulatory requirements pertaining to emission control systems	identify and interpret regulations pertaining to emission control systems
B-11.02.04L	demonstrate knowledge of emerging technologies and practices related to emission control systems	describe how emission control systems contribute to reduction of harmful emissions and pollution
		describe impact of hybrid and electric equipment on emission control systems and reduction in carbon footprint

## Range of Variables

**components** include: catalytic converters, scrubber, EGR components, PCV valves, exhaust gas coolers, sensors, DPF, DOC, SCR, injectors, actuators, pumps, AOC

**consumables** include: filters, DEF, coolant, gaskets, seals

**types of emission control systems** include: tier 1, tier 2, tier 3, tier 4 interim, tier 4 final, tier 5

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, vacuum gauges, flow meters, dynamometers, electronic service tools, injector testers, gas analyzer, computer, multimeters, temperature measuring tools, refractometer, manufacturer-specific equipment, laptop

**hazards** include: high pressure, high temperatures, flammable and explosive materials, airborne contaminants, noxious fumes, skin irritation, toxic materials, spills, noise

**symptoms of problems** include: exhaust smoke, rough running engine, poor engine performance, no start, fuel leaks, excessive smoke, damaged components, fault codes, exhaust leaks

**tests** include: regeneration, pressure, DEF system integrity, exhaust after treatment fuel injector flow, DEF injector flow, emission system functionality, EGR

**conditions** include: wear, damage, defects, failure, leaks

### B-11.03 Repairs emission control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
B-11.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-11.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
B-11.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-11.03.04P	remove, disassemble and inspect <b>components for conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-11.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
B-11.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
B-11.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
B-11.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>



B-11.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
B-11.03.10P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
B-11.03.11P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
B-11.03.12P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
B-11.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
B-11.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: torque wrenches, manufacturer-specific equipment, pullers, dial indicators, electronic service tools, scan tools, exhaust gas analyzers, heating equipment, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: catalytic converters, scrubber, EGR components, PCV valves, exhaust gas coolers, sensors, DPF, DOC, SCR, injectors, actuators, pumps, AOC

**conditions** include: damage, defect, wear, failure, leaks

**parts and materials** include: gaskets, sealants, fastening devices

**methods** include: running equipment at operating condition, performing manufacturers' test procedures, performing exhaust gas analysis

## Knowledge

	Learning Outcomes	Learning Objectives
B-11.03.01L	demonstrate knowledge of emission control systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of emission control systems</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of emission control systems
		interpret information pertaining to emission control systems found in <b>manufacturers' service information</b>
		identify quality of DEF, and describe its characteristics and applications
B-11.03.02L	demonstrate knowledge of procedures to repair emission control systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair emission control systems and their <b>components</b> , and describe their applications and procedures for use

		identify <b>hazards</b> and describe safe work practices to repair emission control systems
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair or replace <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		describe procedures to perform software updates
		identify materials that can be reconditioned or reused
		identify practices that reduce material waste
B-11.03.03L	demonstrate knowledge of regulatory requirements pertaining to emission control systems	identify and interpret regulations pertaining to emission control systems
B-11.03.04L	demonstrate knowledge of emerging technologies and practices related to emission control systems	describe how emission control systems contribute to reduction of harmful emissions and pollution
		describe impact of hybrid and electric equipment on emission control systems and reduction in carbon footprint

## Range of Variables

**components** include: catalytic converters, scrubber, EGR components, PCV valves, exhaust gas coolers, sensors, DPF, DOC, SCR, injectors, actuators, pumps, AOC

**consumables** include: filters, DEF, coolant, gaskets, seals

**types of emission control systems** include: tier 1, tier 2, tier 3, tier 4 interim, tier 4 final, tier 5

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: torque wrenches, manufacturer-specific equipment, pullers, dial indicators, electronic service tools, scan tools, exhaust gas analyzers, heating equipment, laptop, multimeters

**hazards** include: high pressure, high temperatures, flammable and explosive materials, airborne contaminants, noxious fumes, skin irritation, toxic materials, spills, noise

**methods** include: running equipment at operating condition, performing manufacturers' test procedures, performing exhaust gas analysis

# Task B-12 Services, diagnoses and repairs cooling systems

## Task Descriptor

Heavy duty equipment technicians must service, diagnose and repair the cooling system to ensure proper operating temperature of the engine systems.

Servicing includes the replacement of consumables and components as well as their routine maintenance. Diagnosing is required to determine root cause of failures to effectively perform repairs on cooling systems.

### B-12.01 Services cooling systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-12.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-12.01.02P	flush cooling system	cooling system is flushed according to <b>manufacturers' service information</b>
B-12.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
B-12.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> of cooling system are performed to identify <b>problems</b>
B-12.01.05P	adjust belt tension	belt tension is adjusted according to <b>manufacturers' service information</b>
B-12.01.06P	measure coolant pH, sulphate and chloride levels	coolant pH, sulphate and chloride levels are measured to determine if they meet <b>manufacturers' service information</b> based on type of coolant
B-12.01.07P	test freezing point of coolant	freezing point of coolant is tested using <b>tools and equipment</b>
B-12.01.08P	release <b>stored energy</b>	<b>stored energy</b> is released by allowing system to cool and vent
B-12.01.09P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-12.01.10P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
B-12.01.11P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>

B-12.01.12P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
B-12.01.13P	adjust <b>components</b>	<b>components</b> are adjusted according to <b>manufacturers' service information</b>
B-12.01.14P	document service information and inspection findings	service information and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: refractometers, test strips, hydrometers, vacuum fill kits, flushing equipment, infrared temperature gun, coolant pressure kit, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: oil cooler, thermostats, cooling fan, radiators, hoses, fans, fan drives, radiator shrouds, belts, radiator caps, recovery tanks, coolant heaters, sensors, mechanical and electric water pumps, piping, shrouds, coolant, heat exchangers

**sensory inspections** include: smelling leaking coolant, looking for leaks

**problems** include: coolant leaks, low levels, condition of coolant, deterioration and contamination, cracked or missing fan blades, damaged hoses and belts, white exhaust, holes in radiator, restricted air flow, blockages

**stored energy** includes: heat, pressure

**measurements** include: temperature differential, fan speed, pressure, coolant strength, pH

**consumables** include: coolant conditioner, coolant

## Knowledge

	Learning Outcomes	Learning Objectives
B-12.01.01L	demonstrate knowledge of cooling systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of cooling systems, their <b>consumables</b> and <b>components</b> , and describe their characteristics and applications
		describe operating principles of cooling systems
		interpret information pertaining to cooling systems found in <b>manufacturers' service information</b>
		identify <b>types of coolants</b> and coolant additives, and describe their characteristics and applications
		describe <b>coolant properties</b>
		identify types and quality of fluids and describe their characteristics and applications

B-12.01.02L	demonstrate knowledge of procedures to service cooling systems, their <b>components</b> and <b>consumables</b>	identify <b>tools and equipment</b> used to service cooling systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service cooling systems
		describe procedures to release pressure of coolant
		describe procedures to inspect cooling systems and their <b>components</b>
		describe procedures to clean <b>components</b>
		describe procedures to test coolants
		describe procedures to adjust and measure cooling system <b>components</b>
		describe procedures to remove, replace, recycle and dispose of cooling system <b>consumables</b>
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-12.01.03L	demonstrate knowledge of emerging technologies and practices pertaining to cooling systems	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

### Range of Variables

**components** include: oil cooler, thermostats, cooling fan, radiators, hoses, fans, fan drives, radiator shrouds, belts, radiator caps, recovery tanks, coolant heaters, sensors, mechanical and electric water pumps, piping, shrouds, coolant, heat exchangers

**consumables** include: coolant conditioner, coolant

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of coolants** include: conventional inorganic acid technology (IAT), extended life organic acid technology (OAT), hybrid organic acid technology (HOAT)

**coolant properties** include: pH, freezing point, additive concentrations, conductivity

**tools and equipment** include: refractometers, test strips, hydrometers, vacuum fill kits, flushing equipment, infrared temperature gun, coolant pressure kit, laptop, multimeters

**hazards** include: pressure, steam, extreme heat, moving parts, skin irritation, toxicity

## B-12.02 Diagnoses cooling systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-12.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
B-12.02.02P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
B-12.02.03P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-12.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
B-12.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
B-12.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
B-12.02.07P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
B-12.02.08P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
B-12.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-12.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
B-12.02.11P	analyze cooler condition for reuse	cooler condition is analyzed for reuse according to <b>manufacturers' service information</b> and expected outcome
B-12.02.12P	test coolant concentration and condition	coolant concentration and condition is tested according to <b>manufacturers' service information</b>
B-12.02.13P	test radiator efficiency	radiator efficiency is tested for air flow and heat transfer
B-12.02.14P	perform failure analysis	failure analysis is performed to determine root cause of failure

B-12.02.15P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
B-12.02.16P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: coolant loss, low or high operating temperatures, excessive system pressure, warning lights, no cab heat, cross-contamination

**sensory inspections** include: looking for leaks and cracked hoses, smelling for coolant, tactile inspection of hoses

**tools and equipment** include: leak testing equipment, pressure measuring devices, refractometers, temperature measuring devices, fluid analysis sampling kit, hydrometers, belt tension gauges, coolant testers, air flow meters, coolant pressure testers, UV lights, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tests** include: dye, pressure, temperature, fan speed, radiator cap, air flow, combustion gas leakage detection

**components** include: oil cooler, thermostats, cooling fan, radiator, hoses, fans, fan drives, radiator shrouds, belts, radiator caps, recovery tanks, coolant heaters, sensors, mechanical and electric water pumps, piping, shrouds, coolant, heat exchangers

**consumables** include: gaskets, clamps, sealants, coolant

**conditions** include: wear, damage, defect, failure

**measurements** include: temperature, coolant properties

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
B-12.02.01L	demonstrate knowledge of cooling systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of cooling systems and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of cooling systems
		interpret information pertaining to cooling systems found in <b>manufacturers' service information</b>
		identify <b>types of coolants</b> and coolant additives, and describe their characteristics and applications
		describe <b>coolant properties</b>
		identify types and quality of fluids, and describe their characteristics and applications

B-12.02.02L	demonstrate knowledge of procedures to diagnose cooling systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose cooling systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose cooling systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect cooling systems and their <b>components</b>
		describe procedures to test cooling systems and their <b>components</b>
		describe procedures to diagnose cooling systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing cooling systems and their <b>components</b>
		identify steps for failure analysis
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
B-12.02.03L	demonstrate knowledge of regulatory requirements pertaining to cooling systems and their <b>components</b>	identify and interpret standards and regulations pertaining to cooling systems and their <b>components</b>
B-12.02.04L	demonstrate knowledge of emerging technologies and practices related to pertaining to cooling systems	identify technologies that reduce environmental impacts
		identify technologies that address emissions and pollution, and describe their characteristics and applications



## Range of Variables

**components** include: oil cooler, thermostats, cooling fan, radiator, hoses, fans, fan drives, radiator shrouds, belts, radiator caps, recovery tanks, coolant heaters, sensors, mechanical and electric water pumps, piping, shrouds, coolant, heat exchangers

**consumables** include: gaskets, clamps, sealants, coolant

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of coolants** include: conventional IAT, extended life OAT, HOAT

**coolant properties** include: pH, freezing point, additive concentrations, conductivity

**tools and equipment** include: leak testing equipment, pressure measuring devices, refractometers, temperature measuring devices, fluid analysis sampling kit, hydrometers, belt tension gauges, coolant testers, air flow meters, coolant pressure testers, UV lights, laptop, multimeters

**hazards** include: pressure, steam, extreme heat, moving parts, skin irritation, toxicity

**symptoms of problems** include: coolant loss, low or high operating temperatures, excessive system pressure, warning lights, no cab heat, cross-contamination

**conditions** include: wear, damage, defect, failure

## B-12.03 Repairs cooling systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
B-12.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
B-12.03.02P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
B-12.03.03P	select <b>components</b>	<b>components</b> are selected according to repair requirements and <b>manufacturers' service information</b>
B-12.03.04P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
B-12.03.05P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
B-12.03.06P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
B-12.03.07P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
B-12.03.08P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>

B-12.03.09P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
B-12.03.101P	reassemble <b>components</b> and perform <b>measurements</b>	<b>components</b> are reassembled and <b>measurements</b> are performed according to <b>manufacturers' service information</b>
B-12.03.11P	<b>adjust</b> components and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
B-12.03.12P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
B-12.03.13P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: torque wrenches, manufacturer specialty tools, lifting devices, flushing equipment, coolant handling equipment, temperature measuring devices, thermostat testing equipment, hand tools, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: oil cooler, thermostats, cooling fan, radiators, hoses, fans, fan drives, radiator shrouds, belts, radiator caps, recovery tanks, coolant heaters, sensors, mechanical and electric water pumps, piping, shrouds, coolant, heat exchangers

**conditions** include: wear, damage, defects, failure

**consumables** include: gaskets, O-rings, sealants, clamps, coolant

**measurements** include: coolant level, concentration, tolerance, shaft play, temperature, pressure

**adjust** includes: belt tension, hose fit and function

**methods** include: operational testing, pressure testing, temperature testing

Knowledge		
	Learning Outcomes	Learning Objectives
B-12.03.01L	demonstrate knowledge of cooling systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of cooling systems and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of cooling systems
		interpret information pertaining to cooling systems found in <b>manufacturers' service information</b>
		identify <b>types of coolants</b> and coolant additives, and describe their characteristics and applications
		describe <b>coolant properties</b>

		identify types and quality of fluids, and describe their characteristics and applications
B-12.03.02L	demonstrate knowledge of procedures to repair cooling systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair cooling systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair cooling systems
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild, or repair <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
B-12.03.03L	demonstrate knowledge of regulatory requirements pertaining to cooling systems	identify and interpret standards and regulations pertaining to cooling systems
B-12.03.04L	demonstrate knowledge of emerging technologies and practices pertaining to cooling systems	identify technologies that reduce environmental impacts
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: oil cooler, thermostats, cooling fan, radiators, hoses, fans, fan drives, radiator shrouds, belts, radiator caps, recovery tanks, coolant heaters, sensors, mechanical and electric water pumps, piping, shrouds, coolant, heat exchangers

**consumables** include: gaskets, O-rings, sealants, clamps, coolant

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of coolants** include: conventional IAT, extended life OAT, HOAT

**coolant properties** include: pH, freezing point, additive concentrations, conductivity

**tools and equipment** include: torque wrenches, manufacturer specialty tools, lifting devices, flushing equipment, coolant handling equipment, temperature measuring devices, thermostat testing equipment, hand tools, laptop, multimeters

**hazards** include: pressure, steam, extreme heat, moving parts, skin irritation, toxicity

**methods** include: operational testing, pressure testing, temperature testing

# Major Work Activity C

## Services, diagnoses and repairs steering, suspension, brake and undercarriage systems, and wheel assemblies

### Task C-13 Services, diagnoses and repairs steering systems

#### Task Descriptor

Steering systems are designed to allow the operator to control the direction of the equipment. Heavy duty equipment technicians diagnose, service and repair steering systems and components in order to ensure the safe and correct operation of the equipment.

#### C-13.01 Services steering systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
C-13.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-13.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
C-13.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-13.01.04P	perform sensory inspections	sensory inspections are performed to identify worn, damaged and defective <b>components</b>
C-13.01.05P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
C-13.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>

C-13.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
C-13.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
C-13.01.09P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
C-13.01.10P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
C-13.01.11P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
C-13.01.12P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: flow gauges, pressure gauges, multimeters, electronic service tools, onboard computer, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: king pins, drag links, hydraulic cylinders, tie rods, power steering components, steering column, control levers, linkages, control valves, steering clutches, steering brakes, hydraulic pump, hydraulic motor, sprockets, planetary system, electrical controls, electronic controls

**consumables** include: oil, filters, grease

## Knowledge

	Learning Outcomes	Learning Objectives
C-13.01.01L	demonstrate knowledge of steering systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of steering systems</b> and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of steering systems and their <b>components</b>
		interpret information pertaining to steering systems found in <b>manufacturers' service information</b>
		describe primary and secondary steering systems
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		describe <b>steering geometry and alignment</b>

C-13.01.02L	demonstrate knowledge of procedures to service steering systems and their <b>components</b> and <b>consumables</b>	identify <b>tools and equipment</b> used to service steering systems, their <b>components</b> and <b>consumables</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service steering systems
		describe procedures to release and isolate stored energy
		describe procedures to inspect steering systems and their <b>components</b> and <b>consumables</b>
		describe procedures to measure and lubricate steering system <b>components</b>
		describe procedures to remove, replace, recycle and dispose of steering system <b>consumables</b>
		describe procedures to clean <b>components</b>
		describe procedures to service steering systems and their <b>components</b> and <b>consumables</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
C-13.01.03L	demonstrate knowledge of regulatory requirements pertaining to steering systems	identify standards and jurisdictional regulations pertaining to steering systems
C-13.01.04L	demonstrate knowledge of regulatory requirements pertaining to recycling and disposing of steering system <b>consumables</b>	identify and interpret standards and regulations pertaining to recycling and disposing of steering system <b>consumables</b>
C-13.01.05L	demonstrate knowledge of emerging technologies and practices related to autonomous steering	identify technologies that address risk and reduce accidents, and describe their characteristics and applications

## Range of Variables

**components** include: king pins, drag links, hydraulic cylinders, tie rods, power steering components, steering column, control levers, linkages, control valves, steering clutches, steering brakes, hydraulic pump, hydraulic motor, sprockets, planetary system, electrical controls, electronic controls

**consumables** include: oil, filters, grease

**types of steering systems** include: integral, linkage, rack and pinion, hydrostatic, hydraulic, clutch and brake, electric over hydraulic, differential

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**steering geometry and alignment** includes: caster, camber, toe

**tools and equipment** include: flow gauges, pressure gauges, multimeters, electronic service tools, onboard computer, laptop

**hazards** include: stored energy, crush/pinch points, burns

### C-13.02 Diagnoses steering systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

Performance Criteria		Evidence of Attainment
C-13.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
C-13.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-13.02.03P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
C-13.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
C-13.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
C-13.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
C-13.02.07P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
C-13.02.08P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>



C-13.02.09P	measure <b>components</b>	<b>components</b> are measured to determine if they meet <b>manufacturers' service information</b>
C-13.02.10P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b> according to jurisdictional regulations
C-13.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
C-13.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
C-13.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: darting, drifting, hard steering, soft steering, leaks, irregular tire or track wear patterns, worn, bent or broken parts, tracking

**tools and equipment** include: pressure gauges, measuring tools, pry bars, alignment tools, flow gauges, multimeters, electronic service tools, onboard computer, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**sensory inspections** include: looking for leaks, visually inspecting steering components, listening for abnormal noises

**conditions** include: wear, damage, defects

**tests** include: performance, pressure, cylinder leakage, motor leakage, cycle time, secondary steering

**components** include: king pins, drag links, hydraulic cylinders, tie rods, power steering components, steering column, control levers, linkages, control valves, steering clutches, steering brakes, hydraulic pump, hydraulic motor, sprockets, planetary system, electrical controls, electronic controls

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
C-13.02.01L	demonstrate knowledge of steering systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of steering systems</b> and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of steering systems and their <b>components</b>
		interpret information pertaining to steering systems found in <b>manufacturers' service information</b>
		describe primary and secondary steering systems
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications

		describe <b>steering geometry and alignment</b>
C-13.02.02L	demonstrate knowledge of procedures to diagnose steering systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose steering systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose steering systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect steering systems and their <b>components</b>
		describe procedures to test steering systems and their <b>components</b>
		describe procedures to diagnose steering systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing steering systems and their <b>components</b>
		identify steps for failure analysis
C-13.02.03L	demonstrate knowledge of emerging technologies and practices related to autonomous steering	identify technologies that address risk and reduce accidents, and describe their characteristics and applications

## Range of Variables

**components** include: king pins, drag links, hydraulic cylinders, tie rods, power steering components, steering column, control levers, linkages, control valves, steering clutches, steering brakes, hydraulic pump, hydraulic motor, sprockets, planetary system, electrical controls, electronic controls

**consumables** include: oil, filters, grease

**types of steering systems** include: integral, linkage, rack and pinion, hydrostatic, hydraulic, clutch and brake, electric over hydraulic, differential

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**steering geometry and alignment** includes: caster, camber, toe

**tools and equipment** include: pressure gauges, measuring tools, pry bars, alignment tools, flow gauges, multimeters, electronic service tools, onboard computer, laptop

**hazards** include: stored energy, crush/pinch points, burns

**symptoms of problems** include: darting, drifting, hard steering, soft steering, leaks, irregular tire or track wear patterns, worn, bent or broken parts, tracking

**conditions** include: wear, damage, defects

## C-13.03 Repairs steering systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-13.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-13.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
C-13.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-13.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-13.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
C-13.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
C-13.03.07P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
C-13.03.08P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
C-13.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
C-13.03.10P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
C-13.03.11P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
C-13.03.12P	perform pre-lubrication and bleeding procedures	pre-lubrication and bleeding procedures are performed according to <b>manufacturers' service information</b>
C-13.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
C-13.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: pressure gauges, measuring tools, pry bars, alignment tools, flow gauges, multimeters, electronic service tools, onboard computer, hand tools, shop tools, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: king pins, drag links, steering boxes, pitman arms, hydraulic cylinders, tie rods, power steering components, steering column, control levers, linkages, control valves, steering clutches, steering brakes, hydraulic pump, hydraulic motor, sprockets, planetary system, electrical controls, electronic controls

**conditions** include: wear, damage, defects

**methods** include: operational testing, front end alignments, sensory observations

Knowledge		
	Learning Outcomes	Learning Objectives
C-13.03.01L	demonstrate knowledge of steering systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of steering systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of steering systems and their <b>components</b>
		interpret information pertaining to steering systems found in <b>manufacturers' service information</b>
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		describe primary and secondary steering systems
C-13.03.02L	demonstrate knowledge of procedures to repair steering systems and their <b>components</b>	describe <b>steering geometry and alignment</b>
		identify <b>tools and equipment</b> used to repair steering systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair steering systems and their <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild or repair <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>

		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
C-13.03.03L	demonstrate knowledge of regulatory requirements pertaining to steering control systems	identify standards and regulations pertaining to steering control systems
C-13.03.04L	demonstrate knowledge of emerging technologies and practices related to autonomous steering	identify technologies that address risk and reduce accidents, and describe their characteristics and applications

## Range of Variables

**components** include: king pins, drag links, steering boxes, pitman arms, hydraulic cylinders, tie rods, power steering components, steering column, control levers, linkages, control valves, steering clutches, steering brakes, hydraulic pump, hydraulic motor, sprockets, planetary system, electrical controls, electronic controls

**types of steering systems** include: integral, linkage, rack and pinion, hydrostatic, hydraulic, clutch and brake, electric over hydraulic, differential

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**steering geometry and alignment** includes: caster, camber, toe

**tools and equipment** include: pressure gauges, measuring tools, pry bars, alignment tools, flow gauges, multimeters, electronic service tools, onboard computer, hand tools, shop tools, laptop

**hazards** include: stored energy, crush/pinch points, burns

**methods** include: operational testing, front end alignments, sensory observations

# Task C-14 Services, diagnoses and repairs suspension systems

## Task Descriptor

Suspension systems distribute load throughout the frame and withstand varying surface conditions by absorbing energy. Heavy duty equipment technicians service, diagnose and repair suspension systems to ensure correct equipment operation.

### C-14.01 Services suspension systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-14.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-14.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
C-14.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-14.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> of suspension are performed to identify worn, damaged and defective <b>components</b>
C-14.01.05P	measure <b>components</b>	<b>components</b> are measured for ride height and bushings for excessive play to determine if they meet <b>manufacturers' service information</b>
C-14.01.06P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
C-14.01.07P	check fluid levels and pressure	fluid levels and pressure are checked to determine if they meet <b>manufacturers' service information</b>
C-14.01.08P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>

C-14.01.09P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
C-14.01.10P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
C-14.01.11P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: measuring devices, pressure gauges, hand tools, multimeters, electronic service tools, lifting and holding equipment, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: bolster springs, I-beams, torque rods, ride height valves, shock absorbers, torsion bars, walking beams, U-bolts, axle assemblies, pins, bushings, pneumatic system, hydro-pneumatic struts, rubber blocks, valves, accumulators, cylinders, electrical controls, electronic controls

**sensory inspections** include: looking for leaks, visually inspecting suspension components, listening for abnormal noises

Knowledge		
	Learning Outcomes	Learning Objectives
C-14.01.01L	demonstrate knowledge of suspension systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of suspension systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of suspension systems and their <b>components</b>
		interpret information pertaining to suspension systems found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
C-14.01.02L	demonstrate knowledge of procedures to service suspension systems and their <b>components</b>	identify <b>tools and equipment</b> used to service suspension systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service suspension systems and their <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect suspension systems and their <b>components</b>

	describe procedures to clean, measure and lubricate suspension system <b>components</b>
	describe procedures to service suspension systems and their <b>components</b>
	describe procedures to adjust and calibrate <b>components</b>
	describe procedures to remove, replace, recycle and dispose of consumables
	describe procedures to perform software updates
	identify materials that can be reconditioned, reused or recycled

## Range of Variables

**components** include: bolster springs, I-beams, torque rods, ride height valves, shock absorbers, torsion bars, walking beams, U-bolts, axle assemblies, pins, bushings, pneumatic system, hydro-pneumatic struts, rubber blocks, valves, accumulators, cylinders, electrical controls, electronic controls

**types of suspension systems** include: hydro pneumatic (conventional, electronically-controlled), spring, solid block, combination

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: measuring devices, pressure gauges, hand tools, multimeters, electronic service tools, lifting and holding equipment, laptop

**hazards** include: crush/pinch points, pressurized gases and fluids, stored energy

## C-14.02 Diagnoses suspension systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-14.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
C-14.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-14.02.03P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
C-14.02.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>



C-14.02.05P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
C-14.02.06P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
C-14.02.07P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
C-14.02.08P	compare <b>test</b> results	<b>test</b> results are compared to <b>manufacturers' service information</b> or expected values
C-14.02.09P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
C-14.02.10P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-14.02.11P	measure <b>components</b>	<b>components</b> are measured to determine if they meet <b>manufacturers' service information</b>
C-14.02.12P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
C-14.02.13P	perform failure analysis	failure analysis is performed to determine root cause of failure
C-14.02.14P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented
C-14.02.15P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: wandering, drifting, sagging, difficult steering, lack of stability, wear, leakage, cracks, noise, vibration, uneven tire wear

**tools and equipment** include: measuring devices, pressure gauges, hand tools, multimeters, electronic service tools, lifting and holding equipment, laptop, accumulator charge kits

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**sensory inspections** include: looking for leaks, visually inspecting suspension components, listening for abnormal noises

**conditions** include: wear, damage, defects

**tests** include: pressure, leak, ride height

**components** include: bolster springs, I-beams, torque rods, ride height valves, shock absorbers, torsion bars, walking beams, U-bolts, axle assemblies, pins, bushings, pneumatic system, hydro-pneumatic struts, rubber blocks, valves, accumulators, cylinders, electrical control, electronic controls

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

Learning Outcomes	Learning Objectives	
C-14.02.01L	demonstrate knowledge of suspension systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of suspension systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of suspension systems and their <b>components</b>
		interpret information pertaining to suspension systems found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		describe wear limits and load capacity
C-14.02.02L	demonstrate knowledge of procedures to diagnose suspension systems and their <b>components</b>	describe <b>axle applications</b>
		identify <b>tools and equipment</b> used to diagnose suspension systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose suspension systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect suspension systems and their <b>components</b>
		describe procedures to test suspension systems and their <b>components</b>
		describe procedures to diagnose suspension systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing suspension systems
	identify steps for failure analysis	

## Range of Variables

**components** include: bolster springs, I-beams, torque rods, ride height valves, shock absorbers, torsion bars, walking beams, U-bolts, axle assemblies, pins, bushings, pneumatic system, hydro-pneumatic struts, rubber blocks, valves, accumulators, cylinders, electrical control, electronic controls

**types of suspension systems** include: hydro pneumatic (conventional, electronically-controlled), spring, solid block, combination

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**axle applications** include: steering, drive, auxiliary

**tools and equipment** include: measuring devices, pressure gauges, hand tools, multimeters, electronic service tools, lifting and holding equipment, laptop, accumulator charge kits

**hazards** include: crush/pinch points, pressurized gases and fluids, stored energy

**symptoms of problems** include: wandering, drifting, sagging, difficult steering, lack of stability, wear, leakage, cracks, noise, vibration, uneven tire wear

**conditions** include: wear, damage, defects

### C-14.03 Repairs suspension systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-14.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-14.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
C-14.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-14.03.04P	remove, disassemble and inspect <b>components for conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-14.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
C-14.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
C-14.03.07P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
C-14.03.08P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
C-14.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>

C-14.03.10P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
C-14.03.11P	<b>adjust</b> and calibrate <b>components</b> and parts	<b>components</b> and parts are <b>adjusted</b> and calibrated according to <b>manufacturers' service information</b>
C-14.03.12P	perform pre-lubrication and bleeding procedures	pre-lubrication and bleeding procedures are performed according to <b>manufacturers' service information</b>
C-14.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
C-14.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: measuring devices, pressure gauges, multimeters, electronic service tools, lifting and holding equipment, shop equipment, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: bolster springs, I-beams, torque rods, ride height valves, shock absorbers, torsion bars, walking beams, U-bolts, axle assemblies, pins, bushings, pneumatic system, hydro-pneumatic struts, rubber blocks, valves, accumulators, cylinders, electrical controls, electronic controls

**conditions** include: damage, defect, wear

**adjust** includes: setting ride height valves

**methods** include: operational testing, load testing, sensory observations

## Knowledge

	Learning Outcomes	Learning Objectives
C-14.03.01L	demonstrate knowledge of suspension systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of suspension systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of suspension systems and their <b>components</b>
		interpret information pertaining to suspension systems found in <b>manufacturers' service information</b>
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications

C-14.03.02L	demonstrate knowledge of procedures to repair suspension systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair suspension systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair suspension systems and their <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild, or repair suspension systems <b>components</b>
		describe procedures to <b>adjust</b> and calibrate suspension system <b>components</b>
		describe procedures to recycle and dispose of suspension system <b>components</b>
		describe <b>methods</b> to verify repairs
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste

## Range of Variables

**components** include: bolster springs, I-beams, torque rods, ride height valves, shock absorbers, torsion bars, walking beams, U-bolts, axle assemblies, pins, bushings, pneumatic system, hydro-pneumatic struts, rubber blocks, valves, accumulators, cylinders, electrical controls, electronic controls

**types of suspension systems** include: hydro pneumatic (conventional, electronically-controlled), spring, solid block, combination

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: measuring devices, pressure gauges, multimeters, electronic service tools, lifting and holding equipment, shop equipment, laptop

**hazards** include: crush/pinch points, compressed air

**adjust** includes: setting ride height valves

**methods** include: operational testing, load testing, sensory observations

# Task C-15 Services, diagnoses and repairs brake systems

## Task Descriptor

Brake systems slow, stop or park the equipment in a safe and controlled manner by using air, hydraulics or mechanical means in conjunction with electronic controls.

Heavy duty equipment technicians must service, diagnose and repair brake systems to ensure proper function and reduce down time.

### C-15.01 Services brake systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-15.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-15.01.02P	release and isolate stored energy in <b>components</b>	stored energy is released and isolated in <b>components</b> according to <b>manufacturers' service information</b>
C-15.01.03P	clean <b>components</b> for inspection	<b>components</b> are cleaned for inspection according to <b>manufacturers' service information</b>
C-15.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify leaks and worn, damaged and defective <b>components</b>
C-15.01.05P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
C-15.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
C-15.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
C-15.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
C-15.01.09P	adjust brakes and lubricate components	brakes are adjusted and components are lubricated according to <b>manufacturers' service information</b>

C-15.01.10P	check ABS operation	ABS operation is checked according to <b>manufacturers' service information</b>
C-15.01.11P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
C-15.01.12P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: lifting and holding equipment, measuring tools, hand tools, shop tools, electronic service tools, onboard computer, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: pumps, brake valves, brake discs, accumulators, parking brakes, drums, shoes, pads, rotors, cams, slack adjusters, calipers, compressor

**sensory inspections** include: looking for leaks, visually inspecting brake components, listening for abnormal noises, smelling for overheating

**consumables** include: fluids, seals, O-rings

## Knowledge

	Learning Outcomes	Learning Objectives
C-15.01.01L	demonstrate knowledge of brake systems, their <b>components, consumables</b> , characteristics, applications and operation	identify <b>types of brake systems</b> and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of brake systems
		interpret information pertaining to brake systems found in <b>manufacturers' service information</b>
		describe operating principles of ABS and traction control
		identify <b>air brake components</b> , and describe their characteristics and applications
		identify <b>hydraulic brake components</b> , and describe their characteristics and applications
		identify <b>parking brake components</b> , and describe their characteristics and applications
		identify <b>ABS components</b> , and describe their characteristics and applications
		identify traction control systems, and describe their characteristics and applications

		identify warning systems, and describe their characteristics and applications
		identify types of power-assisted hydraulic brakes, and describe their characteristics and applications
C-15.01.02L	demonstrate knowledge of procedures to service brake systems and their <b>components</b>	identify <b>tools and equipment</b> used to service brake systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to servicing of brake systems
		describe procedures to release stored energy
		describe procedures to inspect brake systems and their <b>components</b>
		describe procedures to clean <b>components</b>
		describe procedures to service brake systems and their <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to remove, replace, recycle and dispose of brake system <b>consumables</b>
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
C-15.01.03L	demonstrate knowledge of regulatory requirements pertaining to brake systems	identify and interpret standards and regulations pertaining to brake systems
C-15.01.04L	demonstrate knowledge of <b>emerging technologies</b> and practices related to brake systems	identify technologies that address emissions and pollution, and describe their characteristics and applications



## Range of Variables

**components** include: pumps, brake valves, brake discs, accumulators, parking brakes, drums, shoes, pads, rotors, cams, slack adjusters, calipers, compressor

**consumables** include: fluids, seals, O-rings

**types of brake systems** include: air, hydraulic, parking brake, air over hydraulic, mechanical

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**air brake components** include: brake chambers, slack adjusters, rotors, S-cams, pins, bushings, supply systems, valves

**hydraulic brake components** include: valves, cylinders, pumps, pistons

**parking brake components** include: drums, springs, pistons, friction materials, discs, valves, controls

**ABS components** include: wiring, ECMs, modulating valves, sensors

**tools and equipment** include: lifting and holding equipment, measuring tools, hand tools, shop tools, electronic service tools, onboard computer, laptop, multimeters

**hazards** include: stored energy, hydraulic injection, airborne contaminants, crush/pinch points

**emerging technologies** include: regenerative braking systems

### C-15.02 Diagnoses brake systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
C-15.02.01P	identify <b>symptoms of problem</b>	<b>symptoms of problem</b> are identified by consulting with customer or operator
C-15.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-15.02.03P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
C-15.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
C-15.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
C-15.02.06P	interpret schematics and verify diagnosis	schematics are interpreted and diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values

C-15.02.07P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
C-15.02.08P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-15.02.09P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
C-15.02.10P	perform failure analysis	failure analysis is performed to determine root cause of failure
C-15.02.11P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
C-15.02.12P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: faulty brake operation, leaks, noise, excessive stopping distance, warning lights on, excessive pressure build time

**tools and equipment** include: lifting and holding equipment, measuring tools, hand tools, shop tools, electronic service tools, onboard computer, laptop, multimeters, accumulator charge kits

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**sensory inspections** include: checking braking performance, checking for warning lights, checking for leaks, smelling for overheating

**conditions** include: damage, defect, wear

**tests** include: leak down, performance, operational, leak, pressure

**components** include: pumps, brake valves, brake discs, accumulators, parking brakes, drums, shoes, pads, rotors, cams, slack adjusters, calipers, compressor

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
C-15.02.01L	demonstrate knowledge of brake systems, their <b>components, consumables</b> , characteristics, applications and operation	identify <b>types of brake systems</b> and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of brake systems
		interpret information pertaining to brake systems found in <b>manufacturers' service information</b>
		describe operating principles of ABS and traction control

		identify <b>air brake components</b> , and describe their characteristics and applications
		identify <b>hydraulic brake components</b> , and describe their characteristics and applications
		identify <b>parking brake components</b> , and describe their characteristics and applications
		identify <b>ABS components</b> , and describe their characteristics and applications
		identify traction control systems, and describe their characteristics and applications
		identify warning systems, and describe their characteristics and applications
		identify types of power-assisted hydraulic brakes, and describe their characteristics and applications
C-15.02.02L	demonstrate knowledge of procedures to diagnose brake systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose brake systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose brake systems
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect brake systems and their <b>components</b>
		describe procedures to test brake systems and their <b>components</b>
		describe procedures to diagnose brake systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing brake systems and their <b>components</b>
		identify steps for failure analysis
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
C-15.02.03L	demonstrate knowledge of regulatory requirements pertaining to brake systems	identify and interpret standards and regulations pertaining to brake systems
	demonstrate knowledge of <b>emerging technologies</b> and practices related to brake systems	identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: pumps, brake valves, brake discs, accumulators, parking brakes, drums, shoes, pads, rotors, cams, slack adjusters, calipers, compressor

**consumables** include: friction materials, fluids, drums, discs, plates

**types of brake systems** include: air, hydraulic, parking brake, air over hydraulic, mechanical

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**air brake components** include: brake chambers, slack adjusters, rotors, S-cams, pins, bushings, supply systems, valves

**hydraulic brake components** include: valves, cylinders, pumps, pistons

**parking brake components** include: drums, springs, pistons, friction materials, discs, valves, controls

**ABS components** include: wiring, ECMs, modulating valves, sensors

**tools and equipment** include: lifting and holding equipment, measuring tools, hand tools, shop tools, electronic service tools, onboard computer, laptop, multimeters, accumulator charge kits

**hazards** include: stored energy, hydraulic injection, airborne contaminants, crush/pinch points

**symptoms of problems** include: faulty brake operation, leaks, noise, excessive stopping distance, warning lights on, excessive pressure build time

**conditions** include: damage, defect, wear

**emerging technologies** include: regenerative braking systems

### C-15.03 Repairs brake systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-15.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-15.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
C-15.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-15.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-15.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
C-15.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>

C-15.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
C-15.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
C-15.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
C-15.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
C-15.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
C-15.03.12P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
C-15.03.13P	perform pre-lubrication, pressure build-up, break-in and bleeding procedures	pre-lubrication, pressure build-up, break-in and bleeding procedures are performed according to <b>manufacturers' service information</b>
C-15.03.14P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
C-15.03.15P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: lifting and holding equipment, measuring tools, hand tools, shop tools, electronic service tools, onboard computer, laptop, multimeters, accumulator charge kits

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: pumps, brake valves, brake discs, accumulators, parking brakes, drums, shoes, pads, rotors, cams, slack adjusters, calipers, compressors

**conditions** include: damage, defect, wear

**methods** include: operational testing, sensory observations

Knowledge		
	Learning Outcomes	Learning Objectives
C-15.03.01L	demonstrate knowledge of brake systems, their <b>components, consumables</b> , characteristics, applications and operation	identify <b>types of brake systems</b> and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of brake systems
		interpret information pertaining to brake systems found in <b>manufacturers' service information</b>

		describe operating principles of ABS and traction control
		identify <b>air brake components</b> , and describe their characteristics and applications
		identify <b>hydraulic brake components</b> , and describe their characteristics and applications
		identify <b>parking brake components</b> , and describe their characteristics and applications
		identify <b>ABS components</b> , and describe their characteristics and applications
		identify traction control systems, and describe their characteristics and applications
		identify warning systems, and describe their characteristics and applications
		identify types of power-assisted hydraulic brakes, and describe their characteristics and applications
C-15.03.02L	demonstrate knowledge of procedures to repair brake systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair brake systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair brake systems
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild or repair <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste

C-15.03.03L	demonstrate knowledge of regulatory requirements pertaining to brake systems	identify and interpret standards and regulations pertaining to brake systems
		identify jurisdictional requirements for operational testing and road worthiness
C-15.03.04L	demonstrate knowledge of <b>emerging technologies</b> and practices related to brake systems	identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: pumps, brake valves, brake discs, accumulators, parking brakes, drums, shoes, pads, rotors, cams, slack adjusters, calipers, compressors

**consumables** include: friction materials, fluids, drums, discs, plates

**types of brake systems** include: air, hydraulic, parking brake, air over hydraulic, mechanical

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**air brake components** include: brake chambers, slack adjusters, rotors, S-cams, pins, bushings, supply systems, valves

**hydraulic brake components** include: valves, cylinders, pumps, pistons

**parking brake components** include: drums, springs, pistons, friction materials, discs, valves, controls

**ABS components** include: wiring, ECMs, modulating valves, sensors

**tools and equipment** include: lifting and holding equipment, measuring tools, hand tools, shop tools, electronic service tools, onboard computer, laptop, multimeters, accumulator charge kits

**hazards** include: stored energy, hydraulic injection, airborne contaminants, crush/pinch points

**methods** include: operational testing, sensory observations

**emerging technologies** include: regenerative braking systems

# Task C-16 Services, diagnoses and repairs undercarriage systems

## Task Descriptor

An undercarriage system is a supporting framework that includes steel and rubber track systems that provides mobility. Heavy duty equipment technicians must service, diagnose and repair undercarriage systems to ensure proper function and reduce down time.

### C-16.01 Services undercarriage systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
C-16.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-16.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
C-16.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-16.01.04P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>
C-16.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
C-16.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
C-16.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
C-16.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations



C-16.01.09P	lubricate components	components are lubricated according to <b>manufacturers' service information</b>
C-16.01.10P	adjust components	components are adjusted according to <b>manufacturers' service information</b>
C-16.01.11P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: lifting and holding equipment, shop tools, hand tools, measuring tools, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: tracks, frame, rollers, bogies, idlers, sprockets, pins, bushings, mounting hardware, guards, adjusting mechanism, equalizer bar, pivot shaft, recoil spring, related fasteners, track tensioner

**measurements** include: track tension, undercarriage component wear

**consumables** include: related fasteners, fluids

Knowledge		
	Learning Outcomes	Learning Objectives
C-16.01.01L	demonstrate knowledge of undercarriage systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	<p>identify <b>types of undercarriage systems</b> and their <b>components</b> and <b>consumables</b>, and describe their characteristics and applications</p> <p>describe operating principles of undercarriage systems and their <b>components</b></p> <p>interpret information pertaining to undercarriage systems found in <b>manufacturers' service information</b></p> <p>identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications</p>
C-16.01.02L	demonstrate knowledge of procedures to service undercarriage systems and their <b>components</b>	<p>identify <b>tools and equipment</b> used to service undercarriage systems and their <b>components</b>, and describe their applications and procedures for use</p> <p>identify <b>hazards</b> and describe safe work practices to service undercarriage systems</p> <p>describe procedures to release and isolate stored energy</p> <p>describe procedures to inspect undercarriage systems and their <b>components</b></p> <p>describe procedures to clean <b>components</b></p>

	describe procedures to service undercarriage systems and their <b>components</b>
	describe procedures to adjust <b>components</b>
	describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
	identify <b>components</b> that can be reconditioned, reused or recycled
	identify practices that reduce material waste

## Range of Variables

**components** include: tracks, frame, rollers, bogies, idlers, sprockets, pins, bushings, mounting hardware, guards, adjusting mechanism, equalizer bar, pivot shaft, recoil spring, related fasteners, track tensioner

**consumables** include: related fasteners, fluids

**types of undercarriage systems** include: steel, rubber

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: lifting and holding equipment, shop tools, hand tools, measuring tools, laptop, multimeters

**hazards** include: crush/pinch points, heavy components, stored energy, movement of parts or equipment

## C-16.02 Diagnoses undercarriage systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-16.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
C-16.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-16.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
C-16.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
C-16.02.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>

C-16.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>measurements</b> and comparing them to <b>manufacturers' service information</b> or expected values
C-16.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-16.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
C-16.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-16.02.10P	perform failure analysis	failure analysis is performed to determine root cause of failure
C-16.02.11P	document <b>measurements</b> and inspection findings	<b>measurements</b> and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
C-16.02.12P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: wear, cuts, cracks, leaks, breakage, track is out of alignment, misaligned carrier rollers and idlers

**tools and equipment** include: lifting and holding equipment, shop tools, hand tools, measuring tools laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects

**measurements** include: pin wear, bushing wear, track pad wear, idler and roller wear, sprocket wear, track tension

**components** include: tracks, frame, rollers, bogies, idlers, sprockets, pins, bushings, mounting hardware, guards, adjusting mechanism, equalizer bar, pivot shaft, recoil spring, related fasteners, track tensioner

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
C-16.02.01L	demonstrate knowledge of undercarriage systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of undercarriage systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of undercarriage systems
		interpret information pertaining to undercarriage systems found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications

C-16.02.02L	demonstrate knowledge of procedures to diagnose undercarriage systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose undercarriage systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose undercarriage systems
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect undercarriage systems and their <b>components</b>
		describe procedures to measure undercarriage system <b>components</b>
		describe procedures to diagnose undercarriage systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing undercarriage systems
		identify steps for failure analysis
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled

### Range of Variables

**components** include: tracks, frame, rollers, bogies, idlers, sprockets, pins, bushings, mounting hardware, guards, adjusting mechanism, equalizer bar, pivot shaft, recoil spring, related fasteners, track tensioner

**types of undercarriage systems** include: steel, rubber

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: lifting and holding equipment, shop tools, hand tools, measuring tools laptop, multimeters

**hazards** include: crush/pinch points, heavy components, stored energy, movement of parts or equipment

**symptoms of problems** include: wear, cuts, cracks, leaks, breakage, track is out of alignment, misaligned carrier rollers and idlers

**conditions** include: wear, damage, defects

## C-16.03 Repairs undercarriage systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-16.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-16.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
C-16.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-16.03.04P	remove, disassemble and inspect <b>components for conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-16.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
C-16.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
C-16.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
C-16.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
C-16.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
C-16.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
C-16.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
C-16.03.12P	adjust <b>components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
C-16.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
C-16.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: lifting and holding equipment, shop tools, hand tools, measuring tools laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: tracks, frame, rollers, bogies, idlers, sprockets, pins, bushings, mounting hardware, guards, adjusting mechanism, equalizer bar, pivot shaft, recoil spring, related fasteners, track tensioner

**conditions** include: damage, defect, wear

**methods** include: operational testing, sensory observations

Knowledge		
	Learning Outcomes	Learning Objectives
C-16.03.01L	demonstrate knowledge of undercarriage systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of undercarriage systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of undercarriage systems
		interpret information pertaining to undercarriage systems found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
C-16.03.02L	demonstrate knowledge of procedures to repair undercarriage systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair undercarriage systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair undercarriage systems
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild, or repair <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste

## Range of Variables

**components** include: tracks, frame, rollers, bogies, idlers, sprockets, pins, bushings, mounting hardware, guards, adjusting mechanism, equalizer bar, pivot shaft, recoil spring, related fasteners, track tensioner

**types of undercarriage systems** include: steel, rubber

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: lifting and holding equipment, shop tools, hand tools, measuring tools laptop, multimeters

**hazards** include: crush/crush/pinch points, heavy components, stored energy, movement of parts or equipment

**methods** include: operational testing, sensory observations

## Task C-17 Services, diagnoses and repairs wheel assemblies

### Task Descriptor

Wheel assemblies are composed of tires, rims and hubs and allows equipment to be mobile.

Heavy duty equipment technicians service, diagnose and repair tires, rims and hubs to ensure proper function and reduce down time.

### C-17.01 Services wheel assemblies

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-17.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-17.01.02P	release stored energy in components	stored energy is released in components according to <b>manufacturers' service information</b>
C-17.01.03P	clean components for inspection	components are cleaned for inspection according to <b>manufacturers' service information</b>
C-17.01.04P	perform sensory inspections	sensory inspections are performed to identify <b>worn, damaged and defective components</b>
C-17.01.05P	perform <b>measurements</b> on tires	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>

C-17.01.06P	perform <b>measurements</b> on <b>hub components</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional requirements
C-17.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
C-17.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
C-17.01.09P	lubricate <b>hub components</b>	<b>hub components</b> are lubricated according to <b>manufacturers' service information</b>
C-17.01.10P	adjust tire pressure	tire pressure is adjusted according to <b>manufacturers' service information</b>
C-17.01.11P	torque fasteners	fasteners are torqued according to <b>manufacturers' service information</b>
C-17.01.12P	identify mismatched tires	mismatched tires are identified by size, design and tread depth
C-17.01.13P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
C-17.01.14P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: dial indicators, torque wrenches, TPMS, tread depth gauges, tire pressure gauges, tire inflation cages, inflation tools, hand tools, shop tools, tire-handling equipment, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**worn, damaged and defective components** include: oil leaks from hubs, air leaks from tires, tire wear and damage, damaged rims, broken studs, worn locks, worn spacers

**measurements** (on tires) include: tread depth for wear, air pressure for air leaks

**measurements** (on hub components) include: bearing endplay or preload, fastener torque, pilot pads

**consumables** include: fluids, tires

**hub components** include: studs, nuts, spacers, bearings, races, seals



## Knowledge

Learning Outcomes	Learning Objectives
C-17.01.01L demonstrate knowledge of wheel assemblies, their <b>components</b> , characteristics, applications and operation	identify <b>types of tires</b> , and describe their characteristics and applications
	identify <b>types of rims</b> and their components, and describe their characteristics and applications
	identify <b>types of hubs</b> and their <b>components</b> , and describe their characteristics and applications
	describe operating principles of wheel assemblies and their <b>components</b>
	interpret information pertaining to wheel assemblies, and their <b>components</b> found in <b>manufacturers' service information</b>
	describe tire load ranges, pressures, profiles and sizes
C-17.01.02L demonstrate knowledge of procedures to service wheel assemblies and their <b>components</b>	describe steering and drive tires
	identify <b>tools and equipment</b> used to service wheel assemblies, and their <b>components</b> , and describe their applications and procedures for use
	identify <b>hazards</b> and describe safe work practices to service inflation and removal of tires
	describe procedures to release stored energy
	describe procedures to inspect wheel assemblies, and their <b>components</b>
	describe procedures to measure tire and <b>hub components</b>
	describe procedures to clean <b>components</b>
	describe procedures to service wheel assembly <b>components</b>
	describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
	describe procedures to perform software updates
	identify torque values found in <b>manufacturers' service information</b>
	describe <b>tire inflation methods</b>
describe tire removal and installation procedures	

C-17.01.03L	demonstrate knowledge of training requirements to remove, inspect and mount tires, wheels and hubs	identify training requirements to remove, inspect and mount tires, wheels and hubs
C-17.01.04L	demonstrate knowledge of regulatory requirements pertaining to inspection and mounting of tires, wheels and hubs	identify and interpret standards and regulations pertaining to inspection and mounting of tires, wheels and hubs
C-17.01.05L	demonstrate knowledge of air pressure monitoring and air regulating systems	describe operation of tire pressure monitoring systems (TPMS) and air regulating systems

## Range of Variables

**components** include: rims, spacers, wedges, valve stems, tires, lock rings, seals, tubes, hubs, bearings

**types of tires** include: radial, bias, solid, pneumatic, tube or tubeless

**types of rims** include: steel, multi-piece

**types of hubs** include: spoked, hub pilot

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: dial indicators, torque wrenches, TPMS, tread depth gauges, tire pressure gauges, tire inflation cages, inflation tools, hand tools, shop tools, tire-handling equipment, laptop, multimeters

**hazards** include: stored energy, over inflation, worn or sprung lock ring, crush/pinch points

**consumables** include: fluids, tires

**tire inflation methods** include: liquid-ballast, nitrogen, air, compound-filled (foam, rubber)

## C-17.02 Diagnoses wheel assemblies

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

## Skills

	Performance Criteria	Evidence of Attainment
C-17.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
C-17.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-17.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
C-17.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
C-17.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>

C-17.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
C-17.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-17.02.08P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-17.02.09P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
C-17.02.10P	perform failure analysis	failure analysis is performed to determine root cause of failure
C-17.02.11P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
C-17.02.12P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: wandering, drifting, difficult steering, lack of stability, shaking, wheel hop, shimmy, vibrations, leaks, cracks

**tools and equipment** include: dial indicators, torque wrenches, TPMS, tread depth gauges, tire pressure gauges, tire inflation cages, inflation tools, hand tools, shop tools, tire-handling equipment, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: damage, defect, wear, leaks

**tests** include: tire pressure, wheel fastener torque

**components** include: rims, spacers, wedges, valve stems, tires, lock rings, seals, tubes, hubs, bearings

**measurements** include: torque, air pressure, tread depths, wheel bearing endplay or preload

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
C-17.02.01L	demonstrate knowledge of wheel assemblies, their <b>components</b> , characteristics, applications and operation	identify <b>types of tires</b> , and describe their characteristics and applications
		identify <b>types of rims</b> and their components, and describe their characteristics and applications
		identify <b>types of hubs</b> and their components, and describe their characteristics and applications

		describe operating principles of wheel assemblies and their <b>components</b>
		interpret information pertaining to wheel assemblies, and their <b>components</b> found in <b>manufacturers' service information</b>
		describe tire load ranges, pressures, profiles and sizes
		describe steering and drive tires
		describe effects of <b>related systems</b> on wheel assemblies
C-17.02.02L	demonstrate knowledge of procedures to diagnose wheel assemblies and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose wheel assemblies, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to diagnosing wheel assemblies, and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect wheel assemblies and their <b>components</b>
		describe procedures to test wheel assemblies and their <b>components</b>
		describe procedures to diagnose wheel assemblies and their <b>components</b>
		identify <b>conditions</b> found while diagnosing wheel assemblies and their <b>components</b>
		identify steps for failure analysis
		describe <b>tire inflation methods</b>
		describe tire removal and installation procedures
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
C-17.02.03L	demonstrate knowledge of jurisdictional regulations regarding out-of-service specifications	describe jurisdictional regulations regarding out-of-service specifications

## Range of Variables

**types of tires** include: radial, bias, solid, pneumatic, tube or tubeless

**types of rims** include: steel, multi-piece

**types of hubs** include: spoked, hub pilot

**components** include: rims, spacers, wedges, valve stems, tires, lock rings, seals, tubes, hubs, bearings

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**related systems** include: steering, suspension, brake systems

**tools and equipment** include: dial indicators, torque wrenches, TPMS, tread depth gauges, tire pressure gauges, tire inflation cages, inflation tools, hand tools, shop tools, tire-handling equipment, laptop, multimeters

**hazards** include: stored energy, over inflation, worn or sprung lock ring, crush/pinch points

**symptoms of problems** include: wandering, drifting, difficult steering, lack of stability, shaking, wheel hop, shimmy, vibrations, leaks, cracks

**conditions** include: damage, defect, wear, leaks

**tire inflation methods** include: liquid-ballast, nitrogen, air, compound-filled (foam, rubber)

### C-17.03 Repairs wheel assemblies

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	no	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
C-17.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
C-17.03.02P	release stored energy in components	stored energy is released in components according to <b>manufacturers' service information</b>
C-17.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
C-17.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
C-17.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
C-17.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
C-17.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
C-17.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>

C-17.03.09P	rebuild <b>hub components</b>	<b>hub components</b> are rebuilt according to <b>manufacturers' service information</b>
C-17.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
C-17.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
C-17.03.12P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
C-17.03.13P	adjust bearing endplay or preload	bearing endplay or preload is adjusted according to <b>manufacturers' service information</b>
C-17.03.14P	adjust oil level	oil level is adjusted according to <b>manufacturers' service information</b>
C-17.03.15P	adjust air pressure and torque on wheel assemblies	air pressure and torque are adjusted on wheel assemblies according to <b>manufacturers' service information</b>
C-17.03.16P	measure runout	runout is measured according to <b>manufacturers' service information</b>
C-17.03.17P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
C-17.03.18P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: dial indicators, torque wrenches, TPMS, tread depth gauges, tire pressure gauges, tire inflation cages, inflation tools, hand tools, shop tools, tire-handling equipment, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: rims, spacers, wedges, valve stems, tires, lock rings, seals, tubes, hubs, bearings

**conditions** include: damage, defect, wear

**hub components** include: studs, nuts, spacers, bearings, races, seals

**methods** include: wheel alignment, operational testing, checking for end play or pre-load

## Knowledge

Learning Outcomes	Learning Objectives	
C-17.03.01L	demonstrate knowledge of wheel assemblies, their <b>components</b> , characteristics, applications and operation	identify <b>types of tires</b> , and describe their characteristics and applications
		identify <b>types of rims</b> and their components, and describe their characteristics and applications
		identify <b>types of hubs</b> and their components, and describe their characteristics and applications
		describe operating principles of wheel assemblies and their <b>components</b>
		interpret information pertaining to wheel assemblies, and their <b>components</b> found in <b>manufacturers' service information</b>
		describe tire load ranges, pressures, profiles and sizes
		describe steering and drive tires
		describe wear limits and patterns, and measurement methodology
		describe effects of <b>related systems</b> on wheel assemblies
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
C-17.03.02L	demonstrate knowledge of procedures to repair wheel assemblies, and their <b>components</b>	identify <b>tools and equipment</b> used to repair wheel assemblies, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to repairing wheel assemblies and their <b>components</b>
		describe procedures to release stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild or repair <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>

		describe <b>tire inflation methods</b>
		describe tire removal and installation procedures
		describe <b>methods</b> to verify repairs
		describe procedures to perform software updates
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
C-17.03.03L	demonstrate knowledge of training requirements to remove, inspect and mount tires, wheels and hubs	identify training requirements to remove, inspect and mount tires, wheels and hubs
C-17.03.04L	demonstrate knowledge of inspection requirements related to tire size	identify inspection requirements related to tire size
C-17.03.05L	demonstrate knowledge of regulatory requirements pertaining to inspection and mounting of tires, wheels and hubs	identify and interpret standards and regulations pertaining to inspection and mounting of tires, wheels and hubs
C-17.03.06L	demonstrate knowledge of air pressure monitoring and air regulating systems	describe operation of TPMS and air regulating systems

## Range of Variables

**components** include: rims, spacers, wedges, valve stems, tires, lock rings, seals, tubes, hubs, bearings

**types of tires** include: radial, bias, solid, pneumatic, tube or tubeless

**types of rims** include: steel, multi-piece

**types of hubs** include: spoked, hub pilot

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**related systems** include: steering, suspension, brake systems

**tools and equipment** include: dial indicators, torque wrenches, TPMS, tread depth gauges, tire pressure gauges, tire inflation cages, inflation tools, hand tools, shop tools, tire-handling equipment, laptop, multimeters

**hazards** include: stored energy, over inflation, worn or sprung lock ring, crush/pinch points

**tire inflation methods** include: liquid-ballast, nitrogen, air, compound-filled (foam, rubber)

**methods** include: wheel alignment, operational testing, checking for end play or pre-load



# Major Work Activity D

## Services, diagnoses and repairs electrical and electronic systems

### Task D-18 Services, diagnoses and repairs charging systems

#### Task Descriptor

A charging system is a set of components working to keep a charge and provide electrical energy for electrical devices on equipment.

Heavy duty equipment technicians must have a good understanding of equipment charging systems, their operation and components.

#### D-18.01 Services charging systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
D-18.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-18.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
D-18.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-18.01.04P	perform sensory inspections	sensory inspections are performed to identify worn, damaged and defective <b>components</b>
D-18.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
D-18.01.06P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
D-18.01.07P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations

D-18.01.08P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
D-18.01.09P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
D-18.01.10P	document service information and inspection findings	service information and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, belt tension gauges, torque wrenches, load testers, ammeters, multimeters, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** (charging systems) include: alternators, internal and external regulators, diodes, wiring, relays, belts, cooling fins, ECMs, mounting hardware

**measurements** include: output voltage, output amperage, belt tension, resistance

**consumables** include: belts, wiring, terminals, circuit protection devices, relays

## Knowledge

	Learning Outcomes	Learning Objectives
D-18.01.01L	demonstrate knowledge of charging systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of charging systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of charging systems and their <b>components</b>
		interpret information pertaining to charging systems and their <b>components</b> found in <b>manufacturers' service information</b>
		identify <b>types of alternators</b> and their <b>components</b> , and describe their ratings, characteristics, applications and operation
		describe basic principles of electricity and circuit components
D-18.01.02L	demonstrate knowledge of procedures to service charging systems and their <b>components</b>	identify <b>tools and equipment</b> used to service charging systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to service charging systems and <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect charging systems and their <b>components</b>

	describe procedures to clean charging system <b>components</b>
	describe procedures to adjust and calibrate charging system <b>components</b>
	describe procedures to service charging systems and their <b>components</b>
	describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
	describe procedures to perform software updates
	identify materials that can be reconditioned, reused or recycled
	identify practices that reduce material waste

## Range of Variables

**components** (charging systems) include: alternators, internal and external regulators, diodes, wiring, relays, belts, cooling fins, ECMs, mounting hardware

**types of charging systems** include: 12-volt, 24-volt, externally or internally regulated, onboard charger (lift truck, manlift)

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of alternators** include: air/oil cooled, belt-driven, gear-driven, brush, brushless

**components** (alternators) include: rotors, stators, pulleys, fans, rectifiers, brushes, regulators, diodes, capacitors, slip rings

**tools and equipment** include: hand tools, shop tools, belt tension gauges, torque wrenches, load testers, ammeters, multimeters, laptop

**hazards** include: sparks, moving components, burns, battery explosions, noise, crush/pinch points

**consumables** include: belts, wiring, terminals, circuit protection devices, relays

## D-18.02 Diagnoses charging systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-18.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
D-18.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-18.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>

D-18.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
D-18.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
D-18.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
D-18.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-18.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
D-18.02.09P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
D-18.02.10P	perform failure analysis	failure analysis is performed to determine root cause of failure
D-18.02.11P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
D-18.02.12P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: overcharging, undercharging, fault lights and audible warning systems, smells, failed components, dead battery, noise

**tools and equipment** include: hand tools, shop tools, belt tension gauges, torque wrenches, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: damage, defect, wear

**tests** include: voltage drops, alternator output, checking fault codes, checking belt tension, current

**components** (charging systems) include: alternators, internal and external regulators, diodes, wiring, relays, belts, cooling fins, ECMs, mounting hardware

**measurements** include: voltage, resistance, amperage

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
D-18.02.01L	demonstrate knowledge of charging systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of charging systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of charging systems
		interpret information pertaining to charging systems found in <b>manufacturers' service information</b>
		identify <b>types of alternators</b> and their <b>components</b> , and describe their ratings, characteristics, applications and operation
D-18.02.02L	demonstrate knowledge of procedures to diagnose charging systems and their <b>components</b>	describe basic principles of electricity and circuit components
		identify <b>tools and equipment</b> used to diagnose charging systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose charging systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect charging systems and their <b>components</b>
		describe procedures to test charging systems and their <b>components</b>
		describe procedures to diagnose charging systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing charging systems
		identify steps for failure analysis
		identify practices that reduce material waste
	identify materials that can be reconditioned, reused or recycled	

### Range of Variables

**components** (charging systems) include: alternators, internal and external regulators, diodes, wiring, relays, belts, cooling fins, ECMs, mounting hardware

**types of charging systems** include: 12-volt, 24-volt, externally or internally regulated, onboard charger (lift truck, manlift)

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of alternators** include: air/oil cooled, belt-driven, gear-driven, brush, brushless

**components** (alternators) include: rotors, stators, pulleys, fans, rectifiers, brushes, regulators, diodes, capacitors, slip rings

**tools and equipment** include: hand tools, shop tools, belt tension gauges, torque wrenches, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**hazards** include: sparks, moving components, burns, battery explosions, noise, crush/pinch points

**symptoms of problems** include: overcharging, undercharging, fault lights and audible warning systems, smells, failed components, dead battery, noise

**conditions** include: damage, defect, wear

## D-18.03 Repairs charging systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-18.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-18.03.02P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>
D-18.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-18.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
D-18.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
D-18.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
D-18.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
D-18.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
D-18.03.09P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>

D-18.03.10P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
D-18.03.11P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
D-18.03.12P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, belt tension gauges, torque wrenches, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**components** (charging systems) include: alternators, internal and external regulators, diodes, wiring, relays, belts, cooling fins, ECMs, mounting hardware

**conditions** include: damage, defect, wear

**methods** include: bench testing, on-equipment testing, checking fault codes

Knowledge		
	Learning Outcomes	Learning Objectives
D-18.03.01L	demonstrate knowledge of charging systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of charging systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of charging systems
		interpret information pertaining to charging systems found in <b>manufacturers' service information</b>
		identify <b>types of alternators</b> and their <b>components</b> , and describe their ratings, characteristics, applications and operation
		describe basic principles of electricity and circuit components
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
D-18.03.02L	demonstrate knowledge of procedures to repair charging systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair charging systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to repairing charging systems
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>

	describe procedures to adjust and calibrate <b>components</b>
	describe procedures to recycle and dispose of <b>components</b>
	describe procedures to excite alternators
	describe <b>methods</b> to verify repairs
	describe procedures to perform software updates
	identify materials that can be reconditioned, reused or recycled
	identify practices that reduce material waste

## Range of Variables

**components** (charging systems) include: alternators, internal and external regulators, diodes, wiring, relays, belts, cooling fins, ECMs, mounting hardware

**types of charging systems** include: 12-volt, 24-volt, externally or internally regulated, onboard charger (lift truck, manlift)

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**types of alternators** include: air/oil cooled, belt-driven, gear-driven, brush, brushless

**components** (alternators) include: rotors, stators, pulleys, fans, rectifiers, brushes, regulators, diodes, capacitors, slip rings

**tools and equipment** include: hand tools, shop tools, belt tension gauges, torque wrenches, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**hazards** include: sparks, moving components, burns, battery explosions, noise, crush/pinch points

**methods** include: bench testing, on-equipment testing, checking fault codes



# Task D-19 Services, diagnoses and repairs starting systems

## Task Descriptor

A starting system is an electrical or pneumatic system that starts the engine.

Heavy duty equipment technicians must have a good understanding of starting systems, their operation and components in order to safely service, diagnose and repair them.

### D-19.01 Services starting systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
D-19.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-19.01.02P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>
D-19.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-19.01.04P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
D-19.01.05P	perform <b>tests</b>	<b>tests</b> are performed according to <b>manufacturers' service information</b>
D-19.01.06P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
D-19.01.07P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
D-19.01.08P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
D-19.01.09P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: starters, ECMs, solenoids, relays, connections, terminals, ignition switches, wiring

**conditions** include: corrosion, damage, slow cranking, electrical or mechanical resistance, noise

**tests** include: starter amp draw, voltage drop, control and safety systems, fault codes

**consumables** include: wiring, terminals, circuit protection devices, relays

Knowledge		
	Learning Outcomes	Learning Objectives
D-19.01.01L	demonstrate knowledge of starting systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of starting systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of starting systems and their <b>components</b>
		interpret information pertaining to starting systems and their <b>components</b> found in <b>manufacturers' service information</b>
		describe safety interlock devices designed to prevent starting of equipment in an unsafe condition
D-19.01.02L	demonstrate knowledge of procedures to service starting systems and their <b>components</b>	describe basic principles of electricity and circuit components
		identify <b>tools and equipment</b> used to service starting systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to servicing starting systems
		describe procedures to inspect starting systems and their <b>components</b>
		describe procedures to clean starting systems <b>components</b>
		describe procedures to service starting systems and their <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
identify practices that reduce material waste		

## Range of Variables

**components** include: starters, ECMs, solenoids, relays, connections, terminals, ignition switches, wiring  
**types of starting systems** include: 12-volt, 24-volt

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, shop tools, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**hazards** include: sparks, moving components, burns, noise, crush/pinch points

**consumables** include: wiring, terminals, circuit protection devices, relays

### D-19.02 Diagnoses starting systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
D-19.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
D-19.02.02P	select and use <b>tools and equipment</b> and starter circuit schematics	<b>tools and equipment</b> and starter circuit schematics are selected and used according to task and <b>manufacturers' service information</b>
D-19.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
D-19.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
D-19.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
D-19.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
D-19.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-19.02.08P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
D-19.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>

D-19.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
D-19.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
D-19.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
D-19.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: slow or constant cranking, intermittent operation, noise

**tools and equipment** include: hand tools, shop tools, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: corrosion, damage, slow cranking, electrical or mechanical resistance, noise, wear

**tests** include: starter draw, voltage drop, control and safety systems, fault codes

**components** include: starters, ECMs, solenoids, relays, connections, terminals, ignition switches, wiring

**measurements** include: voltage, amperage, resistance, clearance

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
D-19.02.01L	demonstrate knowledge of starting systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of starting systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of starting systems
		interpret information pertaining to starting systems found in <b>manufacturers' service information</b>
		describe safety interlock devices designed to prevent starting of equipment in an unsafe condition
		describe basic principles of electricity and circuit components

D-19.02.02L	demonstrate knowledge of procedures to diagnose starting systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose starting systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to diagnosing starting systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect starting systems and their <b>components</b>
		describe procedures to test starting systems and their <b>components</b>
		describe procedures to diagnose starting systems and their <b>components</b>
		describe <b>conditions</b> found while inspecting starting systems and their <b>components</b>
		identify steps for failure analysis
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
D-19.02.03L	demonstrate knowledge of <b>safety systems</b> , their characteristics, applications, and operation	identify and interpret <b>safety systems</b> and describe their characteristics, applications, and operating principles

## Range of Variables

**components** include: starters, ECMs, solenoids, relays, connections, terminals, ignition switches, wiring

**types of starting systems** include: 12-volt, 24-volt

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, shop tools, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**hazards** include: sparks, moving components, burns, noise, crush/pinch points

**symptoms of problems** include: slow or constant cranking, intermittent operation, noise

**conditions** include: corrosion, damage, slow cranking, electrical or mechanical resistance, noise, wear

**safety systems** include: neutral safety, interlock, operator presence

## D-19.03 Repairs starting systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-19.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-19.03.02P	isolate and release stored energy in components	stored energy is isolated and released in components according to <b>manufacturers' service information</b>
D-19.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-19.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
D-19.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
D-19.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
D-19.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
D-19.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
D-19.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
D-19.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
D-19.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
D-19.03.12P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
D-19.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
D-19.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**components** include: starters, ECMs, solenoids, relays, connections, terminals, ignition switches, wiring

**conditions** include: corrosion, damage, slow cranking, electrical or mechanical resistance, noise, wear

**methods** (to verify repairs) include: testing bench and starter draw, verifying fault codes

Knowledge		
	Learning Outcomes	Learning Objectives
D-19.03.01L	demonstrate knowledge of starting systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of starting systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of starting systems
		interpret information pertaining to starting systems found in <b>manufacturers' service information</b>
		describe safety interlock devices designed to prevent starting of equipment in an unsafe condition
D-19.03.02L	demonstrate knowledge of procedures to repair starting systems and their <b>components</b>	describe basic principles of electricity and circuit components
		identify <b>tools and equipment</b> used to repair starting systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair starting systems
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild, or repair <b>components</b>
		describe <b>methods</b> to rebuild starters
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
describe <b>methods</b> to verify repairs		
		describe procedures to perform software updates

		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
D-19.03.03L	demonstrate knowledge of <b>safety systems</b> , their characteristics, applications, and operation	identify and interpret <b>safety systems</b> and describe their characteristics, applications, and operating principles

## Range of Variables

**components** include: starters, ECMs, solenoids, relays, connections, terminals, ignition switches, wiring

**types of starting systems** include: 12-volt, 24-volt

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, shop tools, load testers, ammeters, multimeters, electronic service tools, onboard computer, laptop

**hazards** include: sparks, moving components, burns, noise, crush/pinch points

**methods** (to rebuild starters) include: replacing solenoid, brushes, bushings and starter drives; testing armatures and field windings; setting starter drive air gap

**methods** (to verify repairs) include: testing bench and starter draw, verifying fault codes

**safety systems** include: neutral safety, interlock, operator presence

## Task D-20 Services, diagnoses and repairs battery systems

### Task Descriptor

This task covers 12- or 24-volt battery systems. Battery systems that are used in hybrid and electric equipment are covered in another section of this standard.

Heavy duty equipment technicians need to understand battery systems, their applications and limitations in order to service, diagnose and repair them safely. Safety is an important consideration when working with battery systems.

### D-20.01 Services battery systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-20.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-20.01.02P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>



D-20.01.03P	clean battery system <b>components</b>	battery system <b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-20.01.04P	perform sensory inspection of battery system	sensory inspection of battery system is performed to identify worn, damaged and defective <b>components</b> for <b>conditions</b>
D-20.01.05P	load test batteries	batteries are load tested according to <b>manufacturers' service information</b>
D-20.01.06P	measure specific gravity of each cell	specific gravity of each cell is measured according to <b>manufacturers' service information</b>
D-20.01.07P	compare test results	test results are compared to <b>manufacturers' service information</b> or expected values
D-20.01.08P	replace faulty and damaged batteries	faulty and damaged batteries are replaced
D-20.01.09P	check and adjust electrolyte levels	electrolyte levels are checked and adjusted according to battery specifications
D-20.01.10P	recharge batteries	batteries are recharged according to <b>manufacturers' service information</b>
D-20.01.11P	disconnect and connect batteries in sequence	batteries are disconnected and connected in sequence according to <b>manufacturers' service information</b>
D-20.01.12P	apply anti-corrosion compounds to terminals and connections	anti-corrosion compounds are applied to terminals and connections according to <b>manufacturers' service information</b>
D-20.01.13P	recycle and dispose of batteries	batteries are recycled and disposed of according to jurisdictional regulations
D-20.01.14P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, ammeters, multimeters, load testers, hydrometers, refractometers, electronic service tools, laptop, onboard computer, battery chargers

**manufacturers' service information** include: specifications, standards, procedures

**components** include: batteries, terminals, connections, compartment, cables

**conditions** include: corroded and loose terminals, missing caps, damaged casing, loose and missing battery securement (hold-downs), low electrolytes

## Knowledge

Learning Outcomes	Learning Objectives
D-20.01.01L demonstrate knowledge of battery systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of battery systems</b> and <b>batteries</b> and their <b>components</b> , and describe their characteristics and applications
	describe operating principles of battery systems and their <b>components</b>
	interpret information pertaining to battery systems and their <b>components</b> found in <b>manufacturers' service information</b>
	identify <b>battery ratings</b>
D-20.01.02L demonstrate knowledge of procedures to service battery systems and their <b>components</b>	identify <b>tools and equipment</b> used to service battery systems and their <b>components</b> , and describe their applications and procedures for use
	identify <b>hazards</b> and describe safe work practices pertaining to servicing battery systems and their <b>components</b>
	describe battery maintenance schedules
	describe procedures to isolate stored energy
	describe procedures to inspect battery systems and their <b>components</b>
	describe procedures to clean <b>components</b>
	describe procedures to test battery systems and their <b>components</b>
	describe procedures to service battery systems and their <b>components</b>
	describe series and parallel connection procedures
	describe procedures to remove, replace, recharge, recycle and dispose of batteries
	identify materials that can be reconditioned, reused or recycled
	identify practices that reduce material waste
D-20.01.03L demonstrate knowledge of regulatory requirements pertaining to recycling and disposal of batteries	identify and interpret standards and regulations pertaining to recycling and disposal of batteries
D-20.01.04L demonstrate knowledge of emerging technologies and practices related to battery systems	identify emerging technologies that reduce environmental impacts

## Range of Variables

**components** include: batteries, terminals, connections, compartment, cables

**types of battery systems** include: parallel, series, series/parallel, capacitor

**types of batteries** include: sealed or vented flooded cell, absorbed glass mat (AGM), sealed gel cell, deep cycle, lithium

**manufacturers' service information** include: specifications, standards, procedures

**battery ratings** include: cranking amps (CA), cold cranking amps (CCA), reserve capacity (RC), amp hour, voltages

**tools and equipment** include: hand tools, ammeters, multimeters, load testers, hydrometers, refractometers, electronic service tools, laptop, onboard computer, battery chargers

**hazards** include: sparks, explosive gases, acid spillage, acid burns, electrical burns, heavy weight, lead exposure

### D-20.02 Diagnoses battery systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
D-20.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
D-20.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-20.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
D-20.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
D-20.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
D-20.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
D-20.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-20.02.08P	remove <b>components</b>	<b>components</b> are removed to identify or confirm problem
D-20.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>

D-20.02.10P	perform <b>failure</b> analysis	<b>failure</b> analysis is performed to determine root cause of <b>failures</b>
D-20.02.11P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
D-20.02.12P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: no start, hard start, battery smells, battery compartment smoking, noise, charging issues

**tools and equipment** include: hand tools, ammeters, multimeters, load testers, hydrometers, refractometers, electronic service tools, laptop, onboard computer, battery chargers

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**conditions** include: corroded and loose terminals, missing caps, damaged casing, loose and missing battery securement (hold-downs), low electrolytes

**tests** include: dynamic load, inductive load, open circuit voltage, resistance, voltage drop, specific gravity

**components** include: batteries, terminals, connections, compartment, cables

**failures** include: parasitic amperage draw, overcharging, undercharging, loose connections, corroded connections, frozen battery, low open circuit voltage

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
D-20.02.01L	demonstrate knowledge of battery systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of battery systems</b> and <b>batteries</b> , and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of battery systems and their <b>components</b>
		interpret information pertaining to battery systems and their <b>components</b> found in <b>manufacturers' service information</b>
		identify <b>battery ratings</b>
D-20.02.02L	demonstrate knowledge of procedures to diagnose battery systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose battery systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to diagnosing battery systems
		describe common causes and <b>symptoms of problems</b>
		identify procedures and safe work practices to boost equipment

		describe procedures to inspect battery systems and their <b>components</b>
		describe procedures to test battery systems and their <b>components</b>
		describe procedures to diagnose battery systems and their <b>components</b>
		identify <b>conditions</b> and <b>failures</b> found while diagnosing battery systems and their <b>components</b>
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
D-20.02.03L	demonstrate knowledge of regulatory requirements pertaining to recycling and disposal of batteries	identify and interpret standards and regulations pertaining to recycling and disposal of batteries
	demonstrate knowledge of emerging technologies and practices related to battery systems	identify emerging technologies that reduce environmental impacts

## Range of Variables

**components** include: batteries, terminals, connections, compartment, cables

**types of battery systems** include: parallel, series, series/parallel, capacitor

**types of batteries** include: sealed, vented, AGM, gel cell, lithium

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**battery ratings** include: CA, CCA, RC, amp hour, voltages

**tools and equipment** include: hand tools, ammeters, multimeters, load testers, hydrometers, refractometers, electronic service tools, laptop, onboard computer, battery chargers

**hazards** include: sparks, explosive gases, acid spillage, acid burns, electrical burns, heavy weight, lead exposure

**symptoms of problems** include: no start, hard start, battery smells, battery compartment smoking, noise, charging issues

**conditions** include: corroded and loose terminals, missing caps, damaged casing, loose and missing battery securement (hold-downs), low electrolytes

**failures** include: parasitic amperage draw, overcharging, undercharging, loose connections, corroded connections, frozen battery, low open circuit voltage

## D-20.03 Repairs battery systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-20.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-20.03.02P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>
D-20.03.03P	clean battery system <b>components</b>	battery system <b>components</b> are cleaned
D-20.03.04P	disconnect and connect batteries in sequence	batteries are disconnected and connected in sequence according to <b>manufacturers' service information</b>
D-20.03.05P	replace faulty and damaged batteries	faulty and damaged batteries are replaced
D-20.03.06P	apply anti-corrosion compounds to terminals and connections	anti-corrosion compounds are applied to terminals and connections according to <b>manufacturers' service information</b>
D-20.03.07P	replace or repair connecting cables	connecting cables are replaced or repaired according to <b>manufacturers' service information</b>
D-20.03.08P	check battery hold-downs and compartment	battery hold-downs and compartment are checked to ensure they are secure and in good condition
D-20.03.09P	recharge batteries	batteries are recharged according to <b>manufacturers' service information</b>
D-20.03.10P	de-sulphate batteries	batteries are de-sulphated according to <b>manufacturers' service information</b>
D-20.03.11P	recycle and dispose of batteries	batteries are recycled and disposed of according to jurisdictional regulations
D-20.03.12P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

### Range of Variables

**tools and equipment** include: hand tools, ammeters, multimeters, electronic service tools, laptop, onboard computer, battery chargers

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**components** include: batteries, terminals, connections, compartment, cables

## Knowledge

Learning Outcomes	Learning Objectives
D-20.03.01L demonstrate knowledge of battery systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of battery systems</b> and <b>batteries</b> , and their <b>components</b> , and describe their characteristics and applications
	describe operating principles of battery systems and their <b>components</b>
	interpret information pertaining to battery systems and their <b>components</b> found in <b>manufacturers' service information</b>
	identify <b>battery ratings</b>
	identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
D-20.03.02L demonstrate knowledge of procedures to repair battery systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair battery systems and their <b>components</b> , and describe their applications and procedures for use
	identify <b>hazards</b> and describe safe work practices pertaining to repairing battery systems and their <b>components</b>
	describe procedures to remove, disassemble, assemble and inspect battery systems and their <b>components</b>
	describe procedures to replace or repair battery systems and their <b>components</b>
	describe procedures to recharge batteries
	describe procedures to de-sulphate batteries
	describe procedures to recycle and dispose of <b>components</b>
	describe <b>methods</b> to verify repairs
	identify materials that can be reconditioned, reused or recycled
identify practices that reduce material waste	
D-20.03.03L demonstrate knowledge of regulatory requirements pertaining to recycling and disposal of batteries	identify and interpret standards and regulations pertaining to recycling and disposal of batteries
D-20.03.04L demonstrate knowledge of emerging technologies and practices related to battery systems	identify emerging technologies that reduce environmental impacts

## Range of Variables

**components** include: batteries, terminals, connections, compartment, cables

**types of battery systems** include: parallel, series, series-parallel, capacitor

**types of batteries** include: sealed, vented, AGM, gel cell, lithium

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**battery ratings** include: CA, CCA, RC, amp hour, voltages

**tools and equipment** include: hand tools, ammeters, multimeters, electronic service tools, laptop, onboard computer, battery chargers

**hazards** include: sparks, explosive gases, acid spillage, acid burns, electrical burns, heavy weight, lead exposure

**methods** include: operational checks, voltage

## Task D-21 Services, diagnoses and repairs electrical components

### Task Descriptor

Electrical systems are vital to the operation of the equipment and must work together to provide feedback to and from the operator. They control the operation and monitoring of various systems throughout the equipment.

Heavy duty equipment technicians must be able to service, diagnose and repair electrical system faults using specialized tools in order to return the equipment to service. They must have a good understanding of the basic principles of electricity and circuitry.

### D-21.01 Services electrical components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-21.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-21.01.02P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>
D-21.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-21.01.04P	perform sensory inspections	sensory inspections are performed to identify worn, damaged and defective <b>components</b> and connections
D-21.01.05P	perform <b>tests</b>	<b>tests</b> are performed and compared to <b>manufacturers' service information</b>



D-21.01.06P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
D-21.01.07P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
D-21.01.08P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
D-21.01.09P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
D-21.01.10P	perform <b>preventive maintenance</b> on <b>components</b>	<b>preventive maintenance</b> is performed on <b>components</b> according to <b>manufacturers' service information</b>
D-21.01.11P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, diagnostic equipment, terminal service tools, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins, schematics

**components** include: terminals, sockets, junction boxes, lighting devices, fuses, harnesses, plug-in connectors, wiring, resistors, relays, switches, diodes, breakers, motors, electric clutches, heating devices

**tests** include: amp draw, voltage drop, voltage, functional, resistance

**consumables** include: wiring, terminals, circuit protection devices, relays, lighting devices

**preventive maintenance** includes: tightening loose connections, applying anti-corrosion compound

## Knowledge

	Learning Outcomes	Learning Objectives
D-21.01.01L	demonstrate knowledge of electrical <b>components</b> , their characteristics, applications and operation	identify types of electrical <b>components</b> , and describe their characteristics and applications
		describe operating <b>principles</b> of electricity and electrical <b>components</b>
		interpret information pertaining to electricity and electrical <b>components</b> found in <b>manufacturers' service information</b>
		identify systems with stored energy sources
		describe basic wiring principles, and associated schematics and diagrams
		identify wires, and describe their <b>characteristics</b> and applications

		identify <b>types of lighting systems</b> , and describe their characteristics, applications and operation
		identify types of audio and video systems and their <b>components</b> , and describe their characteristics, applications and operation
		identify types of <b>instrumentation systems</b> , and describe their characteristics, applications and operation
		identify <b>safety systems</b> , and describe their characteristics and applications
D-21.01.02L	demonstrate knowledge of procedures to service electrical <b>components</b>	identify <b>tools and equipment</b> used to service electrical <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to servicing electrical <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect electrical <b>components</b>
		describe procedures to clean electrical <b>components</b>
		describe procedures to service electrical <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
D-21.01.03L	demonstrate knowledge of emerging technologies and practices related to electrical <b>components</b>	identify emerging technologies that reduce environmental impacts

## Range of Variables

**components** include: terminals, sockets, junction boxes, lighting devices, fuses, harnesses, plug-in connectors, wiring, resistors, relays, switches, diodes, breakers, motors, electric clutches, heating devices

**principles** include: Ohm's law, electron theory

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins, schematics

**characteristics** (wires) include: gauge, insulation, terminations

**types of lighting systems** include: incandescent, light emitting diode (LED), high intensity discharge (HID), halogen

**instrumentation systems** include: warning indicators, electric gauges

**safety systems** include: warning indicators, interlocks, lighting

**tools and equipment** include: hand tools, shop tools, diagnostic equipment, terminal service tools, laptop, multimeters

**hazards** include: shocks, sparks, burns, punctures

**consumables** include: wiring, terminals, circuit protection devices, relays, lighting devices

## D-21.02 Diagnoses electrical components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-21.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
D-21.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-21.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
D-21.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
D-21.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
D-21.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
D-21.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>

D-21.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
D-21.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
D-21.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
D-21.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
D-21.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to <b>manufacturers' service information</b>
D-21.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: blown fuses, dim or bright lighting, components not operating, noise, smells, smoke, overheating components

**tools and equipment** include: hand tools, shop tools, diagnostic equipment, terminal service tools, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins, schematics

**conditions** include: damage, defect, wear, corrosion

**tests** include: amp draw, voltage drop, voltage, functional, resistance

**components** include: terminals, sockets, junction boxes, lighting devices, fuses, harnesses, plug-in connectors, wiring, resistors, relays, switches, diodes, breakers, motors, electric clutches, heating devices

**measurements** include: amperage, voltage, resistance

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
D-21.02.01L	demonstrate knowledge of electrical <b>components</b> , their characteristics, applications and operation	identify types of electrical <b>components</b> , and describe their characteristics and applications
		describe operating <b>principles</b> of electricity and electrical <b>components</b>
		interpret information pertaining to electricity and electrical <b>components</b> found in <b>manufacturers' service information</b>
		identify systems with stored energy sources
		describe basic wiring principles, and associated schematics and diagrams

		identify wires, and describe their <b>characteristics</b> and applications
		identify <b>types of lighting systems</b> , and describe their characteristics, applications and operation
		identify types of audio and video systems and their <b>components</b> , and describe their characteristics, applications and operation
		identify types of <b>instrumentation systems</b> , and describe their characteristics, applications and operation
		identify <b>safety systems</b> , and describe their characteristics and applications
D-21.02.02L	demonstrate knowledge of procedures to diagnose electrical <b>components</b>	identify <b>tools and equipment</b> used to diagnose electrical <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to diagnosing electrical <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect electrical <b>components</b>
		describe procedures to test electrical <b>components</b>
		describe procedures to diagnose electrical <b>components</b>
		identify <b>conditions</b> found while diagnosing electrical <b>components</b>
		identify steps for failure analysis
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
D-21.02.03L	demonstrate knowledge of emerging technologies and practices related to electrical <b>components</b>	identify emerging technologies that reduce environmental impacts

## Range of Variables

**components** include: terminals, sockets, junction boxes, lighting devices, fuses, harnesses, plug-in connectors, wiring, resistors, relays, switches, diodes, breakers, motors, electric clutches, heating devices

**principles** include: Ohm's law, electron theory

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins, schematics

**characteristics** (wires) include: gauge, insulation, terminations

**types of lighting systems** include: incandescent, LED, HID, halogen

**components** (audio and video systems) include: displays, speakers, cameras, Cat 5, CANBUS, Bluetooth

**instrumentation systems** include: warning indicators, electric gauges

**safety systems** include: warning indicators, interlocks, lighting

**tools and equipment** include: hand tools, shop tools, diagnostic equipment, terminal service tools, laptop, multimeters

**hazards** include: shocks, sparks, burns, punctures

**symptoms of problems** include: blown fuses, dim or bright lighting, components not operating, noise, smells, smoke, overheating components

**conditions** include: damage, defect, wear, corrosion

### D-21.03 Repairs electrical components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
D-21.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-21.03.02P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>
D-21.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-21.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
D-21.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
D-21.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
D-21.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>

D-21.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
D-21.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
D-21.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
D-21.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
D-21.03.12P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
D-21.03.13P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
D-21.03.14P	verify repairs	repairs are verified using methods according to <b>manufacturers' service information</b>
D-21.03.15P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, diagnostic equipment, terminal service tools, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins, schematics

**components** include: terminals, sockets, junction boxes, lighting devices, fuses, harnesses, plug-in connectors, wiring, resistors, relays, switches, diodes, breakers, motors, electric clutches, heating devices

**conditions** include: damage, defect, wear, corrosion

**consumables** include: wiring, terminals, circuit protection devices, relays, lighting devices

Knowledge		
	Learning Outcomes	Learning Objectives
D-21.03.01L	demonstrate knowledge of electrical <b>components</b> , their characteristics, applications and operation	identify types of electrical <b>components</b> , and describe their characteristics and applications
		describe operating <b>principles</b> of electricity and electrical <b>components</b>
		interpret information pertaining to electricity and electrical <b>components</b> found in <b>manufacturers' service information</b>
		identify systems with stored energy sources
		describe basic wiring principles, and associated schematics and diagrams

		identify wires, and describe their <b>characteristics</b> and applications
		identify <b>types of lighting systems</b> , and describe their characteristics, applications and operation
		identify types of audio and video systems and their <b>components</b> , and describe their characteristics, applications and operation
		identify types of <b>instrumentation systems</b> , and describe their characteristics, applications and operation
		identify <b>safety systems</b> , and describe their characteristics and applications
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
D-21.03.02L	demonstrate knowledge of procedures to repair electrical <b>components</b>	identify <b>tools and equipment</b> used to repair electrical <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices pertaining to repairing electrical <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild or repair <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of electrical <b>components</b> and <b>consumables</b>
		describe methods to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
D-21.03.03L	demonstrate knowledge of emerging technologies and practices related to electrical <b>components</b>	identify emerging technologies that reduce environmental impacts



## Range of Variables

**components** include: terminals, sockets, junction boxes, lighting devices, fuses, harnesses, plug-in connectors, wiring, resistors, relays, switches, diodes, breakers, motors, electric clutches, heating devices

**principles** include: Ohm's law, electron theory

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins, schematics

**characteristics** (wires) include: gauge, insulation, terminations

**types of lighting systems** include: incandescent, LED, HID, halogen

**components** (audio and video systems) include: displays, speakers, cameras, Cat 5, CANBUS, Bluetooth

**instrumentation systems** include: warning indicators, electric gauges

**safety systems** include: warning indicators, interlocks, lighting

**tools and equipment** include: hand tools, shop tools, diagnostic equipment, terminal service tools, laptop, multimeters

**hazards** include: shocks, sparks, burns, punctures

**consumables** include: wiring, terminals, circuit protection devices, relays, lighting devices

# Task D-22 Services, diagnoses and repairs equipment management systems and electronic components

## Task Descriptor

Electronic equipment management systems are vital to the operation of the equipment and must work together to provide feedback to and from the operator. They monitor and control the operation of various components throughout the equipment.

Technological advancement throughout the industry has resulted in more complex equipment management systems and electronic components. Heavy duty equipment technicians must have a good understanding of electronic components, systems and networks such as CANBUS, LINBUS and multiplex.

Heavy duty equipment technicians must service, diagnose and repair equipment management systems and electronic components in order to ensure proper function and reduce down time.

### D-22.01 Services equipment management systems and electronic components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-22.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-22.01.02P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>
D-22.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-22.01.04P	perform sensory inspections	sensory inspections are performed to identify <b>component conditions</b> according to <b>manufacturers' service information</b>
D-22.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared to <b>manufacturers' service information</b>
D-22.01.06P	check for fault codes	fault codes are checked according to <b>manufacturers' service information</b>
D-22.01.07P	program or update modules	modules are programmed or updated according to <b>manufacturers' service information</b>
D-22.01.08P	verify operation of updated modules	operation of updated modules is verified according to <b>manufacturers' service information</b>

D-22.01.09P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
D-22.01.10P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, electronic service tools, laptop, onboard computer, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, information bulletins

**components** include: actuators, sensors, switches, ECMs, multi-function controls, wiring, connectors, data links, communication plugs, terminating resistors, display devices

**conditions** include: component securement, overheating, exposure to moisture and contaminants, instrument panel failures, display panel failures, communication problems, low voltage, failed modules, failed or out of adjustment sensors, wiring faults

**measurements** include: resistance, voltage

Knowledge		
	Learning Outcomes	Learning Objectives
D-22.01.01L	demonstrate knowledge of equipment management systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of equipment management systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of equipment management systems
		interpret information pertaining to equipment management systems and their <b>components</b> found in <b>manufacturers' service information</b>
		describe <b>communication protocols</b> , their characteristics and applications
		describe network structure and components, their characteristics and applications
		identify data links and describe network communication between modules
		identify basic computer processes, and describe their characteristics and applications
		identify <b>types of wiring</b> and standards
D-22.01.02L	demonstrate knowledge of procedures to service equipment management systems and their <b>components</b>	identify <b>tools and equipment</b> used to service equipment management systems and their <b>components</b> , and describe their applications and procedures for use

		identify <b>hazards</b> and describe <b>safe work practices</b> pertaining to servicing equipment management systems
		describe procedures to isolate stored energy
		describe procedures to inspect equipment management systems and their <b>components</b>
		describe procedures to clean <b>components</b>
		describe procedures to service equipment management systems and their <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe methods and procedures to program and configure modules
		describe procedures to verify operation of modules
D-22.01.03L	demonstrate knowledge of emerging technologies and practices related to equipment management systems and electronic components	identify emerging technologies that reduce environmental impacts and increase equipment and task efficiency and effectiveness

## Range of Variables

**components** include: actuators, sensors, switches, ECMs, multi-function controls, wiring, connectors, data links, communication plugs, terminating resistors, display devices

**types of equipment management systems** include: ABS/traction control, stability control, operator communication, remote monitoring systems (telematics), guidance systems, controller network systems (CANBUS, LINBUS, multiplex)

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, information bulletins

**communication protocols** include: SAE J1939, Bluetooth, Wi-Fi, cellular

**types of wiring** include: shielded, multi-strand, twisted pairs, coaxial, fibre optic, insulation

**tools and equipment** include: hand tools, shop tools, electronic service tools, laptop, onboard computer, multimeters

**hazards** include: shocks, sparks, punctures

**safe work practices** include: discharging static electricity, avoiding moisture and other contaminants

**D-22.02****Diagnoses equipment management systems and electronic components**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

**Skills**

	Performance Criteria	Evidence of Attainment
D-22.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
D-22.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-22.02.03P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>
D-22.02.04P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
D-22.02.05P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
D-22.02.06P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
D-22.02.07P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
D-22.02.08P	select and use scan tool to monitor and control parameters (data values)	scan tool is selected and used to monitor and control parameters (data values) according to <b>manufacturers' service information</b>
D-22.02.09P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
D-22.02.10P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-22.02.11P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
D-22.02.12P	perform failure analysis	failure analysis is performed to determine root cause of failure
D-22.02.13P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty purposes
D-22.02.14P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: intermittent or no operation, component not operating as expected, instrument panel or display malfunctioning, indicator lights, warning messages

**tools and equipment** include: hand tools, shop tools, electronic service tools, laptop, onboard computer, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, information bulletins

**conditions** include: overheating, exposure to moisture and contaminants, instrument panel failures, display panel failures, communication problems, low voltage, failed modules, failed or out of adjustment sensors, wiring faults

**components** include: actuators, sensors, switches, ECMs, multi-function controls, wiring, connectors, data links, communication plugs, terminating resistors, display devices

**tests** include: scanning for fault codes and events, confirming self-test, resistance, voltage

**next steps** include: repairs, component replacement or adjustment, software updates, further diagnosis

Knowledge		
Learning Outcomes	Learning Objectives	
D-22.02.01L	demonstrate knowledge of equipment management systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of equipment management systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of equipment management systems
		interpret information pertaining to equipment management systems and their <b>components</b> found in <b>manufacturers' service information</b>
		describe <b>communication protocols</b> , their characteristics and applications
		describe network structure and components, their characteristics and applications
		identify data links and describe network communication between modules
		identify basic computer processes, and describe their characteristics and applications
		identify <b>types of wiring</b> and standards

D-22.02.02L	demonstrate knowledge of procedures to diagnose equipment management systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose equipment management systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe <b>safe work practices</b> to diagnose equipment management systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect equipment management systems and their <b>components</b>
		describe procedures to test equipment management systems and their <b>components</b>
		describe procedures to calibrate and test sensor and actuator operation
		describe procedures to diagnose equipment management systems and their <b>components</b>
		describe procedures to isolate stored energy
		describe procedures to monitor and control parameters (data values)
		identify materials that can be reconditioned, reused or recycled
D-22.02.03L	demonstrate knowledge of emerging technologies and practices related to equipment management systems and their <b>components</b>	identify emerging technologies that reduce environmental impacts

## Range of Variables

**components** include: actuators, sensors, switches, ECMs, multi-function controls, wiring, connectors, data links, communication plugs, terminating resistors, display devices

**types of equipment management systems** include: ABS/traction control, stability control, operator communication, remote monitoring systems (telematics), guidance systems, controller network systems (CANBUS, LINBUS, multiplex)

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, information bulletins

**communication protocols** include: SAE J1939, Bluetooth, Wi-Fi, cellular

**types of wiring** include: shielded, multi-strand, twisted pairs, coaxial, fibre optic, insulation

**tools and equipment** include: hand tools, shop tools, electronic service tools, laptop, onboard computer, multimeters

**hazards** include: shocks, sparks, punctures

**safe work practices** include: discharging static electricity, avoiding moisture and other contaminants

**symptoms of problems** include: intermittent or no operation, component not operating as expected, instrument panel or display malfunctioning, indicator lights, warning messages

## D-22.03 Repairs equipment management systems and electronic components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
D-22.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
D-22.03.02P	isolate stored energy in components	stored energy is isolated in components according to <b>manufacturers' service information</b>
D-22.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
D-22.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
D-22.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
D-22.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
D-22.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
D-22.03.08P	check and perform software updates, and program or update modules	software updates are checked and performed, and modules are programmed or updated according to <b>manufacturers' service information</b>
D-22.03.09P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
D-22.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
D-22.03.11P	recondition <b>components</b>	<b>components</b> are reconditioned according to <b>manufacturers' service information</b>
D-22.03.12P	reassemble <b>components</b> and perform <b>measurements</b>	<b>components</b> are reassembled and <b>measurements</b> are performed according to <b>manufacturers' service information</b>
D-22.03.13P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>



D-22.03.14P	verify operation of updated modules	operation of updated modules is verified according to <b>manufacturers' service information</b>
D-22.03.15P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
D-22.03.16P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, electronic service tools, laptop, onboard computer, multimeters, wiring and terminal repair tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, information bulletins

**components** include: actuators, sensors, switches, ECMs, multi-function controls, wiring, connectors, data links, communication plugs, terminating resistors, display devices

**conditions** include: overheating, exposure to moisture and contaminants, instrument panel failures, display panel failures, communication problems, low voltage, failed modules, failed or out of adjustment sensors, wiring faults

**measurements** include: resistance, voltage

**methods** include: clearing codes, performing operational tests

## Knowledge

	Learning Outcomes	Learning Objectives
D-22.03.01L	demonstrate knowledge of equipment management systems, their <b>components</b> , characteristics, applications and operation	identify <b>types of equipment management systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of equipment management systems
		interpret information pertaining to equipment management systems and their <b>components</b> found in <b>manufacturers' service information</b>
		describe <b>communication protocols</b> , their characteristics and applications
		describe network structure and components, their characteristics and applications
		identify data links and describe network communication between modules
		identify basic computer processes, and describe their characteristics and applications
		identify <b>types of wiring</b> and standards

D-22.03.02L	demonstrate knowledge of procedures to repair equipment management systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair equipment management systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe <b>safe work practices</b> to repair equipment management systems
		describe procedures to isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild, repair or recondition <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>procedures to repair wiring</b>
		describe procedures to program and update modules
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
D-22.03.03L	demonstrate knowledge of emerging technologies and practices related to equipment management systems and their <b>components</b>	identify emerging technologies that reduce environmental impacts

## Range of Variables

**components** include: actuators, sensors, switches, ECMs, multi-function controls, wiring, connectors, data links, communication plugs, terminating resistors, display devices

**types of equipment management systems** include: ABS/traction control, stability control, operator communication, remote monitoring systems (telematics), guidance systems, controller network systems (CANBUS, LINBUS, multiplex)

**communication protocols** include: SAE J1939, Bluetooth, Wi-Fi, cellular

**tools and equipment** include: hand tools, shop tools, electronic service tools, laptop, onboard computer, multimeters, wiring and terminal repair tools

**hazards** include: shocks, sparks, punctures, unexpected movement of equipment

**safe work practices** include: discharging static electricity, avoiding moisture and other contaminants

**procedures to repair wiring** include: soldering, splicing, crimping, heat shrinking, terminal installation, insulation protection, complete replacement

**methods** include: clearing codes, performing operational tests

# Major Work Activity E

## Services, diagnoses and repairs drivetrain systems

### Task E-23 Services, diagnoses and repairs clutches

#### Task Descriptor

The clutch transfers energy and provides a means of disconnect from the engine to the driven member. Clutch systems are less common on off-road heavy equipment than in commercial transport, but there are some application-specific equipment that use them, such as over-centre clutches and older heavy equipment.

Heavy duty equipment technicians must service, diagnose and repair the clutch to increase longevity and optimal performance of the equipment.

#### E-23.01 Services clutches

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

Performance Criteria		Evidence of Attainment
E-23.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-23.01.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-23.01.03P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>
E-23.01.04P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
E-23.01.05P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
E-23.01.06P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>

E-23.01.07P	adjust clutch and linkages	clutch and linkages are adjusted according to <b>manufacturers' service information</b>
E-23.01.08P	inspect and adjust cables and linkages	cables and linkages are inspected and adjusted according to <b>manufacturers' service information</b>
E-23.01.09P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: pullers, dial indicators, alignment tools, measuring tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: primary and secondary cylinders, flywheels, pressure plates, friction discs and plates, forks, springs, bearings, seals, gaskets, filters, breathers, component control systems, release springs, release bearings, cross shafts, linkages

**measurements** include: free play, release bearing clearance, shaft play, end play

Knowledge		
	Learning Outcomes	Learning Objectives
E-23.01.01L	demonstrate knowledge of clutches, their <b>components</b> , characteristics, applications and operation	identify <b>types of clutches</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of clutches and their <b>components</b>
		interpret information pertaining to clutches found in <b>manufacturers' service information</b>
		identify types of <b>clutch controls</b> , and describe their characteristics and applications
E-23.01.02L	demonstrate knowledge of procedures to service clutches and their <b>components</b>	identify types, viscosity and quality of fluids, and describe their characteristics and applications
		identify <b>tools and equipment</b> used to service clutches and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service clutches
		describe procedures to inspect clutches and their <b>components</b>
		describe procedures to clean clutches and their <b>components</b>

	describe procedures to lubricate and adjust clutches and their <b>components</b>
	describe procedures to service clutches and their <b>components</b>
	describe procedures to remove, replace, recycle and dispose of <b>consumables</b>

## Range of Variables

**components** include: primary and secondary cylinders, flywheels, pressure plates, friction discs and plates, forks, springs, bearings, seals, gaskets, filters, breathers, component control systems, release springs, release bearings, cross shafts, linkages

**types of clutches** include: over-center, push, pull, dry, wet

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**clutch controls** include: cable, linkage, hydraulic-assisted, electronically controlled

**tools and equipment** include: pullers, dial indicators, alignment tools, measuring tools

**hazards** include: crush/pinch points, airborne contaminants, fluid leaks, hazardous materials

**consumables** include: fluids, solvents, grease

## E-23.02 Diagnoses clutches

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

## Skills

	Performance Criteria	Evidence of Attainment
E-23.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
E-23.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-23.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
E-23.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
E-23.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
E-23.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values

E-23.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-23.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
E-23.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-23.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
E-23.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
E-23.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
E-23.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: hard shifting, loss of free play, excessive free play, slipping clutch, high engine RPMs, leaks, odours, low power, vibration, noise

**tools and equipment** include: feeler gauges, spring gauges, measuring devices, dial indicators, straight edges, temperature gauges

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, leaks

**tests** include: free play, operational

**components** include: primary and secondary cylinders, flywheels, pressure plates, friction discs and plates, forks, springs, bearings, seals, gaskets, filters, breathers, component control systems, release springs, release bearings, cross shafts, linkages

**measurements** include: free play, release bearing clearance, shaft play, end play, spring tension, torque application

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
E-23.02.01L	demonstrate knowledge of clutches, their <b>components</b> , characteristics, applications and operation	identify <b>types of clutches</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of clutches and their <b>components</b>
		interpret information pertaining to clutches found in <b>manufacturers' service information</b>

		identify types of <b>clutch controls</b> , and describe their characteristics and applications
		identify and describe <b>clutch faults</b>
		identify types, viscosity and quality of fluids, and describe their characteristics and applications
E-23.02.02L	demonstrate knowledge of procedures to diagnose clutches and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose clutches and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> , and describe safe work practices to diagnose clutches and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect clutches and their <b>components</b>
		describe procedures to test clutches and their <b>components</b>
		describe procedures to diagnose clutches and their <b>components</b>
		identify steps for failure analysis

## Range of Variables

**components** include: primary and secondary cylinders, flywheels, pressure plates, friction discs and plates, forks, springs, bearings, seals, gaskets, filters, breathers, component control systems, release springs, release bearings, cross shafts, linkages

**types of clutches** include: over-center, push, pull, dry, wet

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**clutch controls** include: cable, linkage, hydraulic-assisted, electronically controlled

**clutch faults** include: slipping, worn parts, seized release bearings, broken clutch springs

**tools and equipment** include: feeler gauges, spring gauges, measuring devices, dial indicators, straight edges, temperature gauges

**hazards** include: crush/pinch points, airborne contaminants, fluid leaks, air leaks

**symptoms of problems** include: hard shifting, loss of free play, excessive free play, slipping clutch, high engine RPMs, leaks, odours, low power, vibration, noise

## E-23.03 Repairs clutches

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-23.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-23.03.02P	release stored energy in <b>components</b>	stored energy is released in <b>components</b> according to <b>manufacturers' service information</b>
E-23.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-23.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-23.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
E-23.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
E-23.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
E-23.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
E-23.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
E-23.03.10P	reassemble <b>components</b> and perform <b>measurements</b>	<b>components</b> are reassembled and <b>measurements</b> are performed according to <b>manufacturers' service information</b>
E-23.03.11P	adjust clutch and linkages	clutch and linkages are adjusted to <b>manufacturers' service information</b>
E-23.03.12P	verify alignment of discs and pressure plates	alignment of discs and pressure plates are verified according to <b>manufacturers' service information</b>
E-23.03.13P	bleed air from primary and secondary cylinders	air from primary and secondary cylinders are bled
E-23.03.14P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
E-23.03.15P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking



## Range of Variables

**tools and equipment** include: pullers, dial indicators, alignment tools, feeler gauges, spring tension gauges

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: primary and secondary cylinders, flywheels, pressure plates, friction discs and plates, forks, springs, bearings, seals, gaskets, filters, breathers, component control systems, release springs, release bearings, cross shafts, linkages

**conditions** include: wear, damage, defects, failure

**parts and materials** include: gaskets, sealants, fastening devices, shims

**measurements** include: free play, release bearing clearance, shaft play, end play, spring tension, torque application

**methods** include: operational testing, sensory observations

Knowledge		
Learning Outcomes	Learning Objectives	
E-23.03.01L	demonstrate knowledge of clutches, their <b>components</b> , characteristics, applications and operation	identify <b>types of clutches</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of clutches and their <b>components</b>
		interpret information pertaining to clutches found in <b>manufacturers' service information</b>
		identify types of <b>clutch controls</b> , and describe their characteristics and applications
		identify types, viscosity and quality of fluids, and describe their characteristics and applications
E-23.03.02L	demonstrate knowledge of procedures to repair clutches and their <b>components</b>	identify <b>tools and equipment</b> used to repair clutches and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair clutches and their <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair, replace or recondition <b>components</b>
		describe procedures to adjust clutches, cables and linkages
		describe procedures to recycle and dispose of <b>components</b>

	describe <b>methods</b> to verify repairs
	identify materials that can be reconditioned or reused
	identify practices that reduce material waste

## Range of Variables

**components** include: primary and secondary cylinders, flywheels, pressure plates, friction discs and plates, forks, springs, bearings, seals, gaskets, filters, breathers, component control systems, release springs, release bearings, cross shafts, linkages

**types of clutches** include: over-center, push, pull, dry, wet

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**clutch controls** include: cable, linkage, hydraulic-assisted, electronically controlled

**tools and equipment** include: pullers, dial indicators, alignment tools, feeler gauges, spring tension gauges

**hazards** include: crush/pinch points, airborne contaminants, fluid leaks, hazardous materials

**conditions** include: wear, damage, defects, failure

**parts and materials** include: gaskets, sealants, fastening devices, shims

**measurements** include: free play, release bearing clearance, shaft play, end play, spring tension, torque application

**methods** include: operational testing, sensory observations

## Task E-24 Services, diagnoses and repairs torque converters, fluid couplers and hydraulic retarders

### Task Descriptor

Torque converters provide engine power to various types of transmissions. Fluid couplers are used to transmit torque between two engines connected in series. Hydraulic retarders are used to slow down the forward momentum of equipment.

Heavy duty equipment technicians must diagnose, service and repair these components to increase longevity and optimal performance of the equipment.

### E-24.01 Services torque converters, fluid couplers and hydraulic retarders

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-24.01.01P	select and use tools and equipment	tools and equipment are selected and used according to task and <b>manufacturers' service information</b>
E-24.01.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-24.01.03P	perform sensory inspections	sensory inspections are performed to identify worn, damaged and defective <b>components</b> and connections
E-24.01.04P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
E-24.01.05P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
E-24.01.06P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
E-24.01.07P	calibrate lock-up clutch	lock-up clutch is calibrated according to <b>manufacturers' service information</b>
E-24.01.08P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**components** (to be cleaned) include: drain plugs, filter base, screens

**components** include: stators, impellers, turbines, sprag clutches (over running clutches, lock-up clutches), valves, lines, seals, bearings, retarder rotors

**consumables** include: filters, oil, O-rings, gaskets, breathers

Knowledge		
Learning Outcomes	Learning Objectives	
E-24.01.01L	demonstrate knowledge of torque converters, fluid couplers and hydraulic retarders and their <b>components</b> , characteristics, applications and operation	identify types of torque converters, fluid couplers and hydraulic retarders and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of torque converters, fluid couplers and hydraulic retarders
		interpret information pertaining to torque converters, fluid couplers and hydraulic retarders found in <b>manufacturers' service information</b>
		identify types of coolers, and describe their locations, characteristics and applications
E-24.01.02L	demonstrate knowledge of procedures to service torque converters, fluid couplers and hydraulic retarders and their <b>components</b>	identify types, viscosity and quality of fluids, and describe their characteristics and applications
		identify tools and equipment used to service torque converters, fluid couplers and hydraulic retarders, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service torque converters, fluid couplers and hydraulic retarders
		describe procedures to inspect torque converters, fluid couplers and hydraulic retarders
		describe procedures to clean torque converter, fluid coupler and hydraulic retarder <b>components</b>
		describe procedures to service torque converters, fluid couplers and hydraulic retarders
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
describe procedures to calibrate lock-up clutch		

## Range of Variables

**components** include: stators, impellers, turbines, sprag clutches (over running clutches, lock-up clutches), valves, lines, seals, bearings, retarder rotors

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**hazards** include: hot fluids, pressurized fluids, moving parts, rolling equipment, hazardous materials, crush/pinch points

**consumables** include: filters, oil, O-rings, gaskets, breathers

### E-24.02 Diagnoses torque converters, fluid couplers and hydraulic retarders

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
E-24.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
E-24.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-24.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
E-24.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
E-24.02.05P	check fluid level and condition	fluid level and condition are checked
E-24.02.06P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
E-24.02.07P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
E-24.02.08P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-24.02.09P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
E-24.02.10P	inspect <b>components for conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>

E-24.02.11P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
E-24.02.12P	perform failure analysis	failure analysis is performed to determine root cause of failure
E-24.02.13P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
E-24.02.14P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: leaks, excessive heat, odours, abnormal noise, lack of power

**tools and equipment** include: pressure gauges, temperature gauges, flow meters, tachometers, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, contaminated fluids, internal leaks, failures in other parts of system

**tests** include: converter stall speed, flow, lock-up clutch calibration, pressure tests to identify internal leakage, vibration and engagement

**components** include: stators, impellers, turbines, sprag clutches (over running clutches, lock-up clutches), valves, lines, seals, bearings, retarder rotors

**measurements** include: flow, pressure, temperature, RPM

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
E-24.02.01L	demonstrate knowledge of torque converters, fluid couplers and hydraulic retarders and their <b>components</b> , characteristics, applications and operation	identify types of torque converters, fluid couplers and hydraulic retarders, and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of torque converters, fluid couplers and hydraulic retarders
		interpret information pertaining to torque converters, fluid couplers and hydraulic retarders found in <b>manufacturers' service information</b>
		identify types of coolers, and describe their locations, characteristics and applications
		identify types, viscosity and quality of fluids, and describe their characteristics and applications

E-24.02.02L	demonstrate knowledge of procedures to diagnose torque converters, fluid couplers and hydraulic retarders, and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose torque converters, fluid couplers and hydraulic retarders, and their <b>components</b> , and describe their procedures for use
		identify <b>hazards</b> , and describe manufacturers' safety procedures to diagnose torque converters, fluid couplers and hydraulic retarders
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect torque converters, fluid couplers and hydraulic retarders
		describe procedures to test torque converters, fluid couplers and hydraulic retarders
		describe procedures to diagnose torque converters, fluid couplers and hydraulic retarders
		identify <b>conditions</b> found while diagnosing torque converters, fluid couplers and hydraulic retarders
		identify steps for failure analysis
E-24.02.03L	demonstrate knowledge of emerging technologies and practices pertaining to torque converters, fluid couplers and hydraulic retarders	identify effect of hybrid and all-electric equipment on torque converters, fluid couplers and hydraulic retarders

## Range of Variables

**components** include: stators, impellers, turbines, sprag clutches (over running clutches, lock-up clutches), valves, lines, seals, bearings, retarder rotors

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, temperature gauges, flow meters, tachometers, laptop

**hazards** include: hot fluids, pressurized fluids, moving parts, rolling equipment, hazardous materials, crush/pinch points

**symptoms of problems** include: leaks, excessive heat, odours, abnormal noise, lack of power

**conditions** include: wear, damage, contaminated fluids, internal leaks, failures in other parts of system

## E-24.03 Repairs torque converters, fluid couplers and hydraulic retarders

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-24.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-24.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
E-24.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-24.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-24.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
E-24.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
E-24.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
E-24.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
E-24.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
E-24.03.10P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
E-24.03.11P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated to <b>manufacturers' service information</b>
E-24.03.11P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
E-24.03.12P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking



## Range of Variables

**tools and equipment** include: micrometers, feeler gauges, pullers, cooling and heating devices, pressure testing tools, flow meters, lifting equipment, electronic service tools, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: stators, impellers, turbines, sprag clutches (over running clutches, lock-up clutches), valves, lines, seals, bearings, retarder rotors

**conditions** include: damage, defects, wear, failure

**parts and materials** include: gaskets, sealants, fastening devices, bearings, seals, shims

**methods** include: operational test, flow test, pressure test, stall test

Knowledge		
	Learning Outcomes	Learning Objectives
E-24.03.01L	demonstrate knowledge of torque converters, fluid couplers and hydraulic retarders and their <b>components</b> , characteristics, applications and operation	identify types of torque converters, fluid couplers and hydraulic retarders and their <b>components</b> and describe their characteristics and applications
		describe operating principles of torque converters, fluid couplers and hydraulic retarders
		interpret information pertaining to torque converters, fluid couplers and hydraulic retarders found in <b>manufacturers' service information</b>
		identify types of coolers, and describe their locations, characteristics and applications
		identify types, viscosity and quality of fluids, and describe their characteristics and applications
E-24.03.02L	demonstrate knowledge of procedures to repair torque converters, fluid couplers and hydraulic retarders, and their <b>components</b>	identify <b>tools and equipment</b> used to repair torque converters, fluid couplers and hydraulic retarders, and their <b>components</b> , and describe their procedures for use
		identify <b>hazards</b> , and describe manufacturers' safety procedures to repair torque converters, fluid couplers and hydraulic retarders
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>

	describe <b>methods</b> to verify repairs
	describe procedures to perform software updates
	identify materials that can be reconditioned or reused

## Range of Variables

**components** include: stators, impellers, turbines, sprag clutches (over running clutches, lock-up clutches), valves, lines, seals, bearings, retarder rotors

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: micrometers, feeler gauges, pullers, cooling and heating devices, pressure testing tools, flow meters, lifting equipment, electronic service tools, laptop

**hazards** include: hot fluids, pressurized fluids, moving parts, rolling equipment, hazardous materials, crush/pinch points, falling objects

**methods** include: operational test, flow test, pressure test, stall test

## Task E-25 Services, diagnoses and repairs manual transmissions and transfer cases

### Task Descriptor

Manual transmissions and transfer cases transfer power from the engine through the drive shaft to the wheels to enable movement of the equipment. Manual transmission allows for selection of gear ratios needed for various loads and speed conditions. The transfer case allows transmission power to be directed to components such as additional axles and accessories.

Heavy duty equipment technicians diagnose, service and repair manual transmissions and transfer cases minimizing down time of the equipment, and ensuring the safety of the equipment, driver and public.

### E-25.01 Services manual transmissions and transfer cases

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-25.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-25.01.02P	clean <b>components</b>	<b>components</b> are cleaned
E-25.01.03P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>

E-25.01.04P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
E-25.01.05P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
E-25.01.06P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
E-25.01.07P	document service information and inspection findings	service information and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking

### Range of Variables

**tools and equipment** include: shop tools, measuring devices (for clutch pack thickness), pressure gauges, spring scales (for measuring rolling torque), alignment tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** (to be cleaned) include: transmission cases, screens, magnets

**components** (to be inspected) include: seals, gaskets, bearings, splines, secondary cylinders, range valves, filters, detents, hoses, pumps, forward/reverse shuttle

**consumables** include: oil, filters, breathers

### Knowledge

	Learning Outcomes	Learning Objectives
E-25.01.01L	demonstrate knowledge of manual transmissions and transfer cases, their <b>components, consumables, characteristics, applications</b> and operation	identify manual transmissions, and describe their characteristics and <b>applications</b>
		identify transfer cases, and describe their characteristics and <b>applications</b>
		identify manual transmission and transfer case <b>components</b> and <b>consumables</b>
		describe operating principles of manual transmissions and transfer cases
		describe operating principles of <b>transfer case shift controls</b>
		interpret information pertaining to manual transmissions and transfer cases found in <b>manufacturers' service information</b>

E-25.01.02L	demonstrate knowledge of procedures to service manual transmissions and transfer cases, and their <b>components</b>	identify tools and equipment used to service manual transmissions and transfer cases, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and safe work practices to service manual transmissions and transfer cases, and their <b>components</b>
		describe procedures to inspect manual transmission and transfer case <b>components</b>
		describe procedures to clean manual transmission and transfer case <b>components</b>
		describe procedures to service manual transmission and transfer case <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>

## Range of Variables

**components** include: clutch packs, pistons, gears, gear sets, shafts, pumps, bearings, splines, seals, gaskets, fluids, filters, valves, lines, component control systems, coolers, breathers, synchronizers, main shafts, counter shafts, detents, speed sensors

**consumables** include: oil, filters, breathers

**tools and equipment** include: shop tools, measuring devices (for clutch pack thickness), pressure gauges, spring scales (for measuring rolling torque), alignment tools

**applications** (for manual transmissions) include: backhoes, utility tractors, forklifts

**applications** (for transfer cases) include: four wheel drive equipment, high-low range

**transfer case shift controls** include: air, electrical, mechanical, hydraulic

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: spills, crush/pinch points, sharp edges, burns

**components** (to be inspected) include: seals, gaskets, bearings, splines, secondary cylinders, range valves, filters, detents, hoses, pumps, forward/reverse shuttle

**components** (to be cleaned) include: transmission cases, screens, magnets

## E-25.02 Diagnoses manual transmissions and transfer cases

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-25.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
E-25.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-25.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
E-25.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
E-25.02.05P	perform diagnostic procedures and tests	diagnostic procedures and tests are performed according to <b>manufacturers' service information</b>
E-25.02.06P	verify diagnosis	diagnosis results are compared to <b>manufacturers' service information</b> or expected values
E-25.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-25.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
E-25.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-25.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
E-25.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
E-25.02.12P	document test results and inspection findings	test results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
E-25.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: hard shifting, jumping out of gear, noise, vibration, leaks, excessive heat

**tools and equipment** include: pullers, torque wrenches, presses, heating and cooling equipment, lifting equipment, slide hammers, manufacturer-specific tools, shop tools, measuring devices (for clutch pack thickness), pressure gauges, spring scales (for measuring rolling torque), alignment tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure

**components** include: clutch packs, pistons, gears, gear sets, shafts, pumps, bearings, splines, seals, gaskets, fluids, filters, valves, lines, component control systems, coolers, breathers, synchronizers, main shafts, counter shafts, detents, speed sensors

**measurements** include: end play, up and down play, backlash

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
E-25.02.01L	demonstrate knowledge of manual transmissions and transfer cases, their <b>components, consumables</b> , characteristics, <b>applications</b> and operation	identify manual transmissions, and describe their characteristics and <b>applications</b>
		identify transfer cases and describe their characteristics and <b>applications</b>
		identify manual transmission and transfer case <b>components</b> and <b>consumables</b>
		describe operating principles of manual transmissions and transfer cases
		describe operating principles of <b>transfer case shift controls</b>
		interpret information pertaining to manual transmissions and transfer cases found in <b>manufacturers' service information</b>
		identify common <b>faults</b> found in manual transmissions and transfer cases, and their <b>components</b>
		identify types, viscosity and quality of fluids, and describe their characteristics and applications

E-25.02.02L	demonstrate knowledge of procedures to diagnose manual transmissions and transfer cases, and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose manual transmissions and transfer cases, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose manual transmissions and transfer cases, and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect manual transmissions and transfer cases, and their <b>components</b>
		describe procedures to test manual transmissions and transfer cases, and their <b>components</b>
		describe procedures to diagnose manual transmissions and transfer cases, and their <b>components</b>
		identify <b>conditions</b> found while diagnosing manual transmissions and transfer cases and their <b>components</b>
		identify steps for failure analysis

## Range of Variables

**components** include: clutch packs, pistons, gears, gear sets, shafts, pumps, bearings, splines, seals, gaskets, fluids, filters, valves, lines, component control systems, coolers, breathers, synchronizers, main shafts, counter shafts, detents, speed sensors

**consumables** include: oil, filters, breathers

**applications** (for manual transmissions) include: backhoes, utility tractors, forklifts

**applications** (for transfer cases) include: four wheel drive equipment, high-low range

**transfer case shift controls** include: air, electrical, mechanical, hydraulic

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**faults** include: missing teeth in gears, lack of lubrication, worn synchronizers, bearing failure

**tools and equipment** include: pullers, torque wrenches, presses, heating and cooling equipment, lifting equipment, slide hammers, manufacturer-specific tools, shop tools, measuring devices (for clutch pack thickness), pressure gauges, spring scales (for measuring rolling torque), alignment tools

**hazards** include: spills, crush/pinch points, sharp edges

**symptoms of problems** include: hard shifting, jumping out of gear, noise, vibration, leaks, excessive heat

**conditions** include: wear, damage, defects, failure

## E-25.03 Repairs manual transmissions and transfer cases

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-25.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-25.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
E-25.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-25.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-25.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
E-25.03.06P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
E-25.03.07P	repair <b>components</b>	<b>components</b> are repaired following repair sequence according to <b>manufacturers' service information</b>
E-25.03.08P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
E-25.03.09P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
E-25.03.10P	time gears	gears are timed according to <b>manufacturers' service information</b>
E-25.03.11P	install power take-offs (PTOs)	PTOs are installed according to <b>manufacturers' service information</b>
E-25.03.12P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
E-25.03.13P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking



## Range of Variables

**tools and equipment** include: pullers, torque wrenches, presses, heating and cooling equipment, lifting equipment, slide hammers, manufacturer-specific tools, shop tools, measuring devices (for clutch pack thickness), pressure gauges, spring scales (for measuring rolling torque), alignment tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: clutch packs, pistons, gears, gear sets, shafts, pumps, bearings, splines, seals, gaskets, fluids, filters, valves, lines, component control systems, coolers, breathers, synchronizers, main shafts, counter shafts, detents, speed sensors

**conditions** include: damage, defect, wear, failure

**parts and materials** include: gaskets, sealants, fastening devices, bearings, seals, shims

**methods** include: operational testing, sensory observations

Knowledge		
	Learning Outcomes	Learning Objectives
E-25.03.01L	demonstrate knowledge of manual transmissions and transfer cases, their <b>components</b> , <b>consumables</b> , characteristics, <b>applications</b> and operation	identify manual transmissions, and describe their characteristics and <b>applications</b>
		identify transfer cases and describe their characteristics and <b>applications</b>
		identify manual transmission and transfer case <b>components</b> and <b>consumables</b>
		describe operating principles of manual transmissions and transfer cases
		describe operating principles of <b>transfer case shift controls</b>
E-25.03.02L	demonstrate knowledge of procedures to repair manual transmissions and transfer cases, and their <b>components</b>	interpret information pertaining to manual transmissions and transfer cases found in <b>manufacturers' service information</b>
		identify <b>tools and equipment</b> used to repair manual transmissions and transfer cases, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair manual transmissions and transfer cases, and their <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>

	describe procedures to recycle and dispose of <b>components</b>
	describe <b>methods</b> to verify repairs
	identify materials that can be reconditioned or reused

## Range of Variables

**components** include: clutch packs, pistons, gears, gear sets, shafts, pumps, bearings, splines, seals, gaskets, fluids, filters, valves, lines, component control systems, coolers, breathers, synchronizers, main shafts, counter shafts, detents, speed sensors

**consumables** include: oil, filters, solvents, breathers

**applications** (for manual transmissions) include: backhoes, utility tractors, forklifts

**applications** (for transfer cases) include: four wheel drive equipment, high-low range

**transfer case shift controls** include: air, electrical, mechanical, hydraulic

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pullers, torque wrenches, presses, heating and cooling equipment, lifting equipment, slide hammers, manufacturer-specific tools, shop tools, measuring devices (for clutch pack thickness), pressure gauges, spring scales (for measuring rolling torque), alignment tools

**hazards** include: spills, crush/pinch points, sharp edges, burns, falling objects, stored energy

**methods** include: operational testing, sensory observations

# Task E-26 Services, diagnoses and repairs automatic and powershift transmissions

## Task Descriptor

Automatic and powershift transmissions transfer power from the engine to the drivetrain. Heavy duty equipment technicians must have a good understanding of automatic and powershift transmission operation and components in order to service, diagnose and repair these systems and ensure proper function and reduce downtime.

### E-26.01 Services automatic and powershift transmissions

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-26.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-26.01.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-26.01.03P	perform sensory inspections	sensory inspections are performed to identify leaks, breaks and excessive wear
E-26.01.04P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
E-26.01.05P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
E-26.01.06P	collect oil sample for analysis	oil sample is collected and analyzed according to <b>manufacturers' service information</b>
E-26.01.07P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
E-26.01.08P	calibrate <b>components</b>	components are calibrated according to <b>manufacturers' service information</b>
E-26.01.09P	check and perform software updates	software is checked and updates are performed according to <b>manufacturers' service information</b>
E-26.01.10P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: shop tools, fluid recovery system, electronic service tools, laptop, other specialized equipment recommended by manufacturer, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: valve bodies, pumps, solenoids, clutches, clutch packs, bearings, seals, bands, servos, planetaries, sensors, springs, shafts

**consumables** include: oil, filters, breathers

Knowledge		
Learning Outcomes	Learning Objectives	
E-26.01.01L	demonstrate knowledge of automatic and powershift transmissions, their <b>components, consumables</b> , characteristics, applications and operation	identify types of automatic and powershift transmissions, and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of automatic and powershift transmissions
		interpret information pertaining to automatic and powershift transmissions found in <b>manufacturers' service information</b>
		identify types of coolers, and describe their locations, characteristics and applications
E-26.01.02L	demonstrate knowledge of procedures to service automatic and powershift transmissions and their <b>components</b>	identify types, viscosity and quality of fluids, and describe their characteristics and applications
		identify <b>tools and equipment</b> used to service automatic and powershift transmissions and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service automatic and powershift transmissions
		describe procedures to inspect automatic and powershift transmission <b>components</b>
		describe procedures to service automatic and powershift transmission <b>components</b>
E-26.01.03L	demonstrate knowledge of emerging technologies and practices related to automatic and powershift transmissions	describe procedures to remove, replace, recycle and dispose of automatic and powershift transmission <b>consumables</b>
		describe procedures to perform software updates and calibrations
		identify effects of hybrid and all-electric equipment on automatic and powershift transmissions

## Range of Variables

**components** include: valve bodies, pumps, solenoids, clutches, clutch packs, bearings, seals, bands, servos, planetaries, sensors, springs, shafts

**consumables** include: oil, filters, breathers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: shop tools, fluid recovery system, electronic service tools, laptop, other specialized equipment recommended by manufacturer, multimeters

**hazards** include: fluid spills, sharp edges, hot fluids, moving objects, crush/pinch points

### E-26.02 Diagnoses automatic and powershift transmissions

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

Performance Criteria		Evidence of Attainment
E-26.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
E-26.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-26.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
E-26.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
E-26.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
E-26.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
E-26.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-26.02.08P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
E-26.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-26.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>

E-26.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
E-26.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
E-26.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: harsh shifting, noise, delayed shift, no gear selection, vibration, leaks, excessive heat

**tools and equipment** include: shop tools, pressure gauges, fluid recovery system, electronic service tools, laptop, other specialized equipment provided by manufacturer, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, leaks, defects, failure, oil conditions

**tests** include: stall testing, pressure readings, temperature

**components** include: valve bodies, pumps, solenoids, clutches, clutch packs, bearings, seals, bands, servos, planetaries, sensors, springs

**measurements** include: pressure, temperature, RPM

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
E-26.02.01L	demonstrate knowledge of automatic and powershift transmissions, their <b>components, consumables</b> , characteristics, applications and operation	identify automatic and powershift transmissions and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of automatic and powershift transmissions
		interpret information pertaining to automatic and powershift transmissions found in <b>manufacturers' service information</b>
		identify types of coolers, and describe their locations, characteristics and applications
		identify types, viscosity and quality of fluids, and describe their characteristics and applications
		describe effects of <b>component</b> failures

E-26.02.02L	demonstrate knowledge of procedures to diagnose automatic and powershift transmissions and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose automatic and powershift transmissions and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose automatic transmissions and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect automatic and powershift transmissions and their <b>components</b>
		describe procedures to test automatic and powershift transmissions and their <b>components</b>
		describe procedures to diagnose automatic and powershift transmissions and their <b>components</b>
		describe procedures to perform software updates and calibrations
E-26.02.03L	demonstrate knowledge of emerging technologies and practices related to automatic and powershift transmissions	identify effects of hybrid and all-electric equipment on automatic and powershift transmissions

## Range of Variables

**components** include: valve bodies, pumps, solenoids, clutches, clutch packs, bearings, seals, bands, servos, planetaries, sensors, springs

**consumables** include: oil, filters, breathers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: shop tools, pressure gauges, fluid recovery system, electronic service tools, laptop, other specialized equipment provided by manufacturer, multimeters

**hazards** include: fluid spills, sharp edges, hot fluids, crush/pinch points

**symptoms of problems** include: harsh shifting, noise, delayed shift, no gear selection, vibration, leaks, excessive heat

## E-26.03 Repairs automatic and powershift transmissions

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-26.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-26.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
E-26.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-26.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-26.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
E-26.03.06P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
E-26.03.07P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
E-26.03.08P	repair <b>components</b>	<b>components</b> are repaired following repair sequence according to <b>manufacturers' service information</b>
E-26.03.09P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
E-26.03.10P	verify most current version of software is installed in ECM	software installed in ECM is verified to ensure it is most up-to-date version
E-26.03.11P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
E-26.03.12P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking



## Range of Variables

**tools and equipment** include: shop tools, fluid recovery system, pressure gauges, electronic service tools, laptop, manufacturer-specific equipment, pullers, torque wrenches, presses, micrometers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: valve bodies, pumps, solenoids, clutches, clutch packs, bearings, seals, bands, servos, planetaries, sensors

**conditions** include: damage, defect, wear, failure

**parts and materials** include: gaskets, sealants, fastening devices, bearings, seals

**methods** include: operational testing, function testing, stall testing

Knowledge		
	Learning Outcomes	Learning Objectives
E-26.03.01L	demonstrate knowledge of automatic and powershift transmissions, their <b>components, consumables</b> , characteristics, applications and operation	identify automatic and powershift transmissions and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of automatic and powershift transmissions
		interpret information pertaining to automatic and powershift transmissions found in <b>manufacturers' service information</b>
		identify types of coolers, and describe their locations, characteristics and applications
		identify types, viscosity and quality of fluids and additives, and describe their characteristics and applications
E-26.03.02L	demonstrate knowledge of procedures to repair automatic and powershift transmissions and their <b>components</b>	identify <b>tools and equipment</b> used to repair automatic and powershift transmissions and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair automatic and powershift transmissions and their <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair, replace or recondition <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>

		describe procedures to recycle and dispose of <b>components</b>
		describe procedures to perform software updates and calibrations
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned or reused
E-26.03.03L	demonstrate knowledge of emerging technologies and practices related to automatic and powershift transmissions	identify effects of hybrid and all-electric equipment on automatic and powershift transmissions

## Range of Variables

**components** include: valve bodies, pumps, solenoids, clutches, clutch packs, bearings, seals, bands, servos, planetaries, sensors

**consumables** include: oil, additives, filters, breathers, friction discs, plates

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: shop tools, fluid recovery system, pressure gauges, electronic service tools, laptop, manufacturer-specific equipment, pullers, torque wrenches, presses, micrometers

**hazards** include: fluid spills, sharp edges, hot fluids, crush/pinch points, falling objects, stored energy

**methods** include: operational testing, function testing, stall testing

# Task E-27 Services, diagnoses and repairs driveline systems

## Task Descriptor

The driveline provides a mechanical linkage between the drive and driven components. Heavy duty equipment technicians must understand the influence of driveline length, angles and correct phasing on the driveline system.

Heavy duty equipment technicians must be able to efficiently diagnose driveline systems and sub-systems to maintain equipment performance and reliability to reduce equipment down time.

### E-27.01 Services driveline systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
E-27.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-27.01.02P	perform sensory inspections	sensory inspections are performed to identify worn, damaged, loose and defective <b>components</b> and driveline phasing
E-27.01.03P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
E-27.01.04P	verify phasing	phasing is verified according to <b>manufacturers' service information</b>
E-27.01.05P	lubricate serviceable u-joints, steady bearings and slip joints	serviceable u-joints, steady bearing and slip joints are lubricated according to <b>manufacturers' service information</b>
E-27.01.06P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

### Range of Variables

**tools and equipment** include: hand tools, dial indicators, straight edges, u-joint pullers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** (to be inspected) include: yokes, u-joints, mounting hardware, steady bearings, counterweights

**measurements** include: torque, total indicated runout (TIR)

## Knowledge

	Learning Outcomes	Learning Objectives
E-27.01.01L	demonstrate knowledge of driveline systems, their <b>components</b> , characteristics, applications and operation	identify driveline systems and their <b>components</b> , and describe their characteristics and applications  describe operating principles of driveline systems  interpret information pertaining to driveline systems found in <b>manufacturers' service information</b>  identify and distinguish between serviceable and non-serviceable driveline system <b>components</b>
E-27.01.02L	demonstrate knowledge of procedures to service driveline systems and their <b>components</b>	identify <b>tools and equipment</b> used to service driveline systems and their <b>components</b> , and describe their applications and procedures for use  identify <b>hazards</b> and describe safe work practices to service driveline systems and their <b>components</b>  describe procedures to inspect driveline system <b>components</b>  describe procedures to service driveline system <b>components</b>  describe procedures to lubricate serviceable u-joints, steady bearings and slip joints

### Range of Variables

**components** include: bearings, seals, gaskets, u-joints, yokes, slip joints, mounting hardware, steady bearings, constant-velocity (CV) joints, drive shafts, lubricants

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, dial indicators, straight edges, u-joint pullers

**hazards** include: moving parts, grease injection, sharp edges, airborne contaminants, crush/pinch points

**components** (to be inspected) include: yokes, u-joints, mounting hardware, steady bearings, counterweights

## E-27.02 Diagnoses driveline systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-27.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
E-27.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-27.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
E-27.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
E-27.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
E-27.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
E-27.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-27.02.08P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
E-27.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-27.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
E-27.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
E-27.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
E-27.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: vibration, noise, no movement, lack of power

**tools and equipment** include: vibration analyzers, angle gauges, electronic service tools, dial indicators, straight edges

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure

**tests** include: operational testing, angle gauge

**components** include: hanger bearings, seals, gaskets, u-joints, yokes, slip joints, mounting hardware, steady bearings, CV joints, drive shafts, lubricants, driveline saver

**measurements** include: driveline angle, driveline phasing, slip joint length, play, ride height

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
E-27.02.01L	demonstrate knowledge of driveline systems, their <b>components</b> , characteristics, applications and operation	identify driveline systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of driveline systems
		interpret information pertaining to driveline systems found in <b>manufacturers' service information</b>
		identify and distinguish between serviceable and non-serviceable driveline systems
		identify driveline angles and support bearings, and describe their characteristics, applications and wear limits
		describe correct orientation and phasing of drive shaft
E-27.02.02L	demonstrate knowledge of procedures to diagnose driveline systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose driveline systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose driveline systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect driveline systems and their <b>components</b>
		describe procedures to test driveline systems and their <b>components</b>
		describe procedures to diagnose driveline systems and their <b>components</b>

	identify <b>conditions</b> found while diagnosing driveline systems and their <b>components</b>
	identify steps for failure analysis
	identify materials that can be reconditioned or reused

## Range of Variables

**components** include: hanger bearings, seals, gaskets, u-joints, yokes, slip joints, mounting hardware, steady bearings, CV joints, drive shafts, lubricants, driveline saver

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: vibration analyzers, angle gauges, electronic service tools, dial indicators, straight edges

**hazards** include: moving parts, grease injection, sharp edges, airborne contaminants, crush/pinch points

**symptoms of problems** include: vibration, noise, no movement, lack of power

**conditions** include: wear, damage, defects, failure

## E-27.03 Repairs driveline systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-27.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-27.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
E-27.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-27.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-27.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
E-27.03.06P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
E-27.03.07P	repair <b>components</b>	<b>components</b> are repaired following repair sequence according to <b>manufacturers' service information</b>

E-27.03.08P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
E-27.03.09P	<b>adjust components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
E-27.03.10P	lubricate u-joints and slip joints	u-joints and slip joints are lubricated according to <b>manufacturers' service information</b>
E-27.03.11P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
E-27.03.12P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: u-joint tools, hand tools, pullers, torque wrenches, presses, straight edges, lifting equipment

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: bearings, seals, gaskets, u-joints, yokes, slip joints, mounting hardware, steady bearings, CV joints, drive shafts, lubricants, driveline saver

**conditions** include: damage, defect, wear, failure

**parts and materials** include: gaskets, sealants, fastening devices, u-joints, bearings, slip joints, yokes

**adjust** includes: phasing

**methods** include: operational testing, angle gauges, verifying balancing

## Knowledge

	Learning Outcomes	Learning Objectives
E-27.03.01L	demonstrate knowledge of driveline systems, their <b>components</b> , characteristics, applications and operation	identify driveline systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of driveline systems
		interpret information pertaining to driveline systems found in <b>manufacturers' service information</b>
		identify and distinguish between serviceable and non-serviceable driveline systems
		identify driveline angles and support bearings, and describe their characteristics, applications and wear limits
		describe correct orientation and phasing of drive shaft



E-27.03.02L	demonstrate knowledge of procedures to repair driveline systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair driveline systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair driveline systems and their <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace or repair <b>components</b>
		describe procedures to <b>adjust components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe procedures to lubricate serviceable u-joints and slip joints
		describe procedures to install and phase driveline systems
		describe procedures to install and remove yoke and u-joint
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned or reused

## Range of Variables

**components** include: bearings, seals, gaskets, u-joints, yokes, slip joints, mounting hardware, steady bearings, CV joints, drive shafts, lubricants, driveline saver

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: u-joint tools, hand tools, pullers, torque wrenches, presses, straight edges, lifting equipment

**hazards** include: moving parts, grease injection, sharp edges, airborne contaminants, crush/pinch points, falling objects, stored energy

**adjust** includes: phasing

# Task E-28 Services, diagnoses and repairs drive axles and differentials

## Task Descriptor

Drive axles and differentials transfer power from the transfer case or transmission to the wheels or tracks. Heavy duty equipment technicians must be able to service, diagnose and repair drive axles and differential assembly.

### E-28.01 Services drive axles and differentials

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-28.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-28.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
E-28.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-28.01.04P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>
E-28.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
E-28.01.06P	check fluid level and visually inspect fluid and plug condition	fluid level is checked, and fluid and plug condition is visually inspected during scheduled maintenance for <b>irregularities</b> according to <b>manufacturers' service information</b>
E-28.01.07P	collect oil sample for analysis	oil sample is collected and analyzed according to <b>manufacturers' service information</b>
E-28.01.08P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>

E-28.01.09P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
E-28.01.10P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
E-28.01.11P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, drain pans, pumps, measuring tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** (to be cleaned) include: breathers, vents, drain plugs

**components** include: seals, axles, gaskets, hubs, bearings, spindles, shafts, crown and pinion sets, spider gears, sun gears, limited slip and differential lockups, coolers, lines, pumps, component control systems, breathers, trunnions, shims, adjustment nuts

**measurements** include: thrust pin clearance

**irregularities** include: material, metal attached to drain plug, water in oil, overfilled oil, contamination

**consumables** include: fluids, additives, grease, filters

## Knowledge

	Learning Outcomes	Learning Objectives
E-28.01.01L	demonstrate knowledge of drive axles and differentials, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of drive axles</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		identify <b>types of differentials</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of drive axles and differentials
		interpret information pertaining to drive axles and differentials found in <b>manufacturers' service information</b>
		identify different weight ratings and gear ratios
		identify types, viscosity and quality of fluids, additives and lubricants, and describe their characteristics and applications

E-28.01.02L	demonstrate knowledge of procedures to service drive axles and differentials, and their <b>components</b> and <b>consumables</b>	identify <b>tools and equipment</b> used to service drive axles and differentials, and their <b>components</b> and <b>consumables</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service drive axles and differentials, and their <b>components</b> and <b>consumables</b>
		describe procedures to inspect drive axles and differentials, and their <b>components</b> and <b>consumables</b>
		describe procedures to clean drive axles and differential <b>components</b>
		describe procedures to service drive axles and differentials, and their <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		identify practices that reduce material waste
E-28.01.03L	demonstrate knowledge of emerging technologies and practices related to drive axles and differentials	identify effects of hybrid and all-electric equipment on drive axles and differentials

## Range of Variables

**components** include: seals, axles, gaskets, hubs, bearings, spindles, shafts, crown and pinion sets, spider gears, sun gears, limited slip and differential lockups, coolers, lines, pumps, component control systems, breathers, trunnions, shims, adjustment nuts

**consumables** include: fluids, additives, grease, filters

**types of drive axles** include: semi-floating, full floating, oscillating, planetary drive (inboard, outboard)

**types of differentials** include: locking, limited slip, open

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, drain pans, pumps, measuring tools

**hazards** include: sharp edges, fluid spills, crush/pinch points, hazardous materials

**components** (to be cleaned) include: breathers, vents, drain plugs

## E-28.02 Diagnoses drive axles and differentials

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-28.02.01P	identify <b><i>symptoms of problems</i></b>	<b><i>symptoms of problems</i></b> are identified by consulting with customer or operator
E-28.02.02P	select and use <b><i>tools and equipment</i></b>	<b><i>tools and equipment</i></b> are selected and used according to task and <b><i>manufacturers' service information</i></b>
E-28.02.03P	perform sensory inspections	sensory inspections are performed to identify <b><i>conditions</i></b>
E-28.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b><i>manufacturers' service information</i></b> and by performing operational test
E-28.02.05P	perform diagnostic procedures, <b><i>tests and measurements</i></b>	diagnostic procedures, <b><i>tests and measurements</i></b> are performed according to <b><i>manufacturers' service information</i></b>
E-28.02.06P	verify diagnosis	diagnosis is verified by interpreting test results and comparing them to <b><i>manufacturers' service information</i></b> or expected values
E-28.02.07P	clean <b><i>components</i></b>	<b><i>components</i></b> are cleaned according to <b><i>manufacturers' service information</i></b>
E-28.02.08P	remove and disassemble <b><i>components</i></b> to identify or confirm problem	<b><i>components</i></b> are removed and disassembled to identify or confirm problem
E-28.02.09P	inspect <b><i>components</i></b> for <b><i>conditions</i></b>	<b><i>components</i></b> are inspected for <b><i>conditions</i></b> according to <b><i>manufacturers' service information</i></b>
E-28.02.10P	perform failure analysis	failure analysis is performed to determine root cause of failure
E-28.02.11P	document test results and inspection findings	test results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
E-28.02.12P	interpret diagnostic results to determine <b><i>next steps</i></b>	diagnostic results are interpreted to determine <b><i>next steps</i></b>

## Range of Variables

**symptoms of problems** include: noise, inter-axle differential lock not working, no drive, external leaks, excessive heat, contaminated oil

**tools and equipment** include: temperature gauges, dial indicators

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, incorrect backlash, incorrect preload, fluid contamination, water in oil, metal attached to drain plug

**tests and measurements** include: end play, backlash, trunnion fore and aft movement, preload, thrust pin clearance, wet brake wear, oil sample analysis

**components** include: seals, axles, gaskets, hubs, bearings, spindles, shafts, crown and pinion sets, spider gears, sun gears, limited slip and differential lockups, coolers, lines, pumps, component control systems, breathers, trunnions, shims, adjustment nuts

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
Learning Outcomes	Learning Objectives	
E-28.02.01L	demonstrate knowledge of drive axles and differentials, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of drive axles</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		identify <b>types of differentials</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of drive axles and differentials
		interpret information pertaining to drive axles and differentials found in <b>manufacturers' service information</b>
		identify different weight ratings and gear ratios
		identify types, viscosity and quality of fluids, additives and lubricants, and describe their characteristics and applications
E-28.02.02L	demonstrate knowledge of procedures to diagnose drive axles and differentials, and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose drive axles and differentials, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose drive axles and differentials and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect drive axles and differentials, and their <b>components</b>
		describe procedures to test drive axles and differentials, and their <b>components</b>

		describe procedures to diagnose drive axles and differentials, and their <b>components</b>
		identify <b>conditions</b> found while diagnosing drive axles and differentials and their <b>components</b>
		identify steps for failure analysis
		identify materials that can be reconditioned or reused
E-28.02.03L	demonstrate knowledge of emerging technologies and practices related to drive axles and differentials	identify effects of hybrid and all-electric equipment on drive axles and differentials

## Range of Variables

**components** include: seals, axles, gaskets, hubs, bearings, spindles, shafts, crown and pinion sets, spider gears, sun gears, limited slip and differential lockups, coolers, lines, pumps, component control systems, breathers, trunnions, shims, adjustment nuts

**consumables** include: fluids, additives, grease, filters

**types of drive axles** include: semi-floating, full floating, oscillating, planetary drive (inboard/outboard)

**types of differentials** include: locking, limited slip, open

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**tools and equipment** include: temperature gauges, dial indicators

**hazards** include: sharp edges, fluid spills, crush/pinch points, hazardous materials

**symptoms of problems** include: noise, inter-axle differential lock not working, no drive, external leaks, excessive heat, contaminated oil

**conditions** include: wear, damage, defects, failure, incorrect backlash, incorrect preload, fluid contamination, water in oil, metal attached to drain plug

## E-28.03 Repairs drive axles and differentials

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
E-28.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-28.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
E-28.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>

E-28.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-28.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
E-28.03.06P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
E-28.03.07P	repair <b>components</b>	<b>components</b> are repaired following repair sequence according to <b>manufacturers' service information</b>
E-28.03.08P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
E-28.03.10P	adjust <b>components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
E-28.03.11P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
E-28.03.12P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: manufacturers' specialty tools, measuring tools, hand tools, pullers, torque wrenches, presses, heating and cooling equipment, lifting equipment

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**components** include: seals, axles, gaskets, hubs, bearings, spindles, shafts, crown and pinion sets, spider gears, sun gears, limited slip and differential lockups, coolers, lines, pumps, component control systems, breathers, trunnions

**conditions** include: damage, defect, wear, failure, leaks

**parts and materials** include: gaskets, sealants, fastening devices, shims, bearings, seals

**methods** include: using marking paste, dial indicators, spring scale

## Knowledge

	Learning Outcomes	Learning Objectives
E-28.03.01L	demonstrate knowledge of drive axles and differentials, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of drive axles</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		identify <b>types of differentials</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of drive axles and differentials



		interpret information pertaining to drive axles and differentials found in <b>manufacturers' service information</b>
		identify different weight ratings and gear ratios
		identify types, viscosity and quality of fluids, additives and lubricants, and describe their characteristics and applications
		identify <b>differential lock methods</b> , and describe their characteristics and applications
E-28.03.02L	demonstrate knowledge of procedures to repair drive axles and differentials, and their <b>components</b>	identify <b>tools and equipment</b> used to repair drive axles and differentials, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair drive axles and differentials, and their <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, <b>rebuild</b> , or repair <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned or reused
E-28.03.03L	demonstrate knowledge of emerging technologies and practices related to drive axles and differentials	identify effects of hybrid and all-electric equipment on drive axles and differentials

## Range of Variables

**components** include: seals, axles, gaskets, hubs, bearings, spindles, shafts, crown and pinion sets, spider gears, sun gears, limited slip and differential lockups, coolers, lines, pumps, component control systems, breathers, trunnions

**consumables** include: fluids, additives, grease, filters

**types of drive axles** include: semi-floating, full floating, oscillating, planetary drive (inboard, outboard)

**types of differentials** include: locking, limited slip, open

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**differential lock methods** include: air, all-electric, hydraulic, mechanical (limited slip)

**tools and equipment** include: manufacturers' specialty tools, measuring tools, hand tools, pullers, torque wrenches, presses, heating and cooling equipment, lifting equipment

**hazards** include: sharp edges, fluid spills, crush/pinch points, falling objects, stored energy

**rebuild** includes: setting and adjusting preload and backlash, checking and adjusting crown and pinion gear tooth pattern

**methods** include: using marking paste, dial indicators, spring scale

## Task E-29 Services, diagnoses and repairs final drive systems

### Task Descriptor

The final drive system provides the final gear reduction to increase torque and reduce speed to the final output.

Heavy duty equipment technicians must be able to service, diagnose and repair final drive systems including planetary, chain, and bull and pinion systems.

### E-29.01 Services final drive systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
E-29.01.01P	select and use tools and equipment	tools and equipment are selected and used according to task and <b>manufacturers' service information</b>
E-29.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
E-29.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-29.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify leaks and worn, damaged and defective <b>components</b>

E-29.01.05P	check oil level and inspect oil and plug condition	oil level is checked, and oil and plug condition is inspected during scheduled maintenance for <b>irregularities</b> according to <b>manufacturers' service information</b>
E-29.01.06P	collect oil sample for analysis	oil sample is collected and analyzed according to <b>manufacturers' service information</b>
E-29.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
E-29.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
E-29.01.09P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
E-29.01.10P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** (to be cleaned) include: drain plugs, filters, magnets

**sensory inspections** include: looking for water and fuel discolouration, smelling for odours such as burnt oil

**irregularities** include: material, metal attached to drain plug, water in oil, contaminants

**consumables** include: oil, additives, filters, breathers

**components** include: bearings, gears, seals, gaskets, shafts, covers, housings, chains, sprockets

## Knowledge

	Learning Outcomes	Learning Objectives
E-29.01.01L	demonstrate knowledge of final drive systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of final drive systems</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of final drive systems
		interpret information pertaining to final drive systems found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of oils, additives and lubricants, and describe their characteristics and applications
		identify different gear ratios and calculations used to determine ratios

E-29.01.02L	demonstrate knowledge of procedures to service final drive systems, and their <b>components</b> and <b>consumables</b>	identify tools and equipment used to service final drive systems, and their <b>components</b> and <b>consumables</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service final drive systems, and their <b>components</b> and <b>consumables</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect final drive systems, their <b>components</b> and <b>consumables</b>
		describe procedures to clean final drive systems <b>components</b>
		describe procedures to remove, replace, service, recycle and dispose of final drive system <b>consumables</b>
E-29.01.03L	demonstrate knowledge of emerging technologies and practices related to final drive systems	identify effects of hybrid and all-electric equipment on final drive systems

## Range of Variables

**components** include: bearings, gears, seals, gaskets, shafts, covers, housings, chains, sprockets

**consumables** include: oil, additives, filters, breathers

**types of final drive systems** include: planetary (inboard, outboard), bull and pinion, chain

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: burns, oil spills, crush/pinch points

**components** (to be cleaned) include: drain plugs, filters, magnets

## E-29.02 Diagnoses final drive systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

## Skills

	Performance Criteria	Evidence of Attainment
E-29.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
E-29.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-29.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>

E-29.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
E-29.02.05P	perform diagnostic procedures and operational test	diagnostic procedures and operational test are performed according to <b>manufacturers' service information</b>
E-29.02.06P	verify diagnosis	diagnosis is verified by interpreting operational test results and comparing them to <b>manufacturers' service information</b> or expected values
E-29.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-29.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
E-29.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-29.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
E-29.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
E-29.02.12P	document test results and inspection findings	test results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
E-29.02.13P	interpret <b>diagnostic results</b> to determine <b>next steps</b>	<b>diagnostic results</b> are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: noise, no drive, external leaks, excessive heat

**tools and equipment** include: hand tools, shop tools, blocking equipment, temperature gauges, manufacturer-specific tools

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, incorrect backlash, incorrect preload, leaks, oil contamination

**components** include: bearings, gears, seals, gaskets, shafts, covers, housings, chains, sprockets

**measurements** include: shim pack thickness

**diagnostic results** include: oil sample analysis results, wear patterns, contamination trends

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

Learning Outcomes	Learning Objectives
E-29.02.01L demonstrate knowledge of final drive systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of final drive systems</b> , their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
	describe operating principles of final drive systems
	interpret information pertaining to final drive systems found in <b>manufacturers' service information</b>
	identify types, viscosity and quality of oils, additives and lubricants, and describe their characteristics and applications
E-29.02.02L demonstrate knowledge of procedures to diagnose final drive systems, and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose final drive systems, and their <b>components</b> , and describe their applications and procedures for use
	identify <b>hazards</b> and describe safe work practices to diagnose final drive systems and their <b>components</b>
	describe common causes and <b>symptoms of problems</b>
	describe procedures to inspect final drive systems and their <b>components</b>
	describe procedures to test final drive systems and their <b>components</b>
	describe procedures to diagnose final drive systems and their <b>components</b>
	identify <b>conditions</b> found while diagnosing final drive systems and their <b>components</b>
E-29.02.03L demonstrate knowledge of emerging technologies and practices related to final drive systems	identify steps for failure analysis
	identify materials that can be reconditioned or reused
	identify effects of hybrid and all-electric equipment on final drive systems

## Range of Variables

**components** include: bearings, gears, seals, gaskets, shafts, covers, housings, chains, sprockets

**consumables** include: oil, additives, filters, breathers

**types of final drive systems** include: planetary (inboard, outboard), bull and pinion, chain

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, shop tools, blocking equipment, temperature gauges, manufacturer-specific tools

**hazards** include: burns, oil spills, crush/pinch points, wheel and track assembly removal hazards, unexpected equipment movement

**symptoms of problems** include: noise, no drive, external leaks, excessive heat

**conditions** include: wear, damage, defects, failure, incorrect backlash, incorrect preload, leaks, oil contamination

### E-29.03 Repairs final drive systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
E-29.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
E-29.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
E-29.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
E-29.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
E-29.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
E-29.03.06P	replace <b>components</b> and <b>consumables</b>	<b>components</b> and <b>consumables</b> are replaced according to <b>manufacturers' service information</b>
E-29.03.07P	repair <b>components</b>	<b>components</b> are repaired following repair sequence according to <b>manufacturers' service information</b>
E-29.03.08P	reassemble and install <b>components</b> , and perform measurements	<b>components</b> are reassembled and installed, and measurements are performed according to <b>manufacturers' service information</b>

E-29.03.09P	set and adjust preload, endplay and backlash	preload, endplay and backlash are set and adjusted according to <b>manufacturers' service information</b>
E-29.03.10P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
E-29.03.11P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: manufacturers' specialty tools, measuring tools, hand tools, pullers, torque wrenches, presses, heating and cooling equipment, blocking and lifting equipment

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**components** include: bearings, gears, seals, gaskets, shafts, covers, housings, chains, sprockets

**conditions** include: damage, defect, wear, failure, leaks

**parts and materials** include: gaskets, sealants, fastening devices, bearings, seals, shims

**consumables** include: oil, additives, filters, breathers

**methods** include: using dial indicators, spring scale, torque wrenches

Knowledge		
	Learning Outcomes	Learning Objectives
E-29.03.01L	demonstrate knowledge of final drive systems, their <b>components</b> , consumables, characteristics, applications and operation	<p>identify <b>types of final drive systems</b>, their <b>components</b> and consumables, and describe their characteristics and applications</p> <p>describe operating principles of final drive systems</p> <p>interpret information pertaining to final drive systems found in <b>manufacturers' service information</b></p> <p>identify types, viscosity and quality of oils, additives and lubricants, and describe their characteristics and applications</p>
E-29.03.02L	demonstrate knowledge of procedures to repair final drive systems and their <b>components</b>	<p>identify <b>tools and equipment</b> used to repair final drive systems and their <b>components</b>, and describe their applications and procedures for use</p> <p>identify <b>hazards</b> and describe safe work practices to repair final drive systems and their <b>components</b></p> <p>describe procedures to remove, disassemble, assemble and inspect <b>components</b></p> <p>describe procedures to replace or repair <b>components</b></p>



		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned or reused
E-29.03.03L	demonstrate knowledge of emerging technologies and practices related to final drive systems	identify effects of hybrid and all-electric equipment on final drive systems

### Range of Variables

**components** include: bearings, gears, seals, gaskets, shafts, covers, housings, chains, sprockets

**types of final drive systems** include: planetary (inboard/outboard), bull and pinion, chain

**manufacturers' service information** include: specifications, recommendations, procedures, standards

**tools and equipment** include: manufacturers' specialty tools, measuring tools, hand tools, pullers, torque wrenches, presses, heating and cooling equipment, blocking and lifting equipment

**hazards** include: burns, oil spills, crush/pinch points, falling objects, stored energy, wheel and track assembly removal hazards, unexpected equipment movement

**methods** include: using dial indicators, spring scale, torque wrenches

# Major Work Activity F

## Services, diagnoses and repairs environmental control systems

### Task F-30 Services, diagnoses and repairs heating systems

#### Task Descriptor

Heating systems are used to heat the cab for operator comfort. As a secondary function, heating systems can also be used to heat fluids used in equipment operation. Heavy duty equipment technicians service, diagnose and repair heating systems.

#### F-30.01 Services heating systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
F-30.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-30.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
F-30.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-30.01.04P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>
F-30.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
F-30.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
F-30.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
F-30.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations

F-30.01.09P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
F-30.01.10P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
F-30.01.11P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
F-30.01.12P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, temperature measuring devices, coolant pressure testers, refractometers, multimeters, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** (to be cleaned) include: filters, heater cores, ducting

**components** include: conditioner fins, actuator doors and motors, fans, cables, heater controls, flow valves, pumps, resistors, modules, heater cores, ducting, thermostats, blowers, radiators, heater boxes, filters

**measurements** include: air temperature and flow

**consumables** include: coolant, filters

Knowledge		
	Learning Outcomes	Learning Objectives
F-30.01.01L	demonstrate knowledge of heating systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of heating systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of heating systems
		interpret information pertaining to heating systems found in <b>manufacturers' service information</b>
		identify <b>types of air flow control systems</b> , and describe their characteristics, applications and operation
		identify <b>air flow control system components</b> , and describe their characteristics and applications
		identify electronic control systems, and describe their <b>components</b> , characteristics and applications

F-30.01.02L	demonstrate knowledge of procedures to service heating systems and their <b>components</b> and <b>consumables</b>	identify <b>tools and equipment</b> used to service heating systems, and their <b>components</b> and <b>consumables</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service heating systems
		describe procedures to release and isolate stored energy
		describe procedures to inspect heating systems and their <b>components</b> and <b>consumables</b>
		describe procedures to clean heating system <b>components</b>
		describe procedures to service heating systems and their <b>components</b>
		describe procedures to measure air flow and temperature
		describe procedures to remove, replace, recycle and dispose of heating system <b>consumables</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned or reused
		identify practices that reduce material waste

## Range of Variables

**components** include: conditioner fins, actuator doors and motors, fans, cables, heater controls, flow valves, pumps, resistors, modules, heater cores, ducting, thermostats, blowers, radiators, heater boxes, filters

**consumables** include: coolant, filters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of air flow control systems** include: manual, electric, electronic

**air flow control system components** include: fans, blend doors, motors, levers, actuators

**components** (electronic control systems) include: heating control modules, temperature sensors, humidity sensors, variable speed fan

**tools and equipment** include: hand tools, temperature measuring devices, coolant pressure testers, refractometers, multimeters, laptop

**hazards** include: hot surfaces, sharp edges, hot fluids, moving parts, fall hazards, confined spaces, airborne contaminants, pressurized fluids

**components** (to be cleaned) include: filters, heater cores, ducting

## F-30.02 Diagnoses heating systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-30.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
F-30.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-30.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
F-30.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
F-30.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
F-30.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
F-30.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-30.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
F-30.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
F-30.02.10P	measure air flow and temperature	air flow and temperature are measured and compared with <b>manufacturers' service information</b>
F-30.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
F-30.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
F-30.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: malfunctioning heat controls, steaming windshield, coolant smell, no heat, lack of air flow, fan noise

**tools and equipment** include: hand tools, breakout harnesses, multimeters, air flow gauges, vacuum cleaners, electronic service tools, onboard computer, temperature measuring devices

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, leaks, flow restrictions

**tests** include: operational, air flow, temperature, pressure, pH, other additive related tests

**components** include: conditioner fins, actuator doors and motors, fans, cables, heater controls, flow valves, pumps, resistors, modules, heater cores, ducting, thermostats, blowers, radiators, heater boxes, filters

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
F-30.02.01L	demonstrate knowledge of heating systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of heating systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of heating systems
		interpret information pertaining to heating systems found in <b>manufacturers' service information</b>
		identify <b>types of air flow control systems</b> , and describe their characteristics, applications and operation
		identify <b>air flow control system components</b> , and describe their characteristics and applications
F-30.02.02L	demonstrate knowledge of procedures to diagnose heating systems and their <b>components</b>	identify electronic control systems, and describe their <b>components</b> , characteristics and applications
		identify <b>tools and equipment</b> used to diagnose heating systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose heating systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect heating systems and their <b>components</b>
		describe procedures to test heating systems and their <b>components</b>

	describe procedures to diagnose heating systems and their <b>components</b>
	identify <b>conditions</b> found while diagnosing heating systems and their <b>components</b>
	identify steps for failure analysis

## Range of Variables

**components** include: conditioner fins, actuator doors and motors, fans, cables, heater controls, flow valves, pumps, resistors, modules, heater cores, ducting, thermostats, blowers, radiators, heater boxes, filters

**consumables** include: coolant, filters, coolant conditioners, supplemental coolant additives

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of air flow control systems** include: manual, electric, electronic

**air flow control system components** include: fans, blend doors, motors, levers, actuators

**components** (electronic control systems) include: heating control modules, temperature sensors, humidity sensors, variable speed fan

**tools and equipment** include: hand tools, breakout harnesses, multimeters, air flow gauges, vacuum cleaners, electronic service tools, onboard computer, temperature measuring devices

**hazards** include: hot surfaces, sharp edges, hot fluids, moving parts, fall hazards, confined spaces, airborne contaminants, pressurized fluids

**symptoms of problems** include: malfunctioning heat controls, steaming windshield, coolant smell, no heat, lack of air flow, fan noise

**conditions** include: wear, damage, defects, failure, leaks, flow restrictions

## F-30.03 Repairs heating systems

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-30.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-30.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
F-30.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-30.03.04P	remove, disassemble and inspect <b>components for conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>

F-30.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
F-30.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
F-30.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
F-30.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
F-30.03.09P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
F-30.03.10P	adjust <b>components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
F-30.03.11P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
F-30.03.12P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, coolant vacuum fill equipment, drain pans

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: conditioner fins, actuator doors and motors, fans, cables, heater controls, flow valves, pumps, resistors, modules, heater cores, ducting, thermostats, blowers, radiators, heater boxes, filters

**conditions** include: wear, damage, defects, failure, leaks, flow restrictions

**parts and materials** include: filters, thermostats, gaskets, fasteners

**methods** include: operational testing, sensory observations, air flow and temperature testing

## Knowledge

	Learning Outcomes	Learning Objectives
F-30.03.01L	demonstrate knowledge of heating systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify types of heating systems, their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of heating systems
		interpret information pertaining to heating systems found in <b>manufacturers' service information</b>



		identify <b>types of air flow control systems</b> , and describe their characteristics, applications and operation
		identify <b>air flow control system components</b> , and describe their characteristics and applications
		identify electronic control systems, and describe their <b>components</b> , characteristics and applications
F-30.03.02L	demonstrate knowledge of procedures to repair heating systems, and their <b>components</b>	identify <b>tools and equipment</b> used to repair heating systems, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair heating systems and their <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair or replace <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		describe procedures to remove, replace, recycle and dispose of heating system <b>consumables</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned or reused
		identify practices that reduce material waste

## Range of Variables

**components** include: conditioner fins, actuator doors and motors, fans, cables, heater controls, flow valves, pumps, resistors, modules, heater cores, ducting, thermostats, blowers, radiators, heater boxes, filters

**consumables** include: coolant, filters, coolant conditioners, supplemental coolant additives

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of air flow control systems** include: manual, electric, electronic

**air flow control system components** include: fans, blend doors, motors, levers, actuators

**tools and equipment** include: hand tools, coolant vacuum fill equipment, drain pans

**hazards** include: hot surfaces, sharp edges, hot fluids, moving parts, fall hazards, confined spaces, airborne contaminants, pressurized fluids

**methods** include: operational testing, sensory observations, air flow and temperature testing

## Task F-31 Services, diagnoses and repairs ventilation and filtration systems

### Task Descriptor

Positive cabin pressure and filtered air are needed to reduce the dust in the cabin and to protect the operator and sensitive electronic circuits.

Heavy duty equipment technicians service, diagnose and repair ventilation and filtration systems.

### F-31.01 Services ventilation and filtration systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-31.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-31.01.02P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-31.01.03P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>
F-31.01.04P	measure air flow	air flow is measured and compared with <b>manufacturers' service information</b>

F-31.01.05P	remove and replace filters	filters are removed and replaced according to <b>manufacturers' service information</b>
F-31.01.06P	recycle and dispose of filters	filters are recycled and disposed of
F-31.01.07P	lubricate door and window seals	door and window seals are lubricated to maintain their pliability according to <b>manufacturers' service information</b>
F-31.01.08P	adjust <b>components</b>	<b>components</b> are adjusted according to <b>manufacturers' service information</b>
F-31.01.09P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: vacuum cleaners, hand tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: heater cores, ducting, evaporators, fins, sensors, filters (washable and high efficiency particulate air [HEPA]), door and window seals, latches

Knowledge		
	Learning Outcomes	Learning Objectives
F-31.01.01L	demonstrate knowledge of ventilation and filtration systems, their <b>components</b> , characteristics, applications and operation	identify types of ventilation and filtration systems, their <b>components</b> , and describe their characteristics and applications
		describe operating principles of ventilation and filtration systems
		interpret information pertaining to ventilation and filtration systems found in <b>manufacturers' service information</b>
		identify <b>types of air flow control systems</b> , and describe their characteristics, applications and operation
		identify <b>air flow control system components</b> , and describe their characteristics and applications
F-31.01.02L	demonstrate knowledge of procedures to service ventilation and filtration systems and their <b>components</b>	identify <b>tools and equipment</b> used to service ventilation and filtration systems, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service ventilation and filtration systems
		describe procedures to inspect ventilation and filtration systems and their <b>components</b>

	describe procedures to clean ventilation and filtration system <b>components</b>
	describe procedures to service ventilation and filtration systems and their <b>components</b>
	describe procedures to measure air flow
	describe procedures to adjust ventilation and filtration system <b>components</b>
	describe procedures to remove, replace, recycle and dispose of ventilation and filtration system <b>components</b>
	identify materials that can be reconditioned or reused
	identify practices that reduce material waste

## Range of Variables

**components** include: heater cores, ducting, evaporators, fins, sensors, filters (washable and high efficiency particulate air [HEPA]), door and window seals, latches

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of air flow control systems** include: manual, electric, electronic

**air flow control system components** include: fans, blend doors, motors, levers, actuators

**tools and equipment** include: vacuum cleaners, hand tools

**hazards** include: hot surfaces, sharp edges, hot coolant, allergens, airborne contaminants, confined spaces, falling hazards, moving parts

## F-31.02 Diagnoses ventilation and filtration systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-31.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
F-31.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-31.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>

F-31.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
F-31.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
F-31.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
F-31.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-31.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
F-31.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
F-31.02.10P	measure air flow	air flow is measured and compared with <b>manufacturers' service information</b>
F-31.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
F-31.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
F-31.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: no heat, no cooling, dust in cab, lack of air flow

**tools and equipment** include: hand tools, multimeters, air flow gauges, vacuum cleaners, temperature measuring devices

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, leaks, air and inlet restrictions

**tests** include: operational, air flow, temperature

**components** include: heater cores, ducting, evaporators, fins, sensors, filters (washable and HEPA), door and window seals, latches

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

Learning Outcomes	Learning Objectives	
F-31.02.01L	demonstrate knowledge of ventilation and filtration systems, their <b>components</b> , characteristics, applications and operation	identify types of ventilation and filtration systems, their <b>components</b> and describe their characteristics and applications
		describe operating principles of ventilation and filtration systems
		interpret information pertaining to ventilation and filtration systems found in <b>manufacturers' service information</b>
		identify <b>types of air flow control systems</b> , and describe their characteristics, applications and operation
F-31.02.02L	demonstrate knowledge of procedures to diagnose ventilation and filtration systems, and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose ventilation and filtration systems, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose ventilation and filtration systems, and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect ventilation and filtration systems, and their <b>components</b>
		describe procedures to test ventilation and filtration systems, and their <b>components</b>
		describe procedures to measure air flow
		describe procedures to diagnose ventilation and filtration systems, and their <b>components</b>
		identify <b>conditions</b> found while diagnosing ventilation and filtration systems and their <b>components</b>
	identify steps for failure analysis	

## Range of Variables

**components** include: heater cores, ducting, evaporators, fins, sensors, filters (washable and HEPA), door and window seals, latches

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of air flow control systems** include: manual, electric, electronic

**air flow control system components** include: fans, blend doors, motors, levers, actuators

**tools and equipment** include: hand tools, multimeters, air flow gauges, vacuum cleaners, temperature measuring devices

**hazards** include: hot surfaces, sharp edges, hot coolant, allergens, airborne contaminants, confined spaces, falling hazards, moving parts

**symptoms of problems** include: no heat, no cooling, dust in cab, lack of air flow

**conditions** include: wear, damage, defects, failure, leaks, air and inlet restrictions

### F-31.03 Repairs ventilation and filtration systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

Performance Criteria		Evidence of Attainment
F-31.03.01P	select and use tools and equipment	tools and equipment are selected and used according to task and <b>manufacturers' service information</b>
F-31.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
F-31.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-31.03.04P	remove, disassemble and inspect <b>components for conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
F-31.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
F-31.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
F-31.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
F-31.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
F-31.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>

F-31.03.10P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
F-31.03.11P	adjust <b>components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
F-31.03.12P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
F-31.03.13P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: heater cores, ducting, evaporators, fins, sensors, filters (washable and HEPA), door and window seals, latches, heater boxes, solenoids

**conditions** include: wear, damage, defects, failure, leaks, air and inlet restrictions

**parts and material** include: sealants, adhesives, fasteners, gaskets, hose

**methods** include: operational testing, sensory observations, air flow testing

Knowledge		
	Learning Outcomes	Learning Objectives
F-31.03.01L	demonstrate knowledge of ventilation and filtration systems, their <b>components</b> , characteristics, applications and operation	<p>identify types of ventilation and filtration systems, their <b>components</b> and describe their characteristics and applications</p> <p>describe operating principles of ventilation and filtration systems</p> <p>interpret information pertaining to ventilation and filtration systems found in <b>manufacturers' service information</b></p> <p>identify <b>types of air flow control systems</b>, and describe their characteristics, applications and operation</p> <p>identify <b>air flow control system components</b>, and describe their characteristics and applications</p>
F-31.03.02L	demonstrate knowledge of procedures to repair ventilation and filtration systems, and their <b>components</b>	<p>identify tools and equipment used to repair ventilation and filtration systems, and their <b>components</b>, and describe their applications and procedures for use</p> <p>identify <b>hazards</b> and describe safe work practices to repair ventilation and filtration systems, and their <b>components</b></p> <p>describe procedures to remove, disassemble, assemble and inspect <b>components</b></p>



	describe procedures to repair or replace <b>components</b>
	describe procedures to adjust <b>components</b>
	describe procedures to recycle and dispose of <b>components</b>
	describe <b>methods</b> to verify repairs
	identify materials that can be reconditioned or reused
	identify practices that reduce material waste

### Range of Variables

**components** include: heater cores, ducting, evaporators, fins, sensors, filters (washable and HEPA), door and window seals, latches, heater boxes, solenoids

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**types of air flow control systems** include: manual, electric, electronic

**air flow control system components** include: fans, blends doors, motors, levers, actuators

**hazards** include: hot surfaces, sharp edges, hot coolant, allergens, airborne contaminants, confined spaces, falling hazards, moving parts, crush/pinch points

**methods** include: operational testing, sensory observations, air flow testing

## Task F-32 Services, diagnoses and repairs air conditioning systems

### Task Descriptor

Air conditioning systems provide climate control for the operator.

Heavy duty equipment technicians service, diagnose and repair air conditioning systems.

### F-32.01 Services air conditioning systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-32.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-32.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>

F-32.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-32.01.04P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>
F-32.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
F-32.01.06P	remove and replace <b>refrigerants, blended refrigerants</b> and <b>lubricants</b>	<b>refrigerants, blended refrigerants</b> and <b>lubricants</b> are removed and replaced according to <b>manufacturers' service information</b> and jurisdictional regulations
F-32.01.07P	recycle and dispose of <b>refrigerants, blended refrigerants</b> and <b>lubricants</b>	<b>refrigerants, blended refrigerants</b> and <b>lubricants</b> are recycled and disposed of according to jurisdictional regulations
F-32.01.08P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
F-32.01.09P	adjust <b>components</b>	<b>components</b> are adjusted according to <b>manufacturers' service information</b>
F-32.01.10P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
F-32.01.11P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking
F-32.01.12P	interpret diagnostic results to determine next steps	diagnostic results are interpreted to determine next steps

## Range of Variables

**tools and equipment** include: A/C recovery machine, gauges, scales, identifier (dye), black lights, temperature measuring devices, vacuum pumps, feeler gauges, electronic gas analyzers, leak detectors

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** (to be cleaned) include: condensers, evaporator cores, filters, blower motor

**components** include: evaporators, condensers, compressors, receiver dryers, expansion valves, orifice tubes, accumulators, sensors, controls, lines, filters, blower motor, A/C clutches, belts

**measurements** include: air flow, temperature, pressures, air gap (of A/C clutch)

**refrigerants** include: R-134a, R-1234yf

**blended refrigerants** include: butane, propane

**lubricants** include: polyalkylene glycol (PAG) oil, polyolester (POE) oil

## Knowledge

	Learning Outcomes	Learning Objectives
F-32.01.01L	demonstrate knowledge of air conditioning systems, their <b>components</b> , characteristics, applications and operation	identify air conditioning systems and their <b>components</b> , and describe their characteristics and applications  describe operating principles of air conditioning systems and their <b>components</b>  interpret information pertaining to air conditioning systems found in <b>manufacturers' service information</b>  identify <b>refrigerants</b> and <b>blended refrigerants</b> , and describe their characteristics and applications  describe principles of refrigeration  describe consequences of improper mixing of <b>refrigerants</b> and <b>lubricants</b>  identify <b>metering devices</b> , and describe their characteristics and applications  identify <b>types of air flow control systems</b> , and describe their characteristics, applications and operation  identify <b>air flow control system components</b> , and describe their characteristics and applications  identify electronic control systems and <b>components</b> and describe their characteristics and applications
F-32.01.02L	demonstrate knowledge of procedures to service air conditioning systems and their <b>components</b>	identify <b>tools and equipment</b> used to service air conditioning systems and their <b>components</b> , and describe their applications and procedures for use  identify <b>hazards</b> and describe safe work practices to service air conditioning systems and their <b>components</b>  describe procedures to release and isolate stored energy  describe procedures to inspect air conditioning systems and their <b>components</b>  describe procedures to clean air conditioning system <b>components</b>  describe procedures to service air conditioning systems and their <b>components</b>  describe procedures to adjust air conditioning system <b>components</b>

		describe procedures to remove, replace, recycle and dispose of <b>refrigerants, blended refrigerants</b> and <b>lubricants</b>
		describe procedures to perform software updates
		identify materials that can be reused
		identify practices that reduce material waste
F-32.01.03L	demonstrate knowledge of <b>training and certification requirements</b> pertaining to air conditioning systems	identify <b>training and certification requirements</b> pertaining to air conditioning systems
F-32.01.04L	demonstrate knowledge of regulatory requirements pertaining to air conditioning systems	identify and interpret <b>regulations and standards</b> pertaining to air conditioning systems
F-32.01.05L	demonstrate knowledge of <b>emerging technologies</b> and practices related to air conditioning systems	identify technologies that address ozone depletion and pollution, and describe their characteristics and applications
		identify new <b>refrigerants</b> designed to be environmentally friendlier

## Range of Variables

**components** include: evaporators, condensers, compressors, receiver dryers, expansion valves, orifice tubes, accumulators, sensors, controls, lines, filters, blower motor, A/C clutches, belts

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**refrigerants** include: R-134a, R-1234yf

**blended refrigerants** include: butane, propane

**lubricants** include: polyalkylene glycol (PAG) oil, polyolester (POE) oil

**metering devices** include: orifice tubes, expansion valves

**types of air flow control systems** include: manual, electrical, electronic

**air flow control system components** include: fans, blend doors, levers, actuators

**components** (electronic control systems) include: cooling control modules, temperature sensors, humidity sensors, variable speed fan

**tools and equipment** include: A/C recovery machine, gauges, scales, identifier (dye), black lights, temperature measuring devices, vacuum pumps, feeler gauges, electronic gas analyzers, leak detectors

**hazards** include: high pressure, flammable, sharp edges, crush/pinch points, moving parts, corrosive materials, irritants, frostbite, environmentally hazardous materials, falling hazards, wildlife access

**components** (to be cleaned) include: condensers, evaporator cores, filters, blower motor

**training and certification requirements** include: refrigerant handling training and certification

**regulations and standards** include: reclaiming, recycling, disposal and reporting regulations

**emerging technologies** include: auxiliary air conditioning units, refrigerant technology

## F-32.02 Diagnoses air conditioning systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-32.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
F-32.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-32.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
F-32.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
F-32.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
F-32.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
F-32.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-32.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
F-32.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
F-32.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
F-32.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
F-32.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
F-32.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: poor cooling, too cold, noises, windows fogging, system freeze-up

**tools and equipment** include: hand tools, air conditioning recovery machines, pressure gauges, nitrogen, multimeters, electronic service tools, leak detectors, onboard computer, air flow gauge, temperature measuring devices, electronic gas analyzers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, leaks, restrictions

**tests** include: pressure, electrical, leakage, vacuum, air flow, temperature

**components** include: evaporators, condensers, compressors, receiver dryers, expansion valves, orifice tubes, accumulators, sensors, controls, lines, filters, blower motor, A/C clutches, belts, heater box

**measurements** include: pressure, temperature, flow, cycle times, engine speed

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
F-32.02.01L	demonstrate knowledge of air conditioning systems, their <b>components</b> , characteristics, applications and operation	identify air conditioning systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of air conditioning systems and their <b>components</b>
		interpret information pertaining to air conditioning systems found in <b>manufacturers' service information</b>
		identify <b>refrigerants, blended refrigerants</b> and describe their characteristics and applications
		describe principles of refrigeration
		describe consequences of improper mixing of <b>refrigerants, blended refrigerants</b> and <b>lubricants</b>
		identify <b>metering devices</b> , and describe their characteristics and applications
		identify <b>types of air flow control systems</b> , and describe their characteristics, applications and operation
		identify <b>air flow control system components</b> , and describe their characteristics and applications
		identify electronic control systems and <b>components</b> and describe their characteristics and applications
F-32.02.02L	demonstrate knowledge of procedures to diagnose air conditioning systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose air conditioning systems and their <b>components</b> , and describe their applications and procedures for use

		identify <b>hazards</b> and describe safe work practices to diagnose air conditioning systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect air conditioning systems and their <b>components</b>
		describe procedures to <b>test</b> air conditioning systems and their <b>components</b>
		describe procedures to diagnose air conditioning systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing air conditioning systems and their <b>components</b>
		identify steps for failure analysis
F-32.02.03L	demonstrate knowledge of <b>training and certification requirements</b> pertaining to air conditioning systems	identify <b>training and certification requirements</b> pertaining to air conditioning systems
F-32.02.04L	demonstrate knowledge of regulatory requirements pertaining to air conditioning systems	identify and interpret <b>regulations and standards</b> pertaining to air conditioning systems
F-32.02.05L	demonstrate knowledge of <b>emerging technologies</b> and practices related to air conditioning systems	identify technologies that address ozone depletion and pollution, and describe their characteristics and applications
		identify new refrigerants designed to be environmentally friendlier

## Range of Variables

**components** include: evaporators, condensers, compressors, receiver dryers, expansion valves, orifice tubes, accumulators, sensors, controls, lines, filters, blower motor, A/C clutches, belts, heater box

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**refrigerants** include: R-134a, R-1234yf

**blended refrigerants** include: butane, propane

**lubricants** include: PAG oil, POE oil

**metering devices** include: orifice tubes, expansion valves

**types of air flow control systems** include: manual, electrical, electronic

**air flow control system components** include: fans, blend doors, levers, actuators

**components** (electronic control systems) include: cooling control modules, temperature sensors, humidity sensors, variable speed fan

**tools and equipment** include: hand tools, air conditioning recovery machines, pressure gauges, nitrogen, multimeters, electronic service tools, leak detectors, onboard computer, air flow gauge, temperature measuring devices, electronic gas analyzers

**hazards** include: high pressure, flammable, sharp edges, crush/pinch points, moving parts, corrosive materials, irritants, frostbite, environmentally hazardous materials, falling hazards, wildlife access

**symptoms of problems** include: poor cooling, too cold, noises, windows fogging, system freeze-up

**tests** include: pressure, electrical, leakage, vacuum, air flow, temperature

**conditions** include: wear, damage, defects, failure, leaks, restrictions

**training and certification requirements** include: refrigerant handling training and certification

**regulations and standards** include: reclaiming, recycling, disposal and reporting regulations

**emerging technologies** include: auxiliary air conditioning units, refrigerant technology

## F-32.03 Repairs air conditioning systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-32.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-32.03.02P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
F-32.03.03P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
F-32.03.04P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
F-32.03.05P	replace or repair <b>components</b>	<b>components</b> are replaced or repaired according to <b>manufacturers' service information</b>
F-32.03.06P	reassemble <b>components</b> and perform <b>measurements</b>	<b>components</b> are reassembled and <b>measurements</b> are performed according to <b>manufacturers' service information</b>
F-32.03.07P	adjust <b>components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
F-32.03.08P	adjust <b>refrigerant</b> pressures	<b>refrigerant</b> pressures are adjusted to ensure proper operation of <b>component</b> and equipment
F-32.03.09P	evacuate, clean and recharge system <b>refrigerant</b> and <b>blended refrigerant</b>	system <b>refrigerant</b> and <b>blended refrigerant</b> is evacuated, cleaned and recharged according to <b>manufacturers' service information</b> and jurisdictional regulations
F-32.03.10P	recycle <b>refrigerant</b> and <b>blended refrigerant</b>	<b>refrigerant</b> and <b>blended refrigerant</b> are recycled according to jurisdictional regulations



F-32.03.11P	verify repair	repair is verified by running air conditioning system
F-32.03.12P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: air conditioning recovery system, pressure and temperature gauges, vacuum pumps, refrigerant identifiers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: evaporators, condensers, compressors, receiver dryers, expansion valves, orifice tubes, accumulators, sensors, controls, lines, filters, blower motor, A/C clutches, belts, heater box

**conditions** include: wear, damage, defects, failure, leaks, restrictions

**parts and material** include: gaskets, seals, dyes, fasteners

**measurements** include: pressure, temperature, flow, cycle times

**refrigerants** include: R-12, R-134a, R-1234yf

**blended refrigerants** include: butane, propane

Knowledge		
	Learning Outcomes	Learning Objectives
F-32.03.01L	demonstrate knowledge of air conditioning systems, their <b>components</b> , characteristics, applications and operation	identify air conditioning systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of air conditioning systems and their <b>components</b>
		interpret information pertaining to air conditioning systems found in <b>manufacturers' service information</b>
		identify <b>refrigerants</b> and <b>blended refrigerants</b> , and describe their characteristics and applications
		describe principles of refrigeration
		describe consequences of improper mixing of <b>refrigerants, blended refrigerants</b> and <b>lubricants</b>
		identify <b>metering devices</b> , and describe their characteristics and applications
		identify <b>types of air flow control systems</b> , and describe their characteristics, applications and operation
		identify <b>air flow control system components</b> , and describe their characteristics and applications

		identify electronic control systems and their <b>components</b> , and describe their characteristics and applications
F-32.03.02L	demonstrate knowledge of procedures to repair air conditioning systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair air conditioning systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair air conditioning systems and their <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair or replace <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		identify materials that can be reconditioned or reused
		identify practices that reduce material waste
F-32.03.03L	demonstrate knowledge of <b>training and certification requirements</b> pertaining to air conditioning systems	identify <b>training and certification requirements</b> pertaining to air conditioning systems
F-32.03.04L	demonstrate knowledge of regulatory requirements pertaining to air conditioning systems	identify and interpret <b>regulations and standards</b> pertaining to air conditioning systems
F-32.03.05L	demonstrate knowledge of <b>emerging technologies</b> and practices related to air conditioning systems	identify technologies that address ozone depletion and pollution, and describe their characteristics and applications
		identify new refrigerants designed to be environmentally friendlier

## Range of Variables

**components** include: evaporators, condensers, compressors, receiver dryers, expansion valves, orifice tubes, accumulators, sensors, controls, lines, filters, blower motor, A/C clutches, belts, heater box  
**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**refrigerants** include: R-12, R-134a, R-1234yf

**blended refrigerants** include: butane, propane

**lubricants** include: PAG oil, POE oil, mineral oil

**metering devices** include: orifice tubes, expansion valves

**types of air flow control systems** include: manual, electrical, electronic

**air flow control system components** include: fans, blend doors, levers, actuators

**components** (electronic control system) include: cooling control modules, temperature sensors, humidity sensors, variable speed fan

**tools and equipment** include: air conditioning recovery system, pressure and temperature gauges, vacuum pumps, refrigerant identifiers

**hazards** include: high pressure, flammable, sharp edges, crush/pinch points, moving parts, corrosive materials, irritants, frostbite, environmentally hazardous materials, falling hazards, wildlife access

**training and certification requirements** include: refrigerant handling training and certification

**regulations and standards** include: reclaiming, recycling, disposal and reporting regulations

**emerging technologies** include: auxiliary air conditioning units, refrigerant technology

## Task F-33 Services, diagnoses and repairs sound suppression systems

### Task Descriptor

Sound suppression systems reduce noise pollution by insulating engine and operator compartments. Heavy duty equipment technicians service, diagnose and repair sound suppression systems.

#### F-33.01 Services sound suppression systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	no	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-33.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-33.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
F-33.01.03P	perform sensory inspections	sensory inspections are performed to identify worn, damaged and defective <b>components</b>
F-33.01.04P	measure noise levels	noise levels are measured and compared with <b>manufacturers' service information</b>
F-33.01.05P	adjust <b>components</b>	<b>components</b> are adjusted according to <b>manufacturers' service information</b>
F-33.01.06P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, decibel meters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: foam, insulation, panels, fasteners

Knowledge		
	Learning Outcomes	Learning Objectives
F-33.01.01L	demonstrate knowledge of sound suppression systems, their <b>components</b> , characteristics, applications and operation	<p>identify sound suppression systems and their <b>components</b>, and describe their characteristics and applications</p> <hr/> <p>describe operating principles of sound suppression systems and their <b>components</b></p> <hr/> <p>interpret information pertaining to sound suppression systems found in <b>manufacturers' service information</b></p>
F-33.01.02L	demonstrate knowledge of procedures to service sound suppression systems and their <b>components</b>	<p>identify <b>tools and equipment</b> used to service sound suppression systems and their <b>components</b>, and describe their applications and procedures for use</p> <hr/> <p>identify <b>hazards</b> and describe safe work practices to service sound suppression systems and their <b>components</b></p> <hr/> <p>describe procedures to inspect sound suppression systems and their <b>components</b></p>

## Range of Variables

**components** include: foam, insulation, panels, fasteners

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, decibel meters

**hazards** include: airborne contaminants, allergens, excessive noise, sharp edges, hot surfaces

## F-33.02 Diagnoses sound suppression systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	no	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
F-33.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
F-33.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-33.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
F-33.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
F-33.02.05P	perform diagnostic procedures and sound level test	diagnostic procedures and sound level test are performed according to <b>manufacturers' service information</b>
F-33.02.06P	verify diagnosis	diagnosis is verified by interpreting sound level test results and comparing them to <b>manufacturers' service information</b> or expected values
F-33.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
F-33.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
F-33.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
F-33.02.10P	perform failure analysis	failure analysis is performed to determine root cause of failure
F-33.02.11P	document noise level test results and inspection findings	noise level test results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
F-33.02.12P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: noise, vibrations

**tools and equipment** include: hand tools, decibel meters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure

**components** include: foam, insulation, panels, fasteners, mounts

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
F-33.02.01L	demonstrate knowledge of sound suppression systems, their <b>components</b> , characteristics, applications and operation	identify sound suppression systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of sound suppression systems and their <b>components</b>
		interpret information pertaining to sound suppression systems found in <b>manufacturers' service information</b>
F-33.02.02L	demonstrate knowledge of procedures to diagnose sound suppression systems and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose sound suppression systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose sound suppression systems and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect sound suppression systems and their <b>components</b>
		describe procedures to test sound suppression systems and their <b>components</b>
		describe procedures to diagnose sound suppression systems and their <b>components</b>
		identify <b>conditions</b> found while diagnosing sound suppression systems and their <b>components</b>
identify steps for failure analysis		

## Range of Variables

**components** include: foam, insulation, panels, fasteners, mounts

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, decibel meters

**hazards** include: airborne contaminants, allergens, excessive noise, sharp edges, hot surfaces, falling hazards

**symptoms of problems** include: noise, vibrations

**conditions** include: wear, damage, defects, failure

### F-33.03 Repairs sound suppression systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	no	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
F-33.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
F-33.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
F-33.03.03P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
F-33.03.04P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
F-33.03.05P	disassemble, assemble and install <b>components</b>	<b>components</b> are disassembled, assembled and installed according to <b>manufacturers' service information</b>
F-33.03.06P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
F-33.03.07P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
F-33.03.08P	adjust <b>components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
F-33.03.09P	verify repairs	repairs are verified using methods according to <b>manufacturers' service information</b>
F-33.03.10P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, decibel meters, ventilators

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**parts and materials** include: adhesives, sealants

**components** include: foam, insulation, panels, fasteners, mounts

Knowledge		
	Learning Outcomes	Learning Objectives
F-33.03.01L	demonstrate knowledge of sound suppression systems, their <b>components</b> , characteristics, applications and operation	identify sound suppression systems and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of sound suppression systems and their <b>components</b>
		interpret information pertaining to sound suppression systems found in <b>manufacturers' service information</b>
F-33.03.02L	demonstrate knowledge of procedures to repair sound suppression systems and their <b>components</b>	identify <b>tools and equipment</b> used to repair sound suppression systems and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair sound suppression systems and their <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair or replace <b>components</b>
		describe procedures to adjust <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		identify materials that can be reused
identify practices that reduce material waste		

## Range of Variables

**components** include: foam, insulation, panels, fasteners, mounts

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: hand tools, decibel meters, ventilators

**hazards** include: airborne contaminants, allergens, excessive noise, sharp edges, hot surfaces, falling hazards



# Major Work Activity G

## Services, diagnoses and repairs hydraulic, hydrostatic and pneumatic systems

### Task G-34 Services, diagnoses and repairs hydraulic systems

#### Task Descriptor

Hydraulic systems pump confined fluid to transfer energy smoothly from one component to another. Advantages of using hydraulics include non-compressible smooth and quiet operation, and variable speed and force, which allows for a versatile and adaptable system.

Heavy duty equipment technicians must service, diagnose and repair hydraulic systems to ensure proper function and reduce down time.

#### G-34.01 Services hydraulic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

Performance Criteria		Evidence of Attainment
G-34.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-34.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
G-34.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
G-34.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify worn, damaged and defective <b>components</b>
G-34.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
G-34.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
G-34.01.07P	collect oil samples for analysis	oil samples are collected for analysis according to <b>manufacturers' service information</b>

G-34.01.08P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
G-34.01.09P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
G-34.01.10P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
G-34.01.11P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
G-34.01.12P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
G-34.01.13P	document service information and inspection findings	service information and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, laptop, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: gaskets, seals, hoses, fittings, pumps, cylinders, hydraulic motor, actuators, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens

**sensory inspections** include: noise, leaks, hot spots, burnt oil, smells

**measurements** include: cycle times, pressure test, drift test, operational test

**consumables** include: filters, oil, hoses, fittings, gaskets, seals

## Knowledge

	Learning Outcomes	Learning Objectives
G-34.01.01L	demonstrate knowledge of hydraulic systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of hydraulic systems</b> , <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of hydraulic systems
		interpret information pertaining to hydraulic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify fluids and <b>fluid conditioning systems</b> , and describe their characteristics and applications

G-34.01.02L	demonstrate knowledge of procedures to service hydraulic systems and <b>components</b>	identify <b>tools and equipment</b> used to service hydraulic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service hydraulic systems
		describe procedures to release and isolate stored energy
		describe procedures to inspect hydraulic systems and <b>components</b>
		describe procedures to clean hydraulic systems and <b>components</b>
		describe procedures to service hydraulic systems and their <b>components</b>
		describe procedures to remove, replace, recycle and dispose of hydraulic system <b>consumables</b>
		identify oil sampling procedures
G-34.01.03L	demonstrate knowledge of emerging technologies pertaining to hydraulic systems	identify emerging technologies pertaining to hydraulic systems
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: gaskets, seals, hoses, fittings, pumps, cylinders, hydraulic motor, actuators, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens

**consumables** include: filters, oil, hoses, fittings, gaskets, seals

**types of hydraulic systems** include: open center, closed center, load sensing, pressure compensated, constant horsepower, negative and positive flow control, meter-in, meter-out, multi-pump unloading

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fluid conditioning systems** include: filtration systems, heating and cooling devices

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, laptop, multimeters

**hazards** include: stored high pressure, skin and eye irritation, flammability, high temperatures, fluid injection

## G-34.02 Diagnoses hydraulic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
G-34.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
G-34.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-34.02.03P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
G-34.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
G-34.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
G-34.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
G-34.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
G-34.02.08P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
G-34.02.09P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
G-34.02.10P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
G-34.02.11P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b>
G-34.02.12P	obtain oil samples	oil samples are obtained and results interpreted to identify problems and trends

G-34.02.13P	perform failure analysis	failure analysis is performed to determine root cause of failure
G-34.02.14P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
G-34.02.15P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: fail to raise or lower, slow operation, intermittent or erratic operation, noisy operation, weak performance, overheating, internal and external leaking

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, laptop, multimeters, stopwatches

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**sensory inspections** include: noise, leaks, hot spots, burnt oil, smells

**conditions** include: wear, damage, defects

**tests** include: pressure, flow, restriction, cycle time, drift, operational

**components** include: gaskets, seals, hoses, fittings, pumps, cylinders, hydraulic motor, actuators, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
G-34.02.01L	demonstrate knowledge of hydraulic systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>types of hydraulic systems</b> , <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of hydraulic systems
		interpret information pertaining to hydraulic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify fluids and <b>fluid conditioning systems</b> , and describe their characteristics and applications

G-34.02.02L	demonstrate knowledge of procedures to diagnose hydraulic systems and <b>components</b>	identify <b>tools and equipment</b> used to diagnose hydraulic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose hydraulic systems and <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect hydraulic systems and <b>components</b>
		describe procedures to test hydraulic systems and <b>components</b>
		describe procedures to diagnose hydraulic systems and <b>components</b>
		describe oil sampling procedures
		identify steps for failure analysis
		identify materials that can be reconditioned, reused or recycled
G-34.02.03L	demonstrate knowledge of emerging technologies pertaining to hydraulic systems	identify emerging technologies pertaining to hydraulic systems
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: gaskets, seals, hoses, fittings, pumps, cylinders, hydraulic motor, actuators, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens

**consumables** include: filters, oil, hoses, fittings, gaskets, seals

**types of hydraulic systems** include: open center, closed center, load sensing, pressure compensated, constant horsepower, negative and positive flow control, meter-in, meter-out, multi-pump unloading

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fluid conditioning systems** include: filtration systems, heating and cooling devices

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, laptop, multimeters, stopwatches

**hazards** include: stored high pressure, skin and eye irritation, flammability, high temperatures, fluid injection, spills, unexpected movement of equipment

**symptoms of problems** include: fail to raise or lower, slow operation, intermittent or erratic operation, noisy operation, weak performance, overheating, internal and external leaking

## G-34.03 Repairs hydraulic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
G-34.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-34.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
G-34.03.03P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
G-34.03.04P	flush hydraulic system	hydraulic system is flushed
G-34.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
G-34.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
G-34.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
G-34.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
G-34.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
G-34.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
G-34.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
G-34.03.12P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
G-34.03.13P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
G-34.03.14P	perform pre-lubrication, bleeding and priming procedures	pre-lubrication, bleeding and priming procedures are performed according to <b>manufacturers' service information</b>
G-34.03.15P	perform start-up and break-in procedures	start-up and break-in procedures are performed according to <b>manufacturers' service information</b>

G-34.03.16P	<b>adjust components</b> and parts	<b>components</b> and parts are adjusted according to <b>manufacturers' service information</b>
G-34.03.17P	verify repairs	repairs are verified according to <b>manufacturers' service information</b>
G-34.03.18P	document repairs performed	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, laptop, multimeters, stopwatches

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: gaskets, seals, hoses, fittings, pumps, cylinders, hydraulic motor, actuators, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens

**conditions** include: scoring, wear patterns, heat discolouration, damage, defect, leaks

**consumables** include: filters, oil, hoses, fittings, gaskets, seals

**adjust** includes: pressure, flow, balancing pump output, calibrating electronic controls

## Knowledge

	Learning Outcomes	Learning Objectives
G-34.03.01L	demonstrate knowledge of hydraulic systems, their <b>components, consumables</b> , characteristics, applications and operation	identify <b>types of hydraulic systems, components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of hydraulic systems
		interpret information pertaining to hydraulic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify fluids and <b>fluid conditioning systems</b> , and describe their characteristics and applications
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		identify and describe <b>hydraulically powered applications</b>



G-34.03.02L	demonstrate knowledge of procedures to repair hydraulic systems and <b>components</b>	identify <b>tools and equipment</b> used to repair hydraulic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair hydraulic systems and <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair, replace or rebuild <b>components</b>
		describe procedures to <b>adjust components</b>
		describe procedures to recycle and dispose of <b>components</b> and <b>consumables</b>
		describe methods to verify repairs
		identify materials that can be reconditioned, reused or recycled
G-34.03.03L	demonstrate knowledge of emerging technologies pertaining to hydraulic systems	identify practices that reduce material waste
		identify emerging technologies pertaining to hydraulic systems
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: gaskets, seals, hoses, fittings, pumps, cylinders, hydraulic motor, actuators, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens

**consumables** include: filters, oil, hoses, fittings, gaskets, seals

**types of hydraulic systems** include: open center, closed center, load sensing, pressure compensated, constant horsepower, negative and positive flow control, meter-in, meter-out, multi-pump unloading

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fluid conditioning systems** include: filtration systems, heating and cooling devices

**hydraulically powered applications** include: dump boxes, compactors, snow removal equipment, aerial lifts, mobile cranes, loaders, dozers, excavators

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, laptop, multimeters, stopwatches

**hazards** include: stored high pressure, skin and eye irritation, flammability, high temperatures, fluid injection, spills, unexpected movement of equipment

**adjust** includes: pressure, flow, balancing pump output, calibrating electronic controls

# Task G-35 Services, diagnoses and repairs hydrostatic systems

## Task Descriptor

Hydrostatic systems are primarily closed loop hydraulic systems, which use fluid under pressure to transmit power to drive components such as wheel or track drives.

Heavy duty equipment technicians must service, diagnose and repair hydrostatic systems to ensure proper function and reduce down time.

### G-35.01 Services hydrostatic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
G-35.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-35.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
G-35.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
G-35.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify worn, damaged and defective <b>components</b>
G-35.01.05P	perform operational checks	operational checks are performed according to <b>manufacturers' service information</b>
G-35.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
G-35.01.07P	collect oil samples from hydraulic reservoir or hydrostatic system reservoir	oil samples are collected for analysis according to <b>manufacturers' service information</b>
G-35.01.08P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
G-35.01.09P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
G-35.01.10P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>

G-35.01.11P	<b>adjust components</b>	<b>components</b> are <b>adjusted</b> according to <b>manufacturers' service information</b>
G-35.01.12P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
G-35.01.13P	document service information and inspection findings	service information and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer laptop, micrometers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: gaskets, seals, fluid conductors and conditioners, hoses, pumps, motors, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens, oil coolers

**sensory inspections** include: noise, leaks, hot spots, burnt oil, smells

**consumables** include: filters, oil, hoses, fittings

**adjust** includes: pressure, flow, neutral calibration, safety systems, calibrating electronic controls

## Knowledge

	Learning Outcomes	Learning Objectives
G-35.01.01L	demonstrate knowledge of hydrostatic systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify hydrostatic systems and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of hydrostatic systems
		interpret information pertaining to hydrostatic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify types of <b>hydrostatically powered applications</b>
		identify fluids and <b>fluid conditioning systems</b> , and describe their characteristics and applications

G-35.01.02L	demonstrate knowledge of procedures to service hydrostatic systems and <b>components</b>	identify <b>tools and equipment</b> used to service hydrostatic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service hydrostatic systems
		describe procedures to release and isolate stored energy
		describe procedures to inspect hydrostatic systems and <b>components</b>
		describe procedures to clean hydrostatic system <b>components</b>
		describe procedures to service hydrostatic systems and their <b>components</b>
		describe procedures to remove, replace, recycle and dispose of hydrostatic <b>consumables</b>
		identify oil sampling procedures
G-35.01.03L	demonstrate knowledge of emerging technologies pertaining to hydrostatic systems	identify emerging technologies pertaining to hydrostatic systems
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: gaskets, seals, fluid conductors and conditioners, hoses, pumps, motors, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens, oil coolers

**consumables** include: filters, oil, hoses, fittings

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hydrostatically powered applications** include: skid steers, wheel loaders, dozers, lift trucks, vibratory compactors

**fluid conditioning systems** include: filtration systems, heating and cooling devices, reservoirs

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer laptop, micrometers

**hazards** include: stored high pressure, skin and eye irritation, flammability, high temperatures, fluid injection, spills, unexpected movement

## G-35.02 Diagnoses hydrostatic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

Performance Criteria		Evidence of Attainment
G-35.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
G-35.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-35.02.03P	release and isolate stored energy	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
G-35.02.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
G-35.02.05P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
G-35.02.06P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
G-35.02.07P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
G-35.02.08P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
G-35.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
G-35.02.10P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b>
G-35.02.11P	obtain oil samples	oil samples are obtained and results interpreted to identify problems and trends
G-35.02.12P	perform failure analysis	failure analysis is performed to determine root cause of failure
G-35.02.13P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
G-35.02.14P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: fail to move, low power, slow operation, internal and external leaking, intermittent or erratic operation, noisy operation, creeping in neutral, mistracking, overheating

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, tachometers, laptop, micrometers

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**sensory inspections** include: noise, leaks, hot spots, burnt oil, smells

**conditions** include: wear, damage, defects, leaks

**tests** include: pressure, flow, restriction, cycle time, drift

**components** include: gaskets, seals, fluid conductors and conditioners, hoses, pumps, motors, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens, oil coolers

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
G-35.02.01L	demonstrate knowledge of hydrostatic systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify hydrostatic systems and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of hydrostatic systems
		interpret information pertaining to hydrostatic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify and describe <b>hydrostatically powered applications</b>
		identify fluids and <b>fluid conditioning systems</b> , and describe their characteristics and applications
G-35.02.02L	demonstrate knowledge of procedures to diagnose hydrostatic systems and <b>components</b>	identify <b>tools and equipment</b> used to diagnose hydrostatic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose hydrostatic systems and <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect hydrostatic systems and <b>components</b>

		describe procedures to test hydrostatic systems and <b>components</b>
		describe procedures to diagnose hydrostatic systems and <b>components</b>
		describe oil sampling procedures
		identify steps for failure analysis
		identify materials that can be reconditioned, reused or recycled
G-35.02.03L	demonstrate knowledge of emerging technologies pertaining to hydrostatic systems	identify emerging technologies pertaining to hydrostatic systems
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: gaskets, seals, fluid conductors and conditioners, hoses, pumps, motors, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens, oil coolers

**consumables** include: filters, oil, hoses, fittings

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hydrostatically powered applications** include: skid steers, wheel loaders, dozers, lift trucks, vibratory compactors

**fluid conditioning systems** include: filtration systems, heating and cooling devices, reservoirs

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, tachometers, laptop, micrometers

**hazards** include: stored high pressure, skin and eye irritation, flammability, high temperatures, fluid injection, spills, unexpected equipment movement

**symptoms of problems** include: fail to move, low power, slow operation, internal and external leaking, intermittent or erratic operation, noisy operation, creeping in neutral, mistracking, overheating

## G-35.03 Repairs hydrostatic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
G-35.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-35.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
G-35.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
G-35.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
G-35.03.05P	flush hydrostatic system	hydrostatic system is flushed
G-35.03.06P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
G-35.03.07P	calibrate hydrostatic drive system and components	hydrostatic drive system and components are calibrated according to test results, field observations and <b>manufacturers' service information</b>
G-35.03.08P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
G-35.03.09P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
G-35.03.10P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
G-35.03.11P	repair <b>components</b>	<b>components</b> are repaired following repair sequence according to <b>manufacturers' service information</b>
G-35.03.12P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
G-35.03.13P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
G-35.03.14P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations



G-35.03.15P	perform pre-lubrication, bleeding and priming procedures	pre-lubrication, bleeding and priming procedures are performed according to <b>manufacturers' service information</b>
G-35.03.16P	perform start-up and break-in procedures	start-up and break-in procedures are performed according to <b>manufacturers' service information</b>
G-35.03.17P	<b>adjust components</b> and parts	<b>components</b> and parts are <b>adjusted</b> according to <b>manufacturers' service information</b>
G-35.03.18P	verify repairs	repairs are verified according to <b>manufacturers' service information</b>
G-35.03.19P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, tachometers, laptop, micrometers, stopwatches

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: gaskets, seals, hoses, fluid conductors and conditioners, fittings, pumps, motors, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens, oil coolers

**conditions** include: scoring, wear patterns, heat discoloration, damage, defect

**consumables** include: filters, oil, hoses, fittings, gaskets, seals

**adjust** includes: pressure, flow, neutral calibration, safety systems, calibrating controls

## Knowledge

	Learning Outcomes	Learning Objectives
G-35.03.01L	demonstrate knowledge of hydrostatic systems, their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify hydrostatic systems and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of hydrostatic systems
		interpret information pertaining to hydrostatic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify types of <b>hydrostatically powered applications</b>
		identify fluids and <b>fluid conditioning systems</b> , and describe their characteristics and applications

		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
G-35.03.02L	demonstrate knowledge of procedures to repair hydrostatic systems and <b>components</b>	identify <b>tools and equipment</b> used to repair hydrostatic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair hydrostatic systems and <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair, replace or rebuild <b>components</b>
		describe procedures to <b>adjust components</b>
		describe procedures to recycle and dispose of <b>components</b> and <b>consumables</b>
		describe methods to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
G-35.03.03L	demonstrate knowledge of emerging technologies pertaining to hydrostatic systems	identify emerging technologies pertaining to hydrostatic systems
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: gaskets, seals, hoses, fluid conductors and conditioners, fittings, pumps, motors, relief valves, control valves, reservoir, ECMs, solenoids, sensors, harnesses, accumulators, filters, screens, oil coolers

**consumables** include: filters, oil, hoses, fittings, gaskets, seals

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hydrostatically powered applications** include: skid steers, wheel loaders, dozers, lift trucks, vibratory compactors

**fluid conditioning systems** include: filtration systems, heating and cooling devices, reservoirs

**tools and equipment** include: hand tools, shop tools, lifting and holding equipment, pressure gauges, flow meters, temperature gauges, electronic service tools, onboard computer, tachometers, laptop, micrometers, stopwatches

**hazards** include: stored high pressure, skin and eye irritation, flammability, high temperatures, fluid injection, spills, unexpected equipment movement

**adjust** includes: pressure, flow, neutral calibration, safety systems, calibrating controls

## Task G-36 Services, diagnoses and repairs pneumatic systems

### Task Descriptor

Pneumatic systems compress air to transfer energy smoothly from one component to another. Some applications of pneumatic systems are air starters, drills, hammers and industrial compressors.

Heavy duty equipment technicians must service, diagnose and repair pneumatic systems to ensure proper function and reduce down time.

### G-36.01 Services pneumatic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
G-36.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-36.01.02P	inspect reservoir for signs of rust and structural damage	reservoir is inspected using visual and auditory checks and leak down tests
G-36.01.03P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
G-36.01.04P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>

G-36.01.05P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify worn, damaged and defective <b>components</b>
G-36.01.06P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
G-36.01.07P	perform leak down test	leak down test is performed according to industry standards and <b>manufacturers' service information</b>
G-36.01.08P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
G-36.01.09P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
G-36.01.10P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
G-36.01.11P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
G-36.01.12P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
G-36.01.13P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: pressure gauges, flow meters, temperature measuring devices, tachometers, feeler gauges, dial indicators, micrometers (inside, outside)

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: reservoirs, hoses, fittings, compressors, filters, valves, switches, dryers, gauges, sensors, regulators

**sensory inspections** include: performing walkaround and listening for leaks, inspecting reservoir for structural integrity

**measurements** include: pressure, air flow

**consumables** include: filters, oil, methyl hydrate

## Knowledge

	Learning Outcomes	Learning Objectives
G-36.01.01L	demonstrate knowledge of pneumatic systems, their <b>components</b> and <b>consumables</b> , characteristics, <b>applications</b> and operation	identify pneumatic systems, <b>components</b> and <b>consumables</b> , and describe their characteristics and <b>applications</b>
		describe operating principles of pneumatic systems

		interpret information pertaining to pneumatic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
G-36.01.02L	demonstrate knowledge of procedures to service pneumatic systems and <b>components</b>	identify <b>tools and equipment</b> used to service pneumatic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service pneumatic systems
		describe procedures to release and isolate stored energy
		describe procedures to inspect pneumatic systems and <b>components</b>
		describe procedures to clean pneumatic system <b>components</b>
		describe procedures to service pneumatic systems and <b>components</b>
		describe procedures to adjust and calibrate pneumatic systems and <b>components</b>
		describe procedures to remove, replace, recycle and dispose of pneumatic <b>consumables</b>
		identify materials that can be reused
		identify practices that reduce material waste

## Range of Variables

**components** include: reservoirs, hoses, fittings, compressors, filters, valves, switches, dryers, gauges, sensors, regulators

**consumables** include: filters, oil, methyl hydrate

**applications** include: drills, hammers, industrial air compressors, air starters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, flow meters, temperature measuring devices, tachometers, feeler gauges, dial indicators, micrometers (inside, outside)

**hazards** include: stored high pressure, skin and eye irritation, frostbite, flammability, high temperatures, moving parts, crush/pinch points, heavy objects, injection

## G-36.02 Diagnoses pneumatic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
G-36.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
G-36.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-36.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
G-36.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
G-36.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
G-36.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
G-36.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
G-36.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
G-36.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
G-36.02.10P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
G-36.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
G-36.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
G-36.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: failure to operate, slow or weak operation, internal and external leaking, intermittent or erratic operation, noisy operation

**tools and equipment** include: pressure gauges, flow meters, temperature gauges, restriction gauges

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, leaks, restrictions

**tests** include: pressure, flow, restriction, cycle time

**components** include: reservoirs, hoses, fittings, compressors, filters, valves, switches, dryers, gauges, sensors, regulators

**measurements** include: pressure, air flow, cycle time, temperature

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
G-36.02.01L	demonstrate knowledge of pneumatic systems, their <b>components</b> , <b>consumables</b> , characteristics, <b>applications</b> and operation	identify pneumatic systems, <b>components</b> and <b>consumables</b> , and describe their characteristics and <b>applications</b>
		describe operating principles of pneumatic systems
		interpret information pertaining to pneumatic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
G-36.02.02L	demonstrate knowledge of procedures to diagnose pneumatic systems and <b>components</b>	identify <b>tools and equipment</b> used to diagnose pneumatic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose pneumatic systems and <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect pneumatic systems and <b>components</b>
		describe procedures to test pneumatic systems and <b>components</b>

	describe procedures to diagnose pneumatic systems and <b>components</b>
	identify <b>conditions</b> found while diagnosing pneumatic systems and their <b>components</b>
	identify steps for failure analysis

## Range of Variables

**components** include: reservoirs, hoses, fittings, compressors, filters, valves, switches, dryers, gauges, sensors, regulators

**consumables** include: filters, oil, methyl hydrate

**applications** include: drills, hammers, industrial air compressors, air starters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, flow meters, temperature gauges, restriction gauges

**hazards** include: stored high pressure, skin and eye irritation, frostbite, flammability, high temperatures, moving parts, crush/pinch points, heavy objects, injection

**symptoms of problems** include: failure to operate, slow or weak operation, internal and external leaking, intermittent or erratic operation, noisy operation

**conditions** include: wear, damage, defects, leaks, restrictions

## G-36.03 Repairs pneumatic systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
G-36.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
G-36.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
G-36.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
G-36.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
G-36.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
G-36.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>



G-36.03.07P	disassemble, assemble and install <b>components</b>	<b>components</b> are disassembled, assembled and installed according to <b>manufacturers' service information</b>
G-36.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
G-36.03.09P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
G-36.03.10P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
G-36.03.11P	reassemble <b>components</b> and perform <b>measurements</b>	<b>components</b> are reassembled and <b>measurements</b> are performed according to <b>manufacturers' service information</b>
G-36.03.12P	perform pre-lubrication procedures	pre-lubrication procedures are performed according to <b>manufacturers' service information</b>
G-36.03.13P	perform start-up and break-in procedures	start-up and break-in procedures are performed according to <b>manufacturers' service information</b>
G-36.03.14P	<b>adjust</b> and calibrate <b>components</b> and parts	<b>components</b> and parts are <b>adjusted</b> and calibrated according to <b>manufacturers' service information</b>
G-36.03.15P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
G-36.03.16P	document repairs performed	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: pressure gauges, flow meters, temperature measuring devices, tachometers, feeler gauges, dial indicators, micrometers (inside, outside), laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: reservoirs, hoses, fittings, compressors, filters, valves, switches, dryers, gauges, sensors, regulators

**conditions** include: wear, damage, defects, leaks, restrictions

**parts and materials** include: gaskets, seals, sealants, fasteners, hoses, diaphragms, fittings

**measurements** include: pressure, air flow, cycle time, temperature, tolerances

**adjust** includes: setting pressure, flow, RPM

**methods** include: operational tests, verifying pressures and flow

## Knowledge

Learning Outcomes	Learning Objectives	
G-36.03.01L	demonstrate knowledge of pneumatic systems, their <b>components</b> , <b>consumables</b> , characteristics, <b>applications</b> and operation	identify pneumatic systems, <b>components</b> and <b>consumables</b> , and describe their characteristics and <b>applications</b>
		describe operating principles of pneumatic systems
		interpret information pertaining to pneumatic systems found in <b>manufacturers' service information</b>
		identify pressure limits of hoses, tubing and fittings
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
G-36.03.02L	demonstrate knowledge of procedures to repair pneumatic systems and <b>components</b>	identify <b>tools and equipment</b> used to repair pneumatic systems and <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair pneumatic systems and <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair or replace <b>components</b>
		describe procedures to <b>adjust</b> and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned or reused
		identify practices that reduce material waste

## Range of Variables

**components** include: reservoirs, hoses, fittings, compressors, filters, valves, switches, dryers, gauges, sensors, regulators

**consumables** include: filters, oil, methyl hydrate, desiccant

**applications** include: drills, hammers, industrial air compressors, air starters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: pressure gauges, flow meters, temperature measuring devices, tachometers, feeler gauges, dial indicators, micrometers (inside, outside), laptop

**hazards** include: stored high pressure, skin and eye irritation, frostbite, flammability, high temperatures, moving parts, crush/pinch points, heavy objects, injection

**adjust** includes: setting pressure, flow, RPM

# Major Work Activity H

## Services, diagnoses and repairs structural components, operator stations, attachments and accessories

### Task H-37 Services, diagnoses and repairs structural components

#### Task Descriptor

The structural components provide the framework on which other equipment components are mounted or installed.

Heavy duty equipment technicians service, diagnose and repair structural components to ensure equipment integrity.

#### H-37.01 Services structural components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
H-37.01.01P	select and use tools and equipment	tools and equipment are selected and used according to task and <b>manufacturers' service information</b>
H-37.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
H-37.01.03P	clean <b>structural components</b>	<b>structural components</b> are cleaned according to <b>manufacturers' service information</b>
H-37.01.04P	perform sensory inspections	sensory inspections are performed to identify loose mounting hardware, cracks, distortions, corrosion, and worn, damaged and defective <b>structural components</b>
H-37.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
H-37.01.06P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>

H-37.01.07P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
H-37.01.08P	lubricate <b>structural components</b>	<b>structural components</b> are lubricated according to <b>manufacturers' service information</b>
H-37.01.09P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**structural components** include: cross-members, gussets, frames, chassis, roll-over protective structure (ROPS), falling object protective structure (FOPS), operator protective structure (OPS), guards, covers and belly pans, platform, stairs, rails, swing and articulation bearings

**measurements** include: bore dimensions, tolerances, alignment

**consumables** include: cushion stoppers for joint articulation, wear plates, stopper plates

Knowledge		
	Learning Outcomes	Learning Objectives
H-37.01.01L	demonstrate knowledge of <b>structural components</b> , their characteristics, applications and operation	identify types of <b>structural components</b> , and describe their characteristics and applications
		describe operating principles of <b>structural components</b>
		interpret information pertaining to <b>structural components</b> found in <b>manufacturers' service information</b>
		identify chassis and frame <b>fasteners</b> , and describe their characteristics and applications
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
H-37.01.02L	demonstrate knowledge of procedures to service <b>structural components</b>	identify tools and equipment used to service <b>structural components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service <b>structural components</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect <b>structural components</b>

		describe procedures to clean <b>structural components</b>
		describe procedures to service <b>structural components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		describe procedures to reduce corrosion and maintain structural integrity
H-37.01.03L	demonstrate knowledge of training and certification requirements to service <b>structural components</b>	identify training and certification requirements to service <b>structural components</b>
H-37.01.04L	demonstrate knowledge of regulatory requirements pertaining to <b>structural components</b>	identify codes, standards and regulations pertaining to <b>structural components</b>
H-37.01.05L	demonstrate knowledge of emerging technologies and practices pertaining to <b>structural components</b>	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**structural components** include: cross-members, gussets, frames, chassis, roll-over protective structure (ROPS), falling object protective structure (FOPS), operator protective structure (OPS), guards, covers and belly pans, platform, stairs, rails, swing and articulation bearings

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fasteners** include: rivets, bolts, pins, nuts, screws

**hazards** include: heavy components, falls, crush/pinch points

**consumables** include: cushion stoppers for joint articulation, wear plates, stopper plates

## H-37.02 Diagnoses structural components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
H-37.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
H-37.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>

H-37.02.03P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b>
H-37.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
H-37.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
H-37.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
H-37.02.07P	remove and disassemble <b>structural components</b> to identify or confirm problem	<b>structural components</b> are removed and disassembled to identify or confirm problem
H-37.02.08P	inspect <b>structural components</b> for <b>conditions</b>	<b>structural components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
H-37.02.09P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
H-37.02.10P	perform failure analysis	failure analysis is performed to determine root cause of failure
H-37.02.11P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
H-37.02.12P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: loose or broken components, cracks, bends, twists, corrosion, broken hardware

**tools and equipment** include: laser alignment tools, calipers, straight edges, crack detection tools

**sensory inspections** include: looking for cracked or damaged frames, corrosion, missing or loose hardware

**conditions** include: wear, damage, defects, failure, bending, cracking, corrosion, missing or loose fasteners

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tests** include: magnaflux, crack penetrating dye

**structural components** include: cross-members, gussets, frames, chassis, ROPS, FOPS, OPS, guards, covers and belly pans, platform, stairs, rails, swing and articulation bearings

**measurements** include: bore dimensions, tolerances, alignment

**next steps** include: repairs, component replacement or adjustment

## Knowledge

Learning Outcomes	Learning Objectives
H-37.02.01L demonstrate knowledge of <b>structural components</b> , their characteristics, applications and operation	identify types of <b>structural components</b> and describe their characteristics and applications
	describe operating principles of <b>structural components</b>
	interpret information pertaining to <b>structural components</b> found in <b>manufacturers' service information</b>
	identify chassis and frame <b>fasteners</b> , and describe their characteristics and applications
H-37.02.02L demonstrate knowledge of procedures to diagnose <b>structural components</b>	identify <b>tools and equipment</b> used to diagnose <b>structural components</b> , and describe their applications and procedures for use
	identify <b>hazards</b> and describe safe work practices to diagnose <b>structural components</b>
	describe common causes and <b>symptoms of problems</b>
	describe procedures to inspect <b>structural components</b>
	describe procedures to test <b>structural components</b>
	describe procedures to diagnose <b>structural components</b>
	identify <b>conditions</b> found while diagnosing <b>structural components</b>
	identify steps for failure analysis
	identify practices that reduce material waste
H-37.02.03L demonstrate knowledge of when to recommend specialty shops	identify materials that can be reconditioned, reused or recycled
	identify specialty shops responsible for advanced alignment work



## Range of Variables

**structural components** include: cross-members, gussets, frames, chassis, ROPS, FOPS, OPS, guards, covers and belly pans, platform, stairs, rails, swing and articulation bearings

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fasteners** include: rivets, bolts, pins, nuts, screws

**tools and equipment** include: laser alignment tools, calipers, straight edges, crack detection tools

**hazards** include: crush/pinch points, fall risk, heavy lifting

**symptoms of problems** include: loose or broken components, cracks, bends, twists, corrosion, broken hardware

**conditions** include: wear, damage, defects, failure, bending, cracking, corrosion, missing or loose fasteners

### H-37.03 Performs mechanical repairs on structural components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
H-37.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
H-37.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
H-37.03.03P	clean <b>structural components</b>	<b>structural components</b> are cleaned according to <b>manufacturers' service information</b>
H-37.03.04P	remove, disassemble and inspect <b>structural components</b> for <b>conditions</b>	<b>structural components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
H-37.03.05P	select <b>parts and materials</b>	<b>parts and materials</b> are selected according to repair requirements and <b>manufacturers' service information</b>
H-37.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
H-37.03.07P	assemble and install <b>structural components</b>	<b>structural components</b> are assembled and installed according to <b>manufacturers' service information</b>
H-37.03.08P	replace <b>structural components</b>	<b>structural components</b> are replaced according to <b>manufacturers' service information</b>

H-37.03.09P	rebuild <b>structural components</b>	<b>structural components</b> are rebuilt according to <b>manufacturers' service information</b>
H-37.03.10P	repair <b>structural components</b>	<b>structural components</b> are repaired according to <b>manufacturers' service information</b>
H-37.03.11P	reassemble <b>structural components</b> and perform measurements	<b>structural components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
H-37.03.12P	<b>adjust structural components</b> and parts	<b>structural components</b> and parts are <b>adjusted</b> according to <b>manufacturers' service information</b>
H-37.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
H-37.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: laser alignments, calipers, straight edges

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**structural components** include: cross-members, gussets, frames, chassis, ROPS, FOPS, OPS, guards, covers and belly pans, platform, stairs, rails, swing and articulation bearings

**conditions** include: wear, damage, defects, failure, bending, cracking, corrosion, loose or missing fasteners

**parts and materials** include: plates, gussets, fasteners, hardware, bosses, bushings, bearings

**adjust** includes: shimming, alignments

**methods** include: adding inserts, drilling frames, adjusting length, stress or load, field

## Knowledge

	Learning Outcomes	Learning Objectives
H-37.03.01L	demonstrate knowledge of <b>structural components</b> , their characteristics, applications and operation	identify types of <b>structural components</b> , and describe their characteristics and applications
		describe operating principles of <b>structural components</b>
		interpret information pertaining to <b>structural components</b> found in <b>manufacturers' service information</b>
		identify chassis and frame <b>fasteners</b> , and describe their characteristics and applications
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures

		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
H-37.03.02L	demonstrate knowledge of procedures to repair <b>structural components</b>	identify <b>tools and equipment</b> used to repair <b>structural components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair <b>structural components</b>
		describe procedures to release and isolate stored energy
		describe procedures to remove, disassemble, assemble and inspect <b>structural components</b>
		describe procedures to replace, rebuild or repair <b>structural components</b>
		describe procedures to adjust and calibrate <b>structural components</b>
		describe procedures to recycle and dispose of <b>structural components</b>
		describe <b>methods</b> to verify repairs
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
H-37.03.03L	demonstrate knowledge of welding training and certification requirements to repair <b>structural components</b>	identify welding training and certification requirements to repair <b>structural components</b>

## Range of Variables

**structural components** include: cross-members, gussets, frames, chassis, ROPS, FOPS, OPS, guards, covers and belly pans, platform, stairs, rails, swing and articulation bearings

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**fasteners** include: rivets, bolts, pins, nuts, screws

**tools and equipment** include: laser alignments, calipers, straight edges

**hazards** include: heavy components, falls, crush/pinch points

**methods** include: adding inserts, drilling frames, adjusting length, stress or load, field

# Task H-38 Services, diagnoses and repairs operator station components

## Task Descriptor

Operator stations provide a safe, secure and comfortable environment for the operator. The operator station contains the equipment controls and monitoring systems. The windows of the operator station are important components for UV protection and to support the efficiency of the air conditioning systems. Heavy duty equipment technicians service, diagnose and repair operator station components for the safety and comfort of the operator (ergonomics), and the security and functions of the controls and monitoring systems.

### H-38.01 Services operator station components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
H-38.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
H-38.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
H-38.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
H-38.01.04P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify leaks and worn, damaged and defective <b>components</b>
H-38.01.05P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b>
H-38.01.06P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
H-38.01.07P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
H-38.01.08P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>

H-38.01.09P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
H-38.01.10P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
H-38.01.11P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: vacuum cleaners, hand tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: machine and monitor controls, sound suppression systems, emergency exit system, sun visors and blinds, steering, seat, seat belt, bulbs, glass (clear and tinted for sunlight filtration), wipers, windshield washer, doors, radio, mirrors, Global Positioning System (GPS), ROPS, FOPS, OPS

**sensory inspections** include: looking for missing fasteners, burnt lights, worn or defective components

**consumables** include: air filters, anti-slip materials

Knowledge		
	Learning Outcomes	Learning Objectives
H-38.01.01L	demonstrate knowledge of operator stations, their <b>components</b> , characteristics, applications and operation	identify <b>types of operator stations</b> and <b>components</b> , and describe their characteristics and applications
		describe operating principles of operator station <b>components</b>
		interpret information pertaining to operator station <b>components</b> found in <b>manufacturers' service information</b>
H-38.01.02L	demonstrate knowledge of procedures to service operator station <b>components</b>	identify equipment systems related to operator station <b>components</b>
		identify <b>tools and equipment</b> used to service <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect <b>components</b>
		describe procedures to clean <b>components</b>
		describe procedures to service <b>components</b>

		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
H-38.01.03L	demonstrate knowledge of training requirements to service operator station <b>components</b>	identify training requirements to service operator station <b>components</b>
H-38.01.04L	demonstrate knowledge of regulatory requirements pertaining to operator station <b>components</b>	identify codes, standards and regulations pertaining to operator station <b>components</b>
H-38.01.05L	demonstrate knowledge of emerging technologies and practices pertaining to operator station <b>components</b>	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: machine and monitor controls, sound suppression systems, emergency exit system, sun visors and blinds, steering, seat, seat belt, bulbs, glass (clear and tinted for sunlight filtration), wipers, windshield washer, doors, radio, mirrors, Global Positioning System (GPS), ROPS, FOPS, OPS

**types of operator stations** include: canopies, cabs, towers, wireless remote

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: vacuum cleaners, hand tools

**hazards** include: falling, slipping, crush/pinch points, electrical, tripping

**consumables** include: air filters, anti-slip materials

## H-38.02 Diagnoses operator station components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
H-38.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
H-38.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
H-38.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
H-38.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
H-38.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
H-38.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
H-38.02.07P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
H-38.02.08P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
H-38.02.09P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
H-38.02.10P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
H-38.02.11P	perform failure analysis	failure analysis is performed to determine root cause of failure
H-38.02.12P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
H-38.02.13P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: latches not working, noises, burnt out bulbs, control interference, malfunction of controls, increased heat, brightness and eye strain (resulting from sun filtration component issues)

**tools and equipment** include: electronic service tools, onboard computer, diagnostic equipment, laptop, hand tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, missing fasteners, burnt lights, worn or defective components

**tests** include: air leakage, functional tests

**components** include: machine and monitor controls, sound suppression systems, emergency exit system, sun visors and blinds, steering, seat, seat belt, bulbs, glass (clear and tinted for sunlight filtration), wipers, windshield washer, doors, radio, mirrors, GPS, ROPS, FOPS, OPS

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
Learning Outcomes	Learning Objectives	
H-38.02.01L	demonstrate knowledge of operator stations, their <b>components</b> , characteristics, applications and operation	identify <b>types of operator stations</b> and <b>components</b> , and describe their characteristics and applications
		describe operating principles of operator station <b>components</b>
		interpret information pertaining to operator station <b>components</b> found in <b>manufacturers' service information</b>
		identify equipment systems related to operator station <b>components</b>
H-38.02.02L	demonstrate knowledge of procedures to diagnose operation station <b>components</b>	identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
		identify <b>tools and equipment</b> used to diagnose operator station <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose operator station <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect <b>components</b>
		describe procedures to test <b>components</b>
		describe procedures to diagnose <b>components</b>
		identify <b>conditions</b> found while diagnosing <b>components</b>



		identify steps for failure analysis
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
H-38.02.03L	demonstrate knowledge of training requirements pertaining to operator station <b>components</b>	identify training requirements pertaining to operator station <b>components</b>
H-38.02.04L	demonstrate knowledge of regulatory requirements pertaining to operator station <b>components</b>	identify and interpret standards and regulations pertaining to operator station <b>components</b>
H-38.02.05L	demonstrate knowledge of emerging technologies and practices related to operator station <b>components</b>	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: machine and monitor controls, sound suppression systems, emergency exit system, sun visors and blinds, steering, seat, seat belt, bulbs, glass (clear and tinted for sunlight filtration), wipers, windshield washer, doors, radio, mirrors, GPS, ROPS, FOPS, OPS

**types of operator stations** include: canopies, cabs, towers, wireless remote

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: electronic service tools, onboard computer, diagnostic equipment, laptop, hand tools

**hazards** include: falling, slipping, crush/pinch points, electrical, tripping

**symptoms of problems** include: latches not working, noises, burnt out bulbs, control interference, malfunction of controls, increased heat, brightness and eye strain (resulting from sun filtration component issues)

**conditions** include: wear, damage, defects, failure, missing fasteners, burnt lights, worn or defective components

## H-38.03 Repairs operator station components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
H-38.03.01P	select and use tools and equipment	tools and equipment are selected and used according to task and <b>manufacturers' service information</b>
H-38.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
H-38.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
H-38.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
H-38.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
H-38.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
H-38.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
H-38.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
H-38.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
H-38.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
H-38.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
H-38.03.12P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
H-38.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>
H-38.03.14P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: machine and monitor controls, sound suppression systems, emergency exit system, sun visors, steering, seat, seat belt, bulbs, glass, wiper, windshield washer, doors, radio, mirrors, GPS, ROPS, FOPS, OPS

**conditions** include: wear, damage, defects, failure, missing fasteners, burnt lights, worn or defective components

**methods** include: operational testing, load testing, sensory observations

<b>Knowledge</b>		
<b>Learning Outcomes</b>	<b>Learning Objectives</b>	
H-38.03.01L	demonstrate knowledge of operator stations, their <b>components</b> , characteristics, applications and operation	identify <b>types of operator stations</b> and <b>components</b> , and describe their characteristics and applications
		describe operating principles of operator station <b>components</b>
		interpret information pertaining to operator station <b>components</b> found in <b>manufacturers' service information</b>
		identify equipment systems related to operator station <b>components</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
H-38.03.02L	demonstrate knowledge of procedures to repair operator station <b>components</b>	identify tools and equipment used to repair operator station <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair operator station <b>components</b>
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild and repair <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled

		identify practices that reduce material waste
H-38.03.03L	demonstrate knowledge of training requirements to repair operator station <b>components</b>	identify training requirements to repair operator station <b>components</b>
H-38.03.04L	demonstrate knowledge of regulatory requirements pertaining to operator station <b>components</b>	identify codes, standards and regulations pertaining to operator station <b>components</b>
H-38.03.05L	demonstrate knowledge of emerging technologies and practices pertaining to operator station <b>components</b>	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: machine and monitor controls, sound suppression systems, emergency exit system, sun visors, steering, seat, seat belt, bulbs, glass, wiper, windshield washer, doors, radio, mirrors, GPS, ROPS, FOPS, OPS

**types of operator stations** include: canopies, cabs, towers, wireless remote

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**hazards** include: falling, slipping, crush/pinch points, electrical, tripping

**methods** include: operational testing, load testing, sensory observations

# Task H-39 Services, diagnoses and repairs attachments and accessories

## Task Descriptor

The attachments and accessories are vital to the productivity, versatility and diversity of the equipment. They must work together to be efficient.

Heavy duty equipment technicians service, diagnose and repair attachments and accessories to ensure that they operate in a safe manner.

### H-39.01 Services attachments and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
H-39.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
H-39.01.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
H-39.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
H-39.01.04P	perform sensory inspections	sensory inspections are performed to identify leaks and worn, damaged and defective <b>components</b>
H-39.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
H-39.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>
H-39.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
H-39.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
H-39.01.09P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>

H-39.01.10P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
H-39.01.11P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
H-39.01.12P	document service information	service information is documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: laptop, flow meters, pressure gauges, multimeters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: ground engaging tools, hydraulic actuators, hoses, wiring harnesses

**measurements** include: pressures, dimensions, voltage readings

**consumables** include: ground engaging tools (teeth, cutting edges, knives, hardware), drills

Knowledge		
	Learning Outcomes	Learning Objectives
H-39.01.01L	demonstrate knowledge of attachments and accessories, their <b>components</b> , characteristics, applications and operation	identify <b>types of attachments and accessories</b> and <b>components</b> , and describe their characteristics and applications
		describe operating principles of attachments and accessories
		interpret information pertaining to attachments and accessories found in <b>manufacturers' service information</b>
		describe wear limits and load capacities of attachment and accessory <b>components</b>
		identify and describe equipment systems and their interactions with <b>components</b> , attachments and accessories
H-39.01.02L	demonstrate knowledge of procedures to service attachments and accessories, and their <b>components</b>	describe accessory performance
		identify <b>tools and equipment</b> used to service attachments and accessories, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service attachments and accessories, and their <b>components</b>
		describe procedures to release and isolate stored energy
		describe procedures to inspect attachments and accessories

		describe procedures to clean attachment and accessory <b>components</b>
		describe procedures to service attachments and accessories
		describe procedures to adjust and calibrate attachment and accessory <b>components</b>
		describe procedures to remove, replace, recycle and dispose of <b>consumables</b>
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
H-39.01.03L	demonstrate knowledge of training and certification requirements to service attachments and accessories	identify training and certification requirements to service attachments and accessories
H-39.01.04L	demonstrate knowledge of regulatory requirements pertaining to attachments and accessories	identify codes, standards and regulations pertaining to attachments and accessories
H-39.01.05L	demonstrate knowledge of emerging technologies and practices pertaining to attachments and accessories	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: ground engaging tools, hydraulic actuators, hoses, wiring harnesses

**types of attachments and accessories** include: manufacturers' or after-market attachments (blades, stick, boom, buckets, hammer, forks, tree harvesters, clams, grapples), manufacturers' or after-market accessories (auto greaser, lights, anti-vandalism equipment, cold weather package, platforms), fire suppression system

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: laptop, flow meters, pressure gauges, multimeters

**hazards** include: stored energy potential, crush/pinch points, falls, environmental hazards

**consumables** include: ground engaging tools (teeth, cutting edges, knives, hardware), drills

## H-39.02 Diagnoses attachments and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
H-39.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
H-39.02.02P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
H-39.02.03P	perform sensory inspections	sensory inspections are performed to identify <b>conditions</b>
H-39.02.04P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
H-39.02.05P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
H-39.02.06P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
H-39.02.07P	remove and disassemble <b>components</b> to identify or confirm problem	<b>components</b> are removed and disassembled to identify or confirm problem
H-39.02.08P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
H-39.02.09P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b> and according to jurisdictional regulations
H-39.02.10P	perform failure analysis	failure analysis is performed to determine root cause of failure
H-39.02.11P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
H-39.02.12P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>



## Range of Variables

**symptoms of problems** include: not meeting expected performance, difficult to attach or release, safety features are non-functional

**tools and equipment** include: electrical and electronic testing tools, wear gauges, pressure gauges, laptop, flow meters

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**conditions** include: wear, damage, defects, failure, leaks, interference

**tests** include: pressure, cycle times, load, flow testd

**components** include: ground engaging tools, hydraulic actuators, hoses, wiring harnesses

**measurements** include: pressures, dimensions, voltage readings

**next steps** include: repairs, component replacement or adjustment, further diagnosis

Knowledge		
	Learning Outcomes	Learning Objectives
H-39.02.01L	demonstrate knowledge of attachments and accessories, their <b>components</b> , characteristics, applications and operation	identify <b>types of attachments and accessories</b> and <b>components</b> , and describe their characteristics and applications
		describe operating principles of attachments and accessories
		interpret information pertaining to attachments and accessories found in <b>manufacturers' service information</b>
		interpret tolerance information pertaining to attachments and accessories
		describe wear limits and load capacities of attachment and accessory <b>components</b>
		identify and describe equipment systems and their interactions with <b>components</b> , attachments and accessories
H-39.02.02L	demonstrate knowledge of procedures to diagnose attachments and accessories, and their <b>components</b>	describe accessory performance
		identify <b>tools and equipment</b> used to diagnose attachments and accessories, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose attachments, accessories and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to inspect attachments and accessories
		describe procedures to test attachments and accessories
		describe procedures to diagnose attachments and accessories

		identify <b>conditions</b> found while diagnosing attachments and accessories
		identify steps for failure analysis
		identify practices that reduce material waste
		identify materials that can be reconditioned, reused or recycled
H-39.02.03L	demonstrate knowledge of training and certification requirements to diagnose attachments and accessories	identify training and certification requirements to diagnose attachments and accessories
H-39.02.04L	demonstrate knowledge of regulatory requirements pertaining to attachments and accessories	identify codes, standards and regulations pertaining to attachments and accessories
H-39.02.05L	demonstrate knowledge of emerging technologies and practices pertaining to attachments and accessories	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: ground engaging tools, hydraulic actuators, hoses, wiring harnesses

**types of attachments and accessories** include: manufacturers' or after-market attachments (blades, stick, boom, buckets, hammer, forks, tree harvesters, clams, grapples), ground engaging tools, manufacturers' or after-market accessories (auto greaser, lights, anti-vandalism equipment, cold weather package, platforms), fire suppression system, industry-specific attachments and accessories

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: electrical and electronic testing tools, wear gauges, pressure gauges, laptop, flow meters

**hazards** include: stored energy potential, crush/pinch points, falls, environmental hazards

**symptoms of problems** include: not meeting expected performance, difficult to attach or release, safety features are non-functional

**conditions** include: wear, damage, defects, failure, leaks, interference

## H-39.03 Repairs attachments and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
H-39.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
H-39.03.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
H-39.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
H-39.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
H-39.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
H-39.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
H-39.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
H-39.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
H-39.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>
H-39.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
H-39.03.11P	reassemble <b>components</b> and perform <b>measurements</b>	<b>components</b> are reassembled and <b>measurements</b> are performed according to <b>manufacturers' service information</b>
H-39.03.12P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
H-39.03.13P	verify repairs	repairs are verified using <b>methods</b> according to <b>manufacturers' service information</b>

H-39.03.14P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
H-39.03.15P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
H-39.03.16P	document repairs	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: precision measuring tools, hand tools, shop tools, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: ground engaging tools, hydraulic actuators, hoses, wiring harnesses

**conditions** include: wear, damage, defects, failure, leaks, interference

**measurements** include: pressures, dimensions, voltage readings

**methods** include: performance testing, load testing, sensory observations

Knowledge		
	Learning Outcomes	Learning Objectives
H-39.03.01L	demonstrate knowledge of attachments and accessories, their <b>components</b> , characteristics, applications and operation	identify <b>types of attachments and accessories</b> and <b>components</b> , and describe their characteristics and applications
		describe operating principles of attachments and accessories
		interpret information pertaining to attachments and accessories found in <b>manufacturers' service information</b>
		describe wear limits and load capacities of attachment and accessory <b>components</b>
		identify and describe equipment systems and their interactions with <b>components</b> , attachments and accessories
		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications

H-39.03.02L	demonstrate knowledge of procedures to repair attachments and accessories, and their <b>components</b>	identify <b>tools and equipment</b> used to repair attachments and accessories, and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair attachments and accessories
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to replace, rebuild, and repair <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		describe <b>methods</b> to verify repairs
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
H-39.03.03L	demonstrate knowledge of training and certification requirements to repair attachments and accessories	identify training and certification requirements to repair attachments and accessories
H-39.03.04L	demonstrate knowledge of regulatory requirements pertaining to attachments and accessories	identify codes, standards and regulations pertaining to attachments and accessories
H-39.03.05L	demonstrate knowledge of emerging technologies and practices pertaining to attachments and accessories	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: ground engaging tools, hydraulic actuators, hoses, wiring harnesses

**types of attachments and accessories** include: manufacturers' or after-market attachments (blades, stick, boom, buckets, hammers, forks, tree harvesters, clams, grapples), ground engaging tools, manufacturers' or after-market accessories (auto greaser, light, anti-vandalism equipment, cold weather package, platforms), fire suppression system

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: precision measuring tools, hand tools, shop tools, laptop

**hazards** include: stored energy potential, crush/pinch points, falls, environmental hazards

**methods** include: performance testing, load testing, sensory observations

### H-39.04 Installs attachments and accessories

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
H-39.04.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
H-39.04.02P	release and isolate stored energy in components	stored energy is released and isolated in components according to <b>manufacturers' service information</b>
H-39.04.03P	remove and disassemble <b>components</b>	<b>components</b> are removed and disassembled according to manufacturers' specifications and procedures for installation of attachments and accessories
H-39.04.04P	follow installation sequence	installation sequence is followed according to <b>manufacturers' service information</b>
H-39.04.05P	select parts and materials	parts and materials are selected according to installation requirements and manufacturers' specifications
H-39.04.06P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>

H-39.04.07P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to manufacturers' specifications
H-39.04.08P	complete installation	installation is completed by verifying attachments and accessories function, operation and performance according to manufacturers' specifications
H-39.04.09P	document installation	installation is documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: precision measuring tools, hand tools, shop tools, laptop

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**components** include: ground engaging tools, hydraulic actuators, hoses, wiring harnesses

Knowledge		
	Learning Outcomes	Learning Objectives
H-39.04.01L	demonstrate knowledge of attachments and accessories, their <b>components</b> , characteristics, applications and operation	<p>identify <b>types of attachments and accessories</b>, and their <b>components</b>, and describe their characteristics and applications</p> <p>describe operating principles of attachments and accessories</p> <p>interpret information pertaining to attachments and accessories found in <b>manufacturers' service information</b></p> <p>identify and describe equipment systems and their interactions with <b>components</b>, attachments and accessories</p> <p>describe accessory performance</p> <p>identify potential environmental impacts of repair, and describe associated mitigation and prevention measures</p> <p>identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications</p>
H-39.04.02L	demonstrate knowledge of procedures to install attachments and accessories, and their <b>components</b>	<p>identify <b>tools and equipment</b> used to install attachments and accessories, and their <b>components</b>, and describe their applications and procedures for use</p> <p>identify <b>hazards</b> and describe safe work practices pertaining to installation of attachments and accessories, and their <b>components</b></p> <p>describe procedures to release and isolate stored energy</p>

		describe procedures to remove, disassemble, assemble and install <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
H-39.04.03L	describe methods to verify installation	describe procedures to recycle and dispose of <b>components</b>
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
H-39.04.04L	demonstrate knowledge of training and certification requirements to install attachments and accessories	identify training and certification requirements to install attachments and accessories
H-39.04.05L	demonstrate knowledge of regulatory requirements pertaining to attachments and accessories	identify codes, standards and regulations pertaining to attachments and accessories
H-39.04.06L	demonstrate knowledge of emerging technologies and practices pertaining to attachments and accessories	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**components** include: ground engaging tools, hydraulic actuators, hoses, wiring harnesses

**types of attachments and accessories** include: manufacturers' or after-market attachments (blades, stick, boom, buckets, hammers, forks, tree harvesters, clams, grapples), ground engaging tools, manufacturers' or after-market accessories (auto greaser, light, anti-vandalism equipment, cold weather package, platforms), fire suppression system

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards

**tools and equipment** include: precision measuring tools, hand tools, shop tools, laptop

**hazards** include: stored energy potential, crush/pinch points, falls, environmental hazards



# Major Work Activity I

## Services, diagnoses and repairs hybrid and all-electric equipment

### Task I-40 Services, diagnoses and repairs hybrid equipment

#### Task Descriptor

Heavy duty equipment technicians service, diagnose and repair electric motors, generators, inverters, converters, high-voltage batteries, capacitors and associated support systems in hybrid equipment. Safety is of paramount importance due to the risk of electrocution when working with high voltages.

#### I-40.01 Services hybrid equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	no	no	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
I-40.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to <b>manufacturers' service information</b>
I-40.01.02P	de-energize, release and isolate stored energy in components	stored energy is de-energized, released and isolated in components according to <b>manufacturers' service information</b>
I-40.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
I-40.01.04P	perform sensory inspections	sensory inspections are performed to identify worn, damaged and defective <b>components</b> and leaks
I-40.01.05P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
I-40.01.06P	check <b>fluid</b> levels	<b>fluid</b> levels are checked to determine if they meet <b>manufacturers' service information</b>
I-40.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
I-40.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations

I-40.01.09P	remove and replace <b>components</b>	<b>components</b> are removed and replaced according to <b>manufacturers' service information</b>
I-40.01.10P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
I-40.01.11P	<b>adjust and calibrate components</b>	<b>components</b> are <b>adjusted and calibrated</b> according to <b>manufacturers' service information</b>
I-40.01.12P	read and clear fault codes	fault codes are read and cleared according to <b>manufacturers' service information</b>
I-40.01.13P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
I-40.01.14P	document service information and inspection findings	service information and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: specialized PPE, safety devices, specialized digital multimeters (DMMs), electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**components** include: modules, inverters, high-voltage batteries, capacitors, drive motors, generators, converters, wiring

**measurements** include: tolerances, generator output, motor speed, voltage, amperage, conductivity, resistance, load banks, stall testing, capacitance

**fluids** include: lubricants, coolants

**consumables** include: filters, fluids, fuses, diodes

**adjust and calibrate** includes: motor speed, generator output, resistance

## Knowledge

	Learning Outcomes	Learning Objectives
I-40.01.01L	demonstrate knowledge of <b>hybrid equipment systems</b> , their <b>components</b> , characteristics, applications and operation	identify types of <b>hybrid equipment systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of <b>hybrid equipment systems</b>
		interpret information pertaining to <b>hybrid equipment systems</b> found in <b>manufacturers' service information</b>
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications

I-40.01.02L	demonstrate knowledge of procedures to service <b>hybrid equipment systems</b> and their <b>components</b>	identify <b>tools and equipment</b> used to service <b>hybrid equipment systems</b> and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to service <b>hybrid equipment systems</b> and their <b>components</b>
		describe procedures to de-energize, release or lock out stored energy
		describe procedures to clean hybrid <b>components</b>
		describe procedures to inspect hybrid <b>components</b>
		describe procedures to service <b>hybrid equipment systems</b> and their <b>components</b>
		describe procedures to read and clear fault codes
		describe procedures to perform software updates
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
I-40.01.03L	demonstrate knowledge of training requirements to service <b>hybrid equipment systems</b> and their <b>components</b>	identify training requirements to service <b>hybrid equipment systems</b> and their <b>components</b>
I-40.01.04L	demonstrate knowledge of procedures to measure <b>components</b>	describe procedures to measure <b>components</b>
I-40.01.05L	demonstrate knowledge of emerging technologies and practices related to <b>hybrid equipment systems</b> and their <b>components</b>	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**hybrid equipment systems** include: series, parallel, combination, extended range

**components** include: modules, inverters, high-voltage batteries, capacitors, drive motors, generators, converters, wiring

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**tools and equipment** include: specialized PPE, safety devices, specialized digital multimeters (DMMs), electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**hazards** include: electrocution, arc flash, sparks, heavy weights, falls, high-working temperatures

### I-40.02 Diagnoses hybrid equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	no	no	yes	NV	NV	NV

#### Skills

Performance Criteria		Evidence of Attainment
I-40.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
I-40.02.02P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify <b>conditions</b> according to <b>manufacturers' service information</b>
I-40.02.03P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
I-40.02.04P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
I-40.02.05P	inspect <b>components</b> for <b>conditions</b>	<b>components</b> are inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
I-40.02.06P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
I-40.02.07P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
I-40.02.08P	de-energize, release and isolate stored energy in components	stored energy is de-energized, released and isolated in components according to <b>manufacturers' service information</b>
I-40.02.09P	read and clear fault codes	fault codes are read and cleared according to <b>manufacturers' service information</b>

I-40.02.10P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
I-40.02.11P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
I-40.02.12P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
I-40.02.13P	perform failure analysis	failure analysis is performed to determine root cause of failure
I-40.02.14P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
I-40.02.15P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: lack of power, no equipment movement, no start, noises, indicator lights, components not functioning, intermittent operation

**sensory inspections** include: auditory, visual, tactile

**conditions** include: lack of drive power, failed components, burnt components, audible and visual alarms

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**tools and equipment** include: specialized PPE, safety devices, specialized DMMs, electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**components** include: modules, inverters, high-voltage batteries, drive motors, converters, wiring

**measurements** include: tolerances, generator output, motor speed, voltage, amperage, conductivity, resistance, load banks, stall testing, capacitance

**tests** include: active, voltage and amperage, resistance check, voltage isolation, insulation, operational test

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
I-40.02.01L	demonstrate knowledge of <b>hybrid equipment systems</b> , their <b>components</b> , characteristics, applications and operation	identify types of <b>hybrid equipment systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of <b>hybrid equipment systems</b>
		interpret information pertaining to <b>hybrid equipment systems</b> found in <b>manufacturers' service information</b>

		confirm types, viscosity and quality of fluids, and describe their characteristics and applications
I-40.02.02L	demonstrate knowledge of procedures to diagnose <b>hybrid equipment systems</b> and their <b>components</b>	identify <b>tools and equipment</b> used to diagnose <b>hybrid equipment systems</b> and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to diagnose <b>hybrid equipment systems</b> and their <b>components</b>
		describe common causes and <b>symptoms of problems</b>
		describe procedures to de-energize, release or lock out stored energy
		describe procedures to clean <b>hybrid equipment systems</b> and their <b>components</b>
		describe procedures to inspect <b>hybrid equipment systems</b> and their <b>components</b>
		describe procedures to test <b>hybrid equipment systems</b> and their <b>components</b>
		describe procedures to interpret diagnostic results for <b>hybrid equipment systems</b> and their <b>components</b>
		describe procedures to read and clear fault codes
		describe procedures to perform software updates
		identify <b>defects</b> found while diagnosing <b>hybrid equipment systems</b>
		identify steps for failure analysis
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
I-40.02.03L	demonstrate knowledge of training requirements to service <b>hybrid equipment systems</b> and their <b>components</b>	identify training requirements to service <b>hybrid equipment systems</b> and their <b>components</b>

## Range of Variables

**hybrid equipment systems** include: series, parallel, series/parallel

**components** include: modules, inverters, high-voltage batteries, drive motors, converters, wiring

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**tools and equipment** include: specialized PPE, safety devices, specialized DMMs, electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**hazards** include: shocks, arc flash, sparks, falls

**symptoms of problems** include: lack of power, no equipment movement, no start, noises, indicator lights, components not functioning, intermittent operation

**defects** include: loose components, damaged wiring, leaks, inoperable drive motors, damaged components

### I-40.03 Repairs hybrid equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	yes	yes	yes	no	no	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
I-40.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
I-40.03.02P	de-energize, release and isolate stored energy in components	stored energy is de-energized, released and isolated in components according to <b>manufacturers' service information</b>
I-40.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
I-40.03.04P	remove, disassemble and inspect <b>components</b> for <b>conditions</b>	<b>components</b> are removed, disassembled and inspected for <b>conditions</b> according to <b>manufacturers' service information</b>
I-40.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
I-40.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
I-40.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
I-40.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
I-40.03.10P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>

I-40.03.11P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
I-40.03.12P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
I-40.03.13P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
I-40.03.14P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
I-40.03.15P	read and clear fault codes	fault codes are read and cleared according to <b>manufacturers' service information</b>
I-40.03.16P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
I-40.03.17P	verify repairs	repairs are verified under operating conditions to ensure it is within <b>manufacturers' service information</b>
I-40.03.18P	document repairs performed	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: specialized PPE, safety devices, specialized DMMs, electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**components** include: modules, inverters, high-voltage batteries, drive motors, converters, wiring

**conditions** include: lack of drive power, failed components, burnt components, audible and visual alarms

**measurements** include: tolerances, generator output, motor speed, voltage, amperage, conductivity, resistance, load banks, stall testing

## Knowledge

	Learning Outcomes	Learning Objectives
I-40.03.01L	demonstrate knowledge of <b>hybrid equipment systems</b> , their <b>components</b> , characteristics, applications and operation	<p>identify types of <b>hybrid equipment systems</b> and their <b>components</b>, and describe their characteristics and applications</p> <p>describe operating principles of <b>hybrid equipment systems</b></p> <p>interpret information pertaining to <b>hybrid equipment systems</b> found in <b>manufacturers' service information</b></p>



		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
I-40.03.02L	demonstrate knowledge of procedures to repair <b>hybrid equipment system components</b>	identify <b>tools and equipment</b> used to repair <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair <b>hybrid equipment system components</b>
		describe procedures to de-energize, release or lock out stored energy
		describe procedures to read and clear fault codes
		describe procedures to perform software updates
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to repair, replace or recondition <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
I-40.03.03L	demonstrate knowledge of training requirements to service <b>hybrid equipment systems</b> and their <b>components</b>	identify training requirements to service <b>hybrid equipment systems</b> and their <b>components</b>
I-40.03.04L	demonstrate knowledge of emerging technologies and practices related to <b>hybrid equipment systems</b> and their <b>components</b>	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**hybrid equipment systems** include: series, parallel, series/parallel

**components** include: modules, inverters, high-voltage batteries, drive motors, converters, wiring

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**tools and equipment** include: specialized PPE, safety devices, specialized DMMs, electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**hazards** include: shocks, arc flash, sparks, heavy weights, falls, burns, high-working temperatures

## Task I-41 Services, diagnoses and repairs all-electric equipment

### Task Descriptor

Heavy duty equipment technicians work on electric motors, inverters, converters, high-voltage batteries and associated support systems in all-electric equipment. Safety is of paramount importance due to the risk of electrocution when working with high voltages.

#### I-41.01 Services all-electric equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	no	yes	yes	yes	yes	no	no	yes	NV	NV	NV

### Skills

	Performance Criteria	Evidence of Attainment
I-41.01.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to <b>manufacturers' service information</b>
I-41.01.02P	de-energize, release and isolate stored energy in components	stored energy is de-energized, released and isolated in components according to <b>manufacturers' service information</b>
I-41.01.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
I-41.01.04P	perform sensory inspections	sensory inspections are performed to identify worn, damaged and defective <b>components</b> and leaks
I-41.01.05P	perform measurements	measurements are performed and compared with <b>manufacturers' service information</b>
I-41.01.06P	check fluid levels	fluid levels are checked to determine if they meet <b>manufacturers' service information</b>

I-41.01.07P	remove and replace <b>consumables</b>	<b>consumables</b> are removed and replaced according to <b>manufacturers' service information</b>
I-41.01.08P	recycle and dispose of <b>consumables</b>	<b>consumables</b> are recycled and disposed of according to jurisdictional regulations
I-41.01.09P	remove and replace <b>components</b>	<b>components</b> are removed and replaced according to <b>manufacturers' service information</b>
I-41.01.10P	lubricate <b>components</b>	<b>components</b> are lubricated according to <b>manufacturers' service information</b>
I-41.01.11P	adjust and calibrate <b>components</b>	<b>components</b> are adjusted and calibrated according to <b>manufacturers' service information</b>
I-41.01.12P	read and clear fault codes	fault codes are read and cleared according to <b>manufacturers' service information</b>
I-41.01.13P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
I-41.01.14P	document service information and inspection findings	service information and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking

## Range of Variables

**tools and equipment** include: specialized PPE, safety devices, specialized DMMs, electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**components** include: modules, inverters, high-voltage batteries, capacitors, drive motors, generators, converters, wiring

**consumables** include: filters, fluids, fuses, diodes

Knowledge		
	Learning Outcomes	Learning Objectives
I-41.01.01L	demonstrate knowledge of <b>all-electric equipment systems</b> , their <b>components</b> , <b>consumables</b> , characteristics, applications and operation	identify <b>all-electric equipment systems</b> and their <b>components</b> and <b>consumables</b> , and describe their characteristics and applications
		describe operating principles of <b>all-electric equipment systems</b> and their <b>components</b>
		interpret information pertaining to <b>all-electric equipment systems</b> found in <b>manufacturers' service information</b>

		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
I-41.01.02L	demonstrate knowledge of procedures to service <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>	identify <b><i>tools and equipment</i></b> used to service <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b> , and describe their applications and procedures for use
		identify <b><i>hazards</i></b> and describe safe work practices to service <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>
		describe procedures to de-energize, release or lock out stored energy
		describe procedures to inspect <b><i>components</i></b>
		describe procedures to clean <b><i>components</i></b>
		describe procedures to service <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>
		describe procedures to read and clear fault codes
		describe procedures to perform software updates
		describe procedures to remove, replace, recycle and dispose of <b><i>consumables</i></b>
		identify defects found in <b><i>all-electric equipment systems</i></b>
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
I-41.01.03L	demonstrate knowledge of training requirements to service <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>	identify training requirements to service <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>
I-41.01.04L	demonstrate knowledge of procedures to measure <b><i>components</i></b>	describe procedures to measure <b><i>components</i></b>
I-41.01.05L	demonstrate knowledge of emerging technologies and practices related to <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## Range of Variables

**all-electric equipment systems** include: A/C drives, fast charge, plug-in, extended range

**components** include: modules, inverters, high-voltage batteries, capacitors, drive motors, generators, converters, wiring

**consumables** include: filters, fluids, fuses, diodes

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**tools and equipment** include: specialized PPE, safety devices, specialized DMMs, electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**hazards** include: electrocution, arc flash, sparks, heavy weights, falls, high-working temperatures

### I-41.02 Diagnoses all-electric equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	no	yes	yes	yes	yes	no	no	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
I-41.02.01P	identify <b>symptoms of problems</b>	<b>symptoms of problems</b> are identified by consulting with customer or operator
I-41.02.02P	perform <b>sensory inspections</b>	<b>sensory inspections</b> are performed to identify conditions according to <b>manufacturers' service information</b>
I-41.02.03P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
I-41.02.04P	remove and disassemble <b>components</b> to identify problem	<b>components</b> are removed and disassembled to identify problem
I-41.02.05P	inspect <b>components</b> for conditions	<b>components</b> are inspected for conditions according to <b>manufacturers' service information</b>
I-41.02.06P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
I-41.02.07P	verify complaint and expected performance	complaint and expected performance is verified by comparing equipment operation to <b>manufacturers' service information</b>
I-41.02.08P	de-energize, release and isolate stored energy in components	stored energy is de-energized, released and isolated in components according to <b>manufacturers' service information</b>
I-41.02.09P	read and clear fault codes	fault codes are read and cleared according to <b>manufacturers' service information</b>

I-41.02.10P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
I-41.02.11P	perform diagnostic procedures and <b>tests</b>	diagnostic procedures and <b>tests</b> are performed according to <b>manufacturers' service information</b>
I-41.02.12P	verify diagnosis	diagnosis is verified by interpreting <b>test</b> results and comparing them to <b>manufacturers' service information</b> or expected values
I-41.02.13P	perform failure analysis	failure analysis is performed to determine root cause of failure
I-41.02.14P	document <b>test</b> results and inspection findings	<b>test</b> results and inspection findings are documented according to manufacturers' requirements for warranty, and for future reference and tracking
I-41.02.15P	interpret diagnostic results to determine <b>next steps</b>	diagnostic results are interpreted to determine <b>next steps</b>

## Range of Variables

**symptoms of problems** include: lack of power, no equipment movement, noises, indicator lights, components not functioning, intermittent operation

**sensory inspections** include: auditory, visual, tactile

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**tools and equipment** include: specialized PPE, safety devices, specialized DMMs, electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**components** include: modules, inverters, high-voltage batteries, drive motors, converters, wiring, charging systems

**measurements** include: tolerances, generator output, motor speed, voltage, amperage, conductivity, resistance

**tests** include: active, voltage and amperage, resistance check, voltage isolation, insulation, operational tests

**next steps** include: repairs, component replacement or adjustment, further diagnosis

## Knowledge

	Learning Outcomes	Learning Objectives
I-41.02.01L	demonstrate knowledge of <b>all-electric equipment systems</b> , their <b>components</b> , characteristics, applications and operation	identify types of <b>all-electric equipment systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of <b>all-electric equipment systems</b> and their <b>components</b>
		interpret information pertaining to <b>all-electric equipment systems</b> found in <b>manufacturers' service information</b>

		confirm types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
I-41.02.02L	demonstrate knowledge of procedures to diagnose <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>	identify <b><i>tools and equipment</i></b> used to diagnose <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b> , and describe their applications and procedures for use
		identify <b><i>hazards</i></b> and describe safe work practices to diagnose <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>
		describe common causes and <b><i>symptoms of problems</i></b>
		describe procedures to de-energize, release or lock out stored energy
		describe procedures to clean <b><i>components</i></b>
		describe procedures to inspect <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>
		describe procedures to test <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>
		describe procedures to interpret diagnostic results for <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>
		identify <b><i>defects</i></b> founds while diagnosing <b><i>all-electric equipment systems</i></b>
		identify steps for failure analysis
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
I-41.02.03L	demonstrate knowledge of training requirements to service <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>	identify training requirements to service <b><i>all-electric equipment systems</i></b> and their <b><i>components</i></b>

## Range of Variables

**all-electric equipment systems** include: A/C drives, series, parallel, fast charge, plug-in, extended range  
**components** include: modules, inverters, high-voltage batteries, drive motors, converters, wiring, charging systems

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**tools and equipment** include: specialized PPE, safety devices, specialized DMMs, electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**hazards** include: shocks, arc flash, sparks, falls, high-working temperatures

**symptoms of problems** include: lack of power, no equipment movement, noises, indicator lights, components not functioning, intermittent operation

**defects** include: loose components, damaged wiring, leaks, inoperable drive motors, damaged components

### I-41.03 Repairs all-electric equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	no	yes	yes	yes	yes	no	no	yes	NV	NV	NV

#### Skills

	Performance Criteria	Evidence of Attainment
I-41.03.01P	select and use <b>tools and equipment</b>	<b>tools and equipment</b> are selected and used according to task and <b>manufacturers' service information</b>
I-41.03.02P	de-energize, release and isolate stored energy in components	stored energy is de-energized, released and isolated in components according to <b>manufacturers' service information</b>
I-41.03.03P	clean <b>components</b>	<b>components</b> are cleaned according to <b>manufacturers' service information</b>
I-41.03.04P	remove, disassemble and inspect <b>components</b> for conditions	<b>components</b> are removed, disassembled and inspected for conditions according to <b>manufacturers' service information</b>
I-41.03.05P	select parts and materials	parts and materials are selected according to repair requirements and <b>manufacturers' service information</b>
I-41.03.06P	follow repair sequence	repair sequence is followed according to <b>manufacturers' service information</b>
I-41.03.07P	assemble and install <b>components</b>	<b>components</b> are assembled and installed according to <b>manufacturers' service information</b>
I-41.03.08P	replace <b>components</b>	<b>components</b> are replaced according to <b>manufacturers' service information</b>
I-41.03.09P	rebuild <b>components</b>	<b>components</b> are rebuilt according to <b>manufacturers' service information</b>



I-41.03.10P	repair <b>components</b>	<b>components</b> are repaired according to <b>manufacturers' service information</b>
I-41.03.11P	reassemble <b>components</b> and perform measurements	<b>components</b> are reassembled and measurements are performed according to <b>manufacturers' service information</b>
I-41.03.12P	perform <b>measurements</b>	<b>measurements</b> are performed and compared with <b>manufacturers' service information</b>
I-41.03.13P	adjust and calibrate <b>components</b> and parts	<b>components</b> and parts are adjusted and calibrated according to <b>manufacturers' service information</b>
I-41.03.14P	read and clear fault codes	fault codes are read and cleared according to <b>manufacturers' service information</b>
I-41.03.15P	perform software updates	software updates are performed according to <b>manufacturers' service information</b>
I-41.03.16P	verify repairs	repairs are verified under operating conditions to ensure it is within <b>manufacturers' service information</b>
I-41.03.17P	document repairs performed	repairs are documented according to manufacturers' requirements for warranty, liability, future reference and tracking

## Range of Variables

**tools and equipment** include: specialized PPE, safety devices, specialized digital multimeters (DMMs), electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

**manufacturers' service information** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

**components** include: modules, inverters, high-voltage batteries, drive motors, converters, wiring, charging systems

**measurements** include: tolerances, generator output, motor speed, voltage, amperage, conductivity, resistance

## Knowledge

	Learning Outcomes	Learning Objectives
I-41.03.01L	demonstrate knowledge of <b>all-electric equipment systems</b> , their <b>components</b> , characteristics, applications and operation	identify types of <b>all-electric equipment systems</b> and their <b>components</b> , and describe their characteristics and applications
		describe operating principles of <b>all-electric equipment systems</b> and their <b>components</b>
		interpret information pertaining to <b>all-electric equipment systems</b> found in <b>manufacturers' service information</b>

		identify potential environmental impacts of repair, and describe associated mitigation and prevention measures
		identify types, viscosity and quality of fluids and lubricants, and describe their characteristics and applications
I-41.03.02L	demonstrate knowledge of procedures to repair <b>all-electric equipment systems</b> and their <b>components</b>	identify <b>tools and equipment</b> used to repair <b>all-electric equipment systems</b> and their <b>components</b> , and describe their applications and procedures for use
		identify <b>hazards</b> and describe safe work practices to repair <b>all-electric equipment systems</b> and their <b>components</b>
		describe procedures to de-energize, release or lock out stored energy
		describe procedures to read and clear fault codes
		describe procedures to perform software updates
		describe procedures to remove, disassemble, assemble and inspect <b>components</b>
		describe procedures to adjust and calibrate <b>components</b>
		describe procedures to recycle and dispose of <b>components</b>
		identify materials that can be reconditioned, reused or recycled
		identify practices that reduce material waste
I-41.03.03L	demonstrate knowledge of training requirements to repair <b>all-electric equipment systems</b> and their <b>components</b>	identify training requirements to repair <b>all-electric equipment systems</b> and their <b>components</b>
I-41.03.04L	demonstrate knowledge of emerging technologies and practices related to <b>all-electric equipment systems</b> and their <b>components</b>	identify technologies that reduce environmental impacts
		describe strategies and practices that reduce the carbon footprint
		identify technologies that address emissions and pollution, and describe their characteristics and applications

## **Range of Variables**

***all-electric equipment systems*** include: A/C drives, series, parallel, fast charge, plug-in, extended range  
***components*** include: modules, inverters, high-voltage batteries, drive motors, converters, wiring, charging systems

***manufacturers' service information*** includes: maintenance schedule, specifications, recommendations, procedures, standards, service bulletins

***tools and equipment*** include: specialized PPE, safety devices, specialized digital multimeters (DMMs), electronic service tools, specialized hand tools (insulated tools), manufacturer-specific tools and equipment, megohmmeter, lift-assist tools

***hazards*** include: shocks, arc flash, sparks, falls, heavy weights, high-working temperatures

# Appendix A-

## Acronyms

ABS	anti-lock braking system
A/C	air conditioning
AED	automated external defibrillator
AGM	absorbed glass mat
AOC	ammonia oxidation catalyst
API	American Petroleum Institute
CA	cranking amps
CAN	controller area network
CCA	cold cranking amps
CNG	compressed natural gas
CO <sup>2</sup>	carbon dioxide
CSA	Canadian Standards Association
CV	constant-velocity
DEF	diesel exhaust fluid
DMM	digital multimeter
DOC	diesel oxidation catalyst
DPF	diesel particulate filter
ECM	electronic control module
EGR	exhaust gas recirculation
EPU	electronic processing unit
FOPS	falling object protective structure
GHS	Global Harmonized System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HOAT	hybrid organic acid technology
HID	high intensity discharge
HEPA	high efficiency particulate air
IAT	inorganic acid technology
LED	light emitting diode
LPG	liquefied petroleum gas
MIG	metal inert gas
MECU	machine electronic control unit
SDS	Material Safety Data Sheet
NO <sub>x</sub>	nitric oxide and nitrogen dioxide
OAT	organic acid technology
OEM	original equipment manufacturer

OH&S	Occupational Health and Safety
OPS	operator protection structure
PAG	polyalkylene glycol
PCV	positive crankcase ventilation
POE	polyolester
PPE	personal protective equipment
PTO	power take-off
RC	reserve capacity
ROPS	roll-over protective structure
RPM	revolutions per minute
SAE	Society of Automotive Engineers
SCA	supplement coolant additive
SCR	selective catalytic reduction
SMAW	shielded metal arc welding
TCM	transmission control module
TDG	Transportation of Dangerous Goods
TIG	tungsten inert gas
TIR	total indicated runout
TPMS	tire pressure monitoring system
VGT	variable geometry turbocharger
VIN	vehicle identification number
WHMIS	Workplace Hazardous Materials Information System

# Appendix B

## Tools and Equipment / Outils et équipement

### Personal Protective Equipment (PPE) and Safety Equipment / Équipement de protection individuelle (EPI) et équipement de sécurité

anti-spill kits	trousses antidéversement
aprons	tabliers
automated external defibrillators (AEDs)	défibrillateurs externes automatisés
carbon monoxide sensors	détecteurs de monoxyde de carbone
communication devices	appareils de communication
coveralls (fire rated, high visibility)	combinaisons de travail (résistantes au feu, à visibilité élevée)
CPR accessories (disposable)	accessoires de réanimation cardio-respiratoire (jetables)
emergency backup lighting	lampes d'éclairage d'urgence
emergency showers	douches d'urgence
equipment lock-out tag-out systems (tags and locks)	matériel d'étiquetage et de cadenassage (étiquettes et cadenas)
exhaust ventilation	systèmes de ventilation aspirante
eye wash stations	douches oculaires
face shields	écrans faciaux
fall arrest equipment	dispositifs antichute
fall prevention equipment	équipement de prévention des chutes
fire blankets	couvertures anti-feu
fire extinguishers	extincteurs
fire proof cabinets	armoires incombustibles
first aid kits	trousses de premiers soins
first aid stations	postes de premiers soins
gas masks	masques à gaz
gloves (chemical, welding, latex, nitrile, heavy duty, cut resistant)	gants (de protection contre les produits chimiques, de soudeur, en latex, en caoutchouc nitrile, de qualité industrielle, résistants aux coupures)
goggles	lunettes à coque
guard rails	garde-corps
hard hats	casques de sécurité
hearing protection	protecteurs d'oreilles
high voltage protection (insulated gloves, clothing, tools)	équipement de protection contre la haute tension (gants, manteaux et outils isolés)
masks (dust, particulate, medical)	masques (antipoussières, à filtre de particules, médicaux)
respirators (organic materials, asbestos, other chemicals)	respirateurs (masques respiratoires contre les vapeurs organiques, contre l'amianté et autres produits chimiques)
safety boots	bottes de sécurité
safety cages	cages de sécurité
safety glasses	lunettes de sécurité
safety hats	casques de protection
splash suits	habits contre les éclaboussures
sprinkler systems	gicleurs
stretchers	civière

waste oil containers  
welding chaps  
welding curtains  
welding helmets  
welding personal protective gear  
  
wheel chocks

contenants de vidange d'huile  
jambières de soudure  
écrans de soudeur  
masques de soudeur  
équipement de protection personnelle pour le soudage  
cales de roue

## Hand Tools/Outils à main

adjustable wrenches  
air blow guns  
bars (pry, aligning, heel)  
  
battery posts and clamp cleaners  
battery terminal pullers  
brass drifts  
breaker bars (various drive sizes)  
bushing drivers  
center punches  
chain wrenches  
chisels  
clamps  
convertible 2/3 jaw pullers  
crow foot wrenches  
cutting equipment (side cutters, tube cutters, wire cutters, scissors, razors, knives, plier cutters, shears)  
emery paper/cloth  
files  
filter wrenches  
flaring tools  
flashlights  
H pullers  
hacksaws and blades  
hammers (rubber, soft blow)  
hammers (sledge, slide)  
hex key sets (metric and imperial)  
  
impact wrenches (up to 3/8 - 1 1/2-inch)  
insulated tools  
jumper wires  
magnetic pick-up tools (telescopic, flex)  
  
magnets  
magnifying glasses  
mirrors  
pick sets  
pin punches  
pipe wrenches  
pliers (insulated, snap ring, channel lock, combination, locking)  
pullers  
saws  
scrapers

clés ajustables  
soufflettes  
barres (leviers, barres d'alignement, pieds de biche)  
nettoyeurs de bornes et de pinces pour batterie  
pinces pour écrou de bornes de batterie  
poinçons en laiton  
bras articulés (différentes longueurs)  
outils d'installation de coussinets  
poinçons à centrer  
clés à chaîne  
ciseaux  
pinces  
extracteurs 2/3 transformables  
clés à ergots  
outils de coupe (à tranchant latéral, coupe-tube, coupe-fil, ciseaux, rasoirs, couteaux, pinces coupantes, cisailles, rasoirs)  
papier d'émeri  
limes  
clés à filtre  
évaseurs  
lampes de poche  
extracteurs en H  
scies à métaux et lames  
marteaux (en caoutchouc, sans rebond)  
marteaux (masses, à inertie)  
clés hexagonales (mesures métriques et impériales)  
clés à chocs (jusqu'à 3/8 à 1 1/2 po)  
outils isolés  
fils d'appoint  
ramasse-pièces magnétiques (télescopiques et souples)  
aimants  
loupes  
miroirs  
extracteurs à inertie  
chasse-goupilles  
clés à tuyau  
pinces (isolantes, pour anneau de retenue, multiprises, universelles, pinces-étaux)  
extracteurs  
scies  
grattoirs

screwdrivers  
 scribes  
 seal drivers  
 sockets and ratchets  
 specialty wrenches  
 strong-arms/flex bars  
 stud extractors  
 suction cups  
 tap and die sets  
 tape measurers  
 terminal tool sets  
 test lights  
 thread files  
 tire bars  
 tool chests  
 torque multipliers  
 torque wrenches  
 torx bits  
 tube benders  
 universal swivel joints  
 utility knives  
 valve lapping blocks  
 vices  
 wire brushes  
 wire crimpers and strippers  
 wrench sets, combination (metric & imperial)  
  
 wrench sets, flare nut (metric & imperial)

tournevis  
 pointes à tracer  
 chassoirs  
 douilles et clés à cliquet  
 clés de spécialité  
 barres de flexion  
 extracteurs de goujons  
 ventouses  
 ensembles de tarauds et filières  
 rubans à mesurer  
 ensembles d'outils pour extrémité de câbles  
 lampes témoins  
 limes de filetage  
 barres à pneus  
 boîtes à outils  
 multiplicateurs de couple  
 clés dynamométriques  
 douilles Torx  
 cintreuses à tubes  
 joints universels pivotants  
 couteaux universels  
 blocs de dressage de soupape  
 étaux  
 brosses métalliques  
 pinces métalliques et à dénuder  
 jeux de clés combinées (mesures métriques et impériales)  
 jeux d'écrous évasés (mesures métriques et impériales)

## Power Tools/Outils mécaniques

air arc welding equipment  
 air compressors  
 air cut-off tools  
 air hammers  
 air line adapters  
 battery chargers  
 battery load/starting system testers  
  
 bearing heaters  
 bleeding equipment  
 booster cables  
 butane torches  
 chemical agitators  
 chisels (air, electric, hand)  
  
 component heating or cooling equipment  
  
 containers  
 coolant recycling units  
 crack detecting equipment  
 crimping tools  
 cutting and welding torch sets  
 cylinder carts and tanks

appareils de soudage arc-air  
 compresseurs d'air  
 outils à tronçonner pneumatiques  
 marteaux pneumatiques  
 adaptateurs de canalisation pneumatiques  
 chargeurs de batterie  
 testeurs de charge de batterie et du système de démarrage  
 réchauffeurs de roulement  
 appareils de purge  
 câbles d'appoint  
 chalumeaux au butane  
 agitateurs d'agents chimiques  
 ciseaux (burin pneumatiques, électriques, à main)  
 appareils de refroidissement et de chauffage des composants  
 contenants  
 stations de recyclage du réfrigérant  
 dispositifs de détection des fissures  
 outils de sertissage  
 chalumeaux de coupage ou de soudage  
 chariots porte-bouteilles et bouteilles



drill presses	perceuses à colonne
drills (air, battery-operated)	perceuses (pneumatiques, à piles)
extension cords/trouble lights	rallonges électriques et lampes baladeuses
fast chargers	chargeurs rapides
flushing kits	trousses de rinçage
fuel recovery and storage systems	systèmes de récupération et d'entreposage du carburant
grease guns	pistolets de graissage
grinders (air, electric, battery-operated)	meuleuses (pneumatiques, électriques, à piles)
hand pumps	pompes manuelles
headlight aimers	réglaphares
honing equipment	polisseuses
hot air guns	pistolets à air chaud
hydraulic torque wrenches	clés dynamométriques hydrauliques
impact guns 3/4 inch and up (air, electric, battery-operated)	pistolets cloueurs 3/4 po et plus (pneumatiques, électriques, à piles)
impact guns 3/8 – 1/2 inch (air, electric, battery-operated)	pistolets cloueurs 3/8 po à 1/2 po (pneumatiques, électriques, à piles)
labelling kits	trousses d'étiquetage
lighting devices (trouble lights, flood lights)	appareils d'éclairage (lampes baladeuses, projecteurs extérieurs)
metal inert gas (MIG) welding equipment	soudeuses MIG
nitrogen charging equipment	appareils de remplissage d'azote
oil catches	réservoirs collecteurs d'huile
overhaul tools	outils de révision
oxyacetylene equipment	appareils d'oxycoupage à l'acétylène
parts washers	bacs de dégraissage
plasma cutters	machines de coupage au plasma
power saws (circular, hacksaws)	scies électriques (scies circulaires, scies à métaux)
presses (hydraulic, mechanical, portable hydraulic, arbor, spring, bushing, shop)	presses (hydrauliques, mécaniques, hydrauliques portatives, à crémaillère, à ressorts, à bagues, d'atelier)
pressure washers	laveuses à pression
propane torches	chalumeaux au propane
pullers (bearing, gear, heavy duty, mechanical)	extracteurs (enlève-roulements, d'engrenage, pour service rigoureux, mécaniques)
ratchets (air, battery-operated)	cliquets (pneumatiques, à piles)
reamers	aléseurs
recycling units	stations de recyclage
retrieval and storage equipment	appareils de stockage
ridge reamers	aléseurs de crête
sandblasters	sableuses au jet de sable
saws	scies
shielded metal arc welding (SMAW) welding equipment	soudeuses à l'arc avec électrode enrobée
shop vacuums	aspirateurs d'atelier
soldering irons/guns	fers et pistolets à souder
tungsten inert gas (TIG) welding equipment	soudeuses au tungstène sous gaz inerte
vacuum pumps	pompes à vide
wire wheels/bench grinders	brosses métalliques circulaires et meuleuses d'établi

## Shop Equipment/Équipement d'atelier

brake cleaning equipment  
caustic cleaning tanks  
cleaning cloths  
cleaning gloves  
clutch alignment tools  
creepers  
crocus cloths  
dollies  
funnels  
hot tank degreasers  
hydraulic guards  
parts cleaning solvents  
soft brushes  
solvent washers  
specialty hand tools  
steam cleaners  
valve grinding equipment  
valve guide service kits  
valve seat grinding equipment  
work benches

matériel de nettoyage des freins  
cuves de nettoyage aux agents caustiques  
chiffons  
gants de nettoyage  
outils d'alignement de l'embrayage  
sommiers roulants  
toiles à polir  
chariots  
entonnoirs  
bains chauds pour le dégraissage  
protecteurs hydrauliques  
solvants de dégraissage pour les pièces  
brosses douces  
nettoyeurs de solvants  
outils à main spécialisés  
nettoyeurs à vapeur  
matériel de rectification des soupapes  
trousses d'entretien du guide de soupapes  
matériel de rectification des sièges de soupapes  
établis

## Measuring, Testing and Diagnostic Equipment/Appareils de mesure, d'essai et de diagnostic

air conditioning recovery machines  
air pressure gauges  
ammeters  
analyzers (gas, infrared, vibration meter)  
antifreeze testers  
back pressure testers  
battery load testers  
belt tension gauges  
black lights  
boost gauges  
borescopes  
brake drum gauges  
braking force test equipment  
calipers (disc brake, inside, outside, Vernier)  
  
circuit testers  
compression gauges  
continuity testers  
cooling system pressure testers  
  
cylinder bore gauges  
dial indicators  
differential pressure gauges (delta-P gauges)  
digital multimeters  
duplex gauges  
dynamometers  
electric pressure gauges  
electronic blowby testers

machines de récupération de climatisation  
jauges à pression d'air  
ampèremètres  
analyseurs (de gaz, à infrarouge, vibromètres)  
vérificateurs d'antigel  
outils d'essai de contre-pression  
testeurs de capacité de batterie  
jauges de tension de la courroie  
lumières UV  
manomètres d'admission  
endoscopes  
jauges de tambour de frein  
appareils d'essai de force de freinage  
compas d'épaisseur (frein à disque, d'intérieur, d'extérieur, pieds à coulisse)  
vérificateurs de circuit  
compressiomètres  
vérificateurs de continuité  
contrôleurs de pression du système de refroidissement  
vérificateurs d'alésage de cylindre  
indicateurs à cadran  
manomètres différentiels (delta-P)  
multimètres numériques  
manomètres duplex  
banc dynamomètres  
jauges électriques de pression  
appareils d'essai électroniques de gaz soufflé dans le carter

electronic service tools (computer, handheld)	outils d'entretien électroniques (ordinateurs, outils portatifs)
feeler gauges (steel, brass, stepped)	jauges d'épaisseur (en acier, en laiton, étagées)
flowmeters	débitmètres
fuel pressure gauges	indicateurs de pression du carburant
fuel quality test kits	trousses d'essai de la qualité du carburant
graduated vessels	réipients gradués
harness testers	testeurs de faisceaux
holding gauges	jauges de retenue
hydraulic pressure testing gauges/fittings	indicateurs d'essai de pression hydraulique
hydrometers	hydromètres
inductive pickups (amp clamps)	prises de position inductive (pinces ampèremétriques)
laser alignment tools	outils d'alignement laser
leak detection equipment	appareils de détection des fuites
leakdown testers	contrôleurs d'étanchéité
levels	niveaux
level protractors	rapporateurs d'angles à niveau
liner height protrusion gauges	indicateurs de la hauteur de dépassement des chemises
manifold gauge sets	jeux de manomètres
measuring rods	barres de mesure
mechanical pressure gauges	jauges mécaniques de pression
meter sticks	règles de 1 m
micrometers (inside, outside, depth)	micromètres (d'intérieur, d'extérieur, de profondeur)
module testers	testeurs de module
multimeters	multimètres
oil temperature gauges	jauges de température d'huile
opacity meters	opacimètres
phototachometers	tachymètres à cellule photoélectrique
pinion angle gauges	jauges angulaires des pignons
plastigauges	jauges plastique
plumb bobs	fils à plomb
pressure gauges	jauges de pression de gonflage
pull-type scales	balances tirées
pyrometers	pyromètres
refractometers	réfractomètres
refrigerant identifiers	analyseurs de réfrigérant
scanning tools	analyseurs-contrôleurs
small hole gauges	jauges de petits orifices
spectroscopes	spectroscopes
spring scales	balances à ressort
squares	équerres
steel rulers	règles graduées
stethoscopes	stéthoscopes
straight edges	règles droites
tachometers	tachymètres
tape measurers	rubans à mesurer
telescopic gauges	jauges télescopiques
temperature gauges (infrared, mechanical and electrical)	indicateurs de température (à infrarouge, mécaniques, électriques)
test leads	connexions fils d'essai
test lights	lampes témoins
thermometers	thermomètres
timing lights	lampes stroboscopiques

timing pins  
timing wheels  
tire pressure gauges  
tire tread depth gauges  
torque angle tools  
torque wrenches  
transmission gauge sets  
vacuum gauges  
valve spring testers  
vernier calipers  
vibration analyzers  
video borescopes  
water manometers

goupilles d'arrêt  
roues de distribution  
indicateurs de pressions des pneus  
indicateurs d'usure de pneus  
outils d'angle du couple de serrage  
clés dynamométriques  
jeux de jauges de boîte de vitesses  
vacuomètres  
testeurs de ressort de soupape  
pieds à coulisse  
analyseurs de vibrations  
endoscopes  
manomètres à eau

## **Hoisting, rigging, lifting, cribbing and blocking equipment / Équipement de hissage, de gréage, de levage, de calage et de blocage**

axle lifts  
axle stands  
blockings  
bottle/axle jacks  
cable hoists  
chain hoists  
clevises  
engine cranes  
floor hoists  
forklifts  
hoists  
hydraulic hand jacks  
jacks  
ladders  
mobile cranes  
repair stands  
safety stands  
scaffolding/work platforms  
shop cranes  
slings/cables/chains  
spreader bars  
steps  
stools  
transmission jacks

essieux relevables  
chandelles  
cales  
crics-bouteille et vérins d'essieu  
palans à câble  
palans à chaîne  
manilles  
grues de levage pour moteur  
palans au sol  
chariots élévateurs  
palans  
crics à main hydrauliques  
crics  
échelles  
grues automotrices  
supports de réparation  
supports  
échafaudages et plateformes de travail  
grues d'atelier  
élingues, câbles et chaînes  
barres d'écartement  
escabeaux  
tabourets  
crics de boîte de vitesses

# Appendix C

## Glossary / Glossaire

<b>accessories</b>	non-essential components added to the machine to enhance the operation or extend machine longevity; for example: greasing systems, radio, air conditioning and extra lights. Although some accessories are non-essential to the machine operation, they are sometimes required in extreme operating environments	<b>accessoires</b>	composants non essentiels, comme les circuits de graissage, la radio, le climatiseur et les feux additionnels, ajoutés à une machine pour améliorer son fonctionnement ou pour prolonger sa durée de vie. Bien que certains accessoires ne soient pas essentiels au fonctionnement de la machine, ils sont quelquefois nécessaires dans des environnements de travail extrêmes
<b>attachments</b>	components added to the machine that are integral to its operation to perform a specific job; for example: ripper, winch, thumb, hammer, tamper, powerhead or forks	<b>attachements</b>	composants essentiels à la machine, comme la défonceuse, le treuil, le grappin, le marteau, le dameur, la brosse à moteur ou les fourches, pour effectuer des travaux en particulier
<b>base engine</b>	assembled block and head including internal components and gear trains	<b>moteur de base</b>	assemblage comprenant le bâti, la culasse, les composants internes et les trains d'engrenages
<b>break-in</b>	a controlled operation specified by the manufacturer on new or repaired components to maximize service life	<b>rodage</b>	opération contrôlée exigée par le fabricant afin de prolonger la durée de vie des nouveaux composants ou des composants réparés
<b>cold weather package</b>	accessories used to aid machine start-up and operation in cold weather environments; may include fluid heaters, extra batteries, glow plug systems, starting fluid injection systems, heating pads and inlet air heaters	<b>trousse pour temps froid</b>	trousse d'accessoires utilisés pour faciliter le démarrage et le fonctionnement de la machine par temps froid. Ces accessoires peuvent comprendre des réchauffeurs de fluides, des batteries supplémentaires, des bougies de préchauffage, des injecteurs de liquide d'allumage, des coussins chauffants et des réchauffeurs d'air aspiré
<b>diagnose</b>	tasks involved in inspecting, testing and determining faults in machine systems and components	<b>diagnostic</b>	tâches accomplies lors de l'inspection, des essais et de la détermination des défauts des systèmes et des composants de la machine
<b>drivetrain</b>	the mechanical portion of the driveline from the flywheel to the tires or the track excluding hydrostatic systems and electric motors	<b>transmission</b>	segment mécanique des organes de l'arbre de transmission allant du volant-moteur aux pneus ou aux chenilles à l'exception des systèmes hydrostatiques et des moteurs électriques
<b>driveline</b>	the shafts, bearings and joints identified between a drive component and a driven component	<b>organes de l'arbre de transmission</b>	arbres, paliers et joints qui relient un composant de l'entraînement à un composant entraîné

<b>electronic control module (ECM)</b>	an electronic component which interprets and controls functions of a machine; some common ECMs are electronic processing units (EPUs), electronic control units (ECUs), machine electronic control units (MECUs), transmission control modules (TCMs), and anti-lock braking systems (ABS)	<b>module de commande électronique</b>	composant électronique interprétant et commandant les fonctions d'une machine. Les unités de traitement électroniques, les unités de commande électroniques, les unités de commande électroniques de la machine, les modules de commande de boîte de vitesses et les systèmes ABS figurent parmi les modules de commande électroniques les plus courants
<b>electrical systems</b>	starting, charging, lighting and accessory circuits without computer control modules	<b>circuits électriques</b>	circuits de démarrage, de charge, d'éclairage et d'accessoires non pourvus de modules de commande informatisés
<b>electronic systems</b>	monitoring and control systems operated via computerized electronic control modules, related sensors and wiring, and communications systems	<b>systèmes électroniques</b>	systèmes de surveillance et de commande qui fonctionnent grâce aux modules de commande électroniques, aux capteurs, aux câblages connexes et aux systèmes de communication
<b>equipment management system</b>	electronic control system that monitors and operates the equipment through inputs, outputs and programming	<b>système de gestion de la machine</b>	système de commande électronique surveillant et faisant fonctionner la machine grâce à des entrées, des sorties et des programmes
<b>high voltage</b>	any voltage that has the potential to cause significant injury or harm	<b>haute tension</b>	toute tension susceptible de causer des blessures ou des dommages importants
<b>hydrostatic system</b>	a hydraulic system which uses fluid under pressure to transmit power through tubes or hoses to drive components such as wheel or track drives	<b>système hydrostatique</b>	système hydraulique qui utilise un fluide sous pression pour transmettre l'énergie à travers des tubes ou des tuyaux flexibles pour entraîner des composants comme les roues ou les chenilles
<b>operator station</b>	environment where the operator controls and monitors the equipment	<b>poste de commande</b>	endroit où l'opérateur fait fonctionner et surveille la machine
<b>powertrain</b>	includes the drivetrain plus the engine (including hydrostatic systems and electric motors), used to produce power and transmit that power to the drive components (wheels, tracks, legs, etc.)	<b>groupe motopropulseur</b>	comprend le groupe motopropulseur et le moteur (y compris les systèmes hydrostatiques et les moteurs électriques) utilisés pour produire et transmettre l'énergie aux composants de la transmission (roues, chenilles, jambes, etc.)
<b>power take-off (PTO)</b>	device that couples and uncouples a power source to transfer power to auxiliary systems	<b>prise de force</b>	dispositif qui relie une source d'énergie aux systèmes auxiliaires ou qui les sépare pour transmettre de l'énergie à ces systèmes
<b>rebuild</b>	to restore equipment's components to like-new condition	<b>remise en état</b>	restaurer les composants de la machine pour qu'ils soient comme neufs
<b>repair</b>	activities meant to correct a fault or defect in equipment which include replacement or reconditioning of machines and components	<b>réparation</b>	ensemble des activités effectuées pour corriger des défauts ou des déficiences et qui comprennent le remplacement, la remise en état ou la réparation des machines et des composants

<b>sensory inspection</b>	diagnosing or inspecting using sight, sound, smell and feel	<b>inspection sensorielle</b>	diagnostiquer ou inspecter en utilisant la vue, l'ouïe, l'odorat et le toucher
<b>start-up</b>	a specific procedure to begin operation of a machine or system	<b>démarrage</b>	mise en marche d'une machine ou d'un système
<b>structural components</b>	elements that make up the integral structure of the machine; for example: frame, lift arms, booms, sticks, loader frames, counterweights, ROPS, FOPS and OPS	<b>composants de structure</b>	pièces qui composent la structure intégrale de la machine comme le châssis, les bras de levage, les flèches, les flèches secondaires, les chargeuses, les contrepoids, les ROPS, les FOPS et les OPS
<b>service</b>	activities which include adjustment, lubricating and general maintenance of machines and components	<b>maintenance</b>	ensemble des activités comprenant l'ajustement, la lubrification et l'entretien général des machines et des composants
<b>spark ignition system</b>	system which controls a small amount of electrical power to create and transmit, through a step-up transformer, a high voltage to a sparking device which in turn begins ignition	<b>système d'allumage par étincelles</b>	système commandant un faible courant électrique pour produire et transmettre, par l'entremise d'un transformateur élévateur, un courant haute tension à un dispositif créant des étincelles pour lancer la séquence d'allumage
<b>suspension</b>	components which absorb ground surface irregularities to smooth the machine ride; it is designed to permit controlled wheel or undercarriage movement over irregular surfaces; basic types include spring, hydraulic, air and rubber block	<b>suspension</b>	ensemble des composants qui absorbent les irrégularités de la route pour permettre à la machine de rouler en douceur. La suspension est conçue pour permettre le mouvement contrôlé des roues ou des trains roulants sur des surfaces irrégulières. Les principaux types de suspension sont les suspensions à ressorts, les suspensions hydrauliques, les suspensions pneumatiques et les suspensions à blocs en caoutchouc
<b>undercarriage</b>	steel or rubber track type components required to support the machine and transmit power from the final drive to the ground	<b>train roulant</b>	composants de types chenilles en acier ou en caoutchouc nécessaires pour supporter la machine et transmettre l'énergie du bloc d'entraînement de l'essieu au sol
<b>wheel assembly</b>	made up of the tire, rim, hub and related hardware	<b>roue</b>	assemblage comprenant le pneu, la jante, le moyeu et les fixations connexes