APTA STANDARDS DEVELOPMENT PROGRAM

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Diesel Prime Mover and Drive Systems Periodic Inspections and Maintenance

Abstract: This standard covers the basic procedures for the periodic inspection and maintenance of diesel engine prime movers and drive propulsion systems that are applied to self-powered rail transit vehicles designed for passenger revenue service. These procedures specifically address engines, fuels, lubricants and fluids for diesel prime movers and drive systems.

Keywords: coolant, engine, fuel, gearbox, grease, lubricant, maintenance, oil, periodic inspection, turbocharger

Summary: This standard addresses the inspection and maintenance of drive equipment that is unique to diesel engine prime mover rail transit revenue vehicles. Diesel engine prime mover propelled rail transit vehicles are very similar in design and construction to traditional LRVs that collect power for propulsion from wayside power distribution systems. A diesel engine driven alternator/generator used in diesel-electric drives or a diesel engine hydraulic/mechanical transmission used in diesel-hydraulic drives are the components unique to these self-propelled and self-contained rail transit vehicles.

Scope and purpose: This standard applies to passenger carrying rail transit vehicles. It is intended to be applied, as applicable, by rail transit systems for periodic inspection and maintenance. This standard shall be used in conjunction with the rail transit system (RTS) instructions and original equipment manufacturer (OEM) specifications and recommendations. The requirements contained in this document are intended to provide best practice inspection and maintenance criteria for incorporation into the diesel engine prime mover and hydraulic/mechanical transmission component of a RTS vehicle inspection and maintenance program.

> NOTE: For electric drive vehicles, APTA RT -VIM-RP-010 provides inspection and maintenance guidelines for electrical rotating machinery and APTA RT-VIM-RP-018 provides inspection and maintenance guidelines for electrical/electronic control equipment.

Participants

The American Public Transportation Association greatly appreciates the contributions of Paul Kovacs who provided the primary effort in revising this Rail Standard.

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Introduction

This introduction is not a part of APTA RT-VIM-S-012-03, *Standard for Diesel Prime Mover and Drive Systems Periodic Inspections and Maintenance.*

This standard for Diesel Prime Mover and Drive Systems Periodic Inspections and Maintenance for rail transit revenue Vehicles represents a common viewpoint of those parties concerned with its provisions, namely, rail transit system/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a rail transit system's operations. In those cases, the government regulations take precedence over this standard. APTA recognizes that for certain applications, the standards or practices, as implemented by individual rail transit systems, may be either more or less restrictive than those given in this document.

This standard describes the basic maintenance and inspection requirements for diesel prime movers and drive systems mounted on rail transit revenue vehicles. APTA recommends the use of this standard by:

- Individuals or organizations that maintain diesel prime mover and drive systems on rail transit vehicles;
- Individuals or organizations that contract with others for the maintenance of diesel prime mover and drive systems on rail transit vehicles; and
- Individuals or organizations that influence how diesel prime mover and drive systems are maintained on rail transit vehicles.

Note on alternate practices

APTA recognizes that some rail transit systems may have unique operating environments that make strict compliance with every provision of this standard impossible. As a result, certain rail transit systems may need to implement the standards and practices herein in ways that are more or less restrictive than this document prescribes. A rail transit system may develop alternates to the APTA standards so long as the alternates are based on a safe operating history and are described and documented in the RTS safety program plan (or another document that is referenced in the system safety program plan).

Documentation of alternate practices shall do the following:

- Identify the specific APTA rail transit safety standard requirements that cannot be met.
- State why each of these requirements cannot be met.
- Describe the alternate methods used.
- Describe and substantiate how the alternate methods do not compromise safety and provide a level of safety equivalent to the practices in the APTA safety standard (operating histories or hazard analysis findings may be used to substantiate this claim).

Diesel Prime Mover and Drive Systems Periodic Inspections and Maintenance

1. Frequency of conduct

Periodic inspection and maintenance tasks on the diesel prime mover and drive systems shall be performed on a regular schedule as determined by the RTS. The frequency of any task contained within this periodic inspection and maintenance standard shall comply with all applicable federal, state and local regulations. Further, in the conduct of the RTS's periodic inspection and maintenance programs, frequencies for individual tasks may be established based on a number of additional factors, including but not limited to the following:

- OEM-recommended intervals
- industry experience
- operating environment/conditions
- historical data
- performance requirements
- failure analysis
- RTS testing and experience
- reliability-centered maintenance program

An example of the intervals and the relevant inspections and maintenance tasks to be undertaken are listed in **Table 1**. Individual rail transit systems shall develop their own intervals based on operational experience. Intervals shall be determined that verify correct prime mover operation until the next scheduled inspection and maintenance step. Specific operational conditions may require rail transit systems to adjust intervals.

Table 1 provides a baseline maintenance plan with intervals (calendar day based or operating hours based), neither of which may be exceeded (after the RTS establishes its intervals to be followed). These intervals shall be used in conjunction with OEM inspection and maintenance recommendations for developing the RTS diesel prime mover with an electric drive, or a hydraulic drive system, inspection and preventive maintenance program.

As experience is gained with diesel engine driven rail transit vehicles, inspection and maintenance intervals should be reviewed for effectiveness and, where warranted, the intervals changed to achieve cost-effective reliability without compromising safety or longevity of the equipment. Specific operational conditions may require rail transit systems to adjust intervals. Changes to this standard by an RTS must be done in accordance with its system safety program plan, maintenance plan and/or other plan documents as determined by the RTS.

The RTS may at its option select a maintenance plan that is either based on calendar days or operating hours but initially must not exceed the maximum limits of either methodology shown in **Table 1**.

TABLE 1 - Baseline Diesel Prime Mover and Drive Systems Maintenance Intervals (with text paragraph references)

Inspections and Maintenance Task	Time	Operating Hours
Break-in period inspection and service (2.5.3)	n/a	50 hours
Fueling station inspection and service (2.5.4)	each refueling	n/a
PM 1: Service lubrication points (2.5.5.1) Engine lube oil system check (2.5.5.2) Cooling system checks (2.5.5.3) Fuel system check (2.5.5.4) Engine air intake system check (2.5.5.5) Coupling and drive belt check (2.5.5.6) Actuate emergency manual engine stop (2.5.5.7) Inspect and test fire and smoke detectors (2.5.5.8)	4 months	250 hours
PM 2: Engine exhaust system check (2.5.5.9) Engine performance check (2.5.5.10) Torque converter/transmission/reverse gear checks (2.5.5.11) Engine and transmission oil, fuel and air filter change (2.5.5.12) Engine valve lash adjustment (2.5.5.13)	1 year	1000 hours
PM 3: Radiator/heat exchanger service (2.5.5.14) Engine/transmission mount service (2.5.5.15) Drive belt renewal, hose renewal (2.5.5.16) Engine pre-heating check (2.5.5.17) Engine starting system check (2.5.5.18)	5 years	5000 hours

The maintenance plan develops as follows:

- Fuel station checks are added to and performed as part of PM 1 work.
- PM 2 work includes the combined PM 1 tasks.
- PM 3, which is a major maintenance activity, includes fuel station checks, PM 1 tasks and PM 2 tasks.

2. Specific tasks

WARNING: Verify that equipment is secured against uncontrolled movement, in accordance with the RTS's safety instructions, before commencing inspection and maintenance procedures.

WARNING: Drive system fluids and lubricants can be inherently dangerous. Applicable regulations must be followed when handling, utilizing, storing, and disposing of these substances.

2.1 Materials

Consumable materials such as filters, gaskets, seals, fluids and lubricants will be required. Refer to the OEM for specifications with respect to consumable materials and recommended replacement intervals.

2.2 Tools

OEM test kits in addition to the standard tools carried by maintenance personnel are sufficient for this maintenance task.

2.3 Safety/personal protective equipment

Appropriate personal protective equipment, meeting minimum American National Standards Institute (ANSI) standards and as required by the RTS, shall be worn at all times in the performance of this maintenance task.

RTS established safety practices, rules and procedures shall be followed at all times in the performance of these inspections and tests.

2.4 Training requirements

The RTS and/or its maintenance contractors shall develop and execute training programs that provide employees with the knowledge and skills necessary to safely perform the tasks outlined in this standard.

2.5 Inspection and maintenance procedures

In all of the following instructions, the OEM maintenance manuals shall be referred to for such items as torque values, voltage settings, pass/fail criteria condemning limits, clearance measurements and specific procedure methodology. Devices shall be cleaned for proper inspection. These instructions cover the visual inspection, adjustment, change of consumable materials, and functional testing of diesel prime mover and drive systems mounted on rail transit revenue vehicles. Some procedures will not be applicable due to design variations. Methodologies for the resolution of deficiencies noted while performing these instructions shall be tailored by each RTS, in conjunction with the OEM recommendations. Documentation of the inspection and maintenance process with respect to interval, deficiencies and resolution of those deficiencies found shall be done in a comprehensive manner to create a useful database, which will enhance the reliability and accountability of the process.

The impact on operations and maintenance in terms of costs, reliability and availability depend on inspection and maintenance activities being carried out in accordance with the OEM specifications and instructions. The overall system, of which the prime mover is an integral part, shall be inspected and maintained in such a way as to ensure trouble-free engine operation at all times. For this purpose:

- verify that sufficient fuel is available;
- verify that the combustion air is dry and clean;
- use only dry clean compressed air; and
- use only clean filtered raw water.

In addition, it is essential that:

- inspection and maintenance tasks are completed by trained personnel;
- suitable tools are used; and
- recommended renewal parts, fluids and lubricants per the current OEM specifications are used.

2.5.1 Inspection and maintenance instructions

- Proper care shall be taken to keep the prime mover and associated equipment in a clean and serviceable condition at all times to facilitate early detection of leaks and prevent subsequent damage.
- Protect rubber and synthetic components from oil and fuel. Never apply organic detergents. Wipe with a dry cloth only.
- Replace all seals and gaskets in accordance with OEM recommendations.

  NOTE: To minimize deterioration during extended out-of-service intervals, perform engine preservation tasks in accordance with OEM recommendations.

2.5.2 Inspection and maintenance procedure

The inspection and maintenance procedure recommended in this standard considers:

- operational checks;
- periodic maintenance tasks ensuring safety, reliability and the maximum service life;
- partial prime mover disassembly to replace accessories and components at the end of their service lives; and
- the timing of major overhauls and complete prime mover disassembly required to maintain reliability and optimal performance.

2.5.3 Break-in period inspection and service

New or newly overhauled engines and transmissions require a one-time inspection and service after a short period of running time as recommended by the OEM. In general, maintenance actions include checking for leaks, inspecting hardware and retorquing fasteners that may have loosened after the initial service interval. The initial service interval maintenance procedures also includes draining and replacing break-in lubricating oils, seals and filters to remove machining fines and assembly debris from the engine and transmission.

The following inspection and maintenance tasks are recommended after the break-in period:

TABLE 2 - Break-In Inspection and Maintenance Tasks

Task No.	Break-In Inspection and Maintenance	
1.	Accessory attachments	• Inspect brackets and attachments. Retorque if required.
2.	Belt drives	• Verify proper belt drive tension. Reset tension when required.
3.	Cooling system	• Check coolant level. Inspect coolant for foam or emulsified oil residue. Drain and replace coolant if contamination is observed. • Verify the proper tightness of hose clamps and flange hardware. • Check for leaks at flanges and hose connections with the engine cold and again idling at operating temperature. • Check radiators for indications of leaks. Determine the source of indications. Repair the cause. • Check that fan shrouds and air ducts are secure. Retighten hardware as required. • Verify the proper operation of dampers and shutters. • Check cooling fan drive attachment.
4.	Engine oil	• Change oil and filters.
5.	Engine performance	• Check running noises. • Check for abnormal vibrations. • Check engine and external pipes for leaks. • Check fault log data.
6.	Exhaust system	• Check for exhaust gas leaks. • Check tightness of flanges and securing hardware. Retorque if required. • Check that water has not collected in all low point exhaust system elbows. If equipped, verify that the drain arrangement is functioning. • Drain condensate (if equipped with drain valve).

TABLE 2 - Break-In Inspection and Maintenance Tasks

Task No.	Break-In Inspection and Maintenance	
7.	Fuel system	• Drain the fuel pre-filter water separator. • Change primary and secondary fuel filters. • Inspect system for leaks. Check that engine fuel delivery tubing, hoses and fittings are tight. Reseal and retighten where required. Pay special attention to tightness of suction lines and fittings. • Inspect fuel supply lines for secure attachment and abrasion damage. Retorque loose fuel supply line support brackets and fittings as required. Replace damaged tubing, hoses, and piping. • Inspect fuel tank mounting attachments. Retorque and torque stripe where required. • Verify that the fuel tank breather is open and completely unrestricted. • Verify correct operation of fuel tank liquid level indicator.
8.	Mounts	• Check torque of engine and transmission mounts. Retorque and torque stripe when required.
9.	Torque converter transmission, reverse gear	• Change oils and filter. Check oil level after changing. Inspect for foaming or entrapped air. • Inspect for and correct leaks.
10.	Valve timing	• Check valve lash. Adjust if required.

2.5.4 Fueling station prime mover inspection and maintenance

The out-of-service time required for refueling prime mover equipped rail transit revenue vehicles provides an efficient opportunity to perform a basic inspection and servicing. Since fuel consumption and refueling intervals are proportional to engine wear and tear, basic system integrity checks shall be performed each time the prime mover powered rail transit revenue vehicle is re-fueled.

TABLE 3 -Fuel Station Inspection and Maintenance Tasks

Task No.	Fuel Station Inspection and Maintenance	
1.	Air filter	• Check restriction indicator.
2.	Cooling system	• Check coolant level.
3.	Engine oil	• Check level.
4.	Engine performance	• Check running noises. • Check for unusual vibrations. • Check engine and external pipes for leaks. • Check exhaust gas color and for excessive visible quantity. • Check engine management monitor for faults (if equipped). • Check actual fuel consumption.
5.	Exhaust system	• Check for exhaust gas leaks. • Drain condensate (if equipped with drain valve).
6.	Fuel pre-filter	• Drain water and contaminants (when required by the OEM/RTS).
7.	Monitoring and control system	• Check control lamps and fault code display.

TABLE 3 -Fuel Station Inspection and Maintenance Tasks

Task No.	Fuel Station Inspection and Maintenance	
8.	Torque converter, transmission and reverse gear	• Check oil levels. • Check for oil leaks • Check for pneumatic control air leaks
9.	Engine and transmission mounts	• Visually inspect the engine/transmission resilient mounts.

2.5.5 Periodic preventive maintenance and inspections tasks

The RTS shall develop preventive maintenance intervals that are structured so that the components of the prime mover and drive systems are inspected, serviced, repaired or replaced before they become unsafe, unreliable or inefficient.

2.5.5.1 Lubrication points service

Follow vehicle manufacturer guidelines for applying specified lubricant to all lubrication points. These points shall include (if applicable):

- drive shaft universal and slip joints
- bearings and couplings

2.5.5.2 Engine lube oil system

a. Use periodic chemical and spectrographic analysis of used crankcase oil to determine oil condition as an indication of unusual internal component wear. Analysis shall be done by OEM or approved specialists.
b. Change oil based on chemical or spectrographic analysis of its condition.
c. Change full flow and bypass filters.
d. Monitor oil temperature to gauge effectiveness of lubricating oil cooler.
e. Inspect external lubricating supply pipes, hoses, filter heads and canisters for oil leaks. Find the source of any oil leakage and repair the problem.

   WARNING: Lubricating oil leaks are a fire hazard.

   NOTE: Stop the prime mover and investigate the source of oil leaks, oil accumulations or the smell of hot oil. Repair the source of the oil leak. Thoroughly clean oily residues from the prime mover and the prime mover compartment before restarting the engine.

2.5.5.3 Cooling system

Where applicable:

a. Check radiators for tube to header leaks, damaged fins and dirty heat transfer surfaces.
b. Check radiators for cleanness and wash them if needed following OEM instructions.
c. Inspect pipe and hose connections for leaks or evidence of leaks.
d. Check that temperature control devices maintain uniform coolant temperature through the full range of engine load.
e. Check pH balance and specific gravity of glycol coolants to verify effectiveness.
f. Change coolant, and flush the cooling system as recommended by the OEM.
g. Check drive belt conditions.

h. Inspect cooling fan shrouds and ducts.

2.5.5.4 Fuel system

a. Inspect fuel tank mountings, monitor torque stripes and retorque or replace loose fuel tank mounting hardware.
b. Inspect the fuel tank breather system and verify that it is unrestricted.
c. Clean the fuel tank sight glass and verify accuracy of fuel tank mounted gauges.
d. Inspect fuel supply piping and hoses, and check tightness of suction line fittings.
e. Inspect engine fuel delivery connections, manifolds and tubing for leaks or mechanical damage.

   WARNING: Fuel leaks are a fire hazard. Stop the prime mover when there is a fuel leak in the fuel supply system or an accumulation of fuel oil on or around the prime mover. Investigate the source of fuel oil odors.

   NOTE: Any fuel oil leakage on or around the prime mover must be repaired before restarting the engine. Accumulations of fuel oil must be removed. The area must be thoroughly cleaned and free of oil residue.
f. Monitor fuel suction pressure to determine fuel filter change-out intervals or replace primary and secondary filters on a predetermined periodic basis.

2.5.5.5 Engine air intake system

a. Monitor the inlet air filter indicator and change the filter medium when the flow restriction indicator indicates excessive inlet depression.
b. Ensure that the air filter medium is properly seated in the filter housing.
c. Inspect air inlet ducts and boots for holes, tears and loose clamps that allow intake air to bypass the air filters, and verify that all clamps are tight.

2.5.5.6 Couplings and drives

a. Verify that coupling components are properly aligned.
b. Verify tightness of flange bolts, studs and nuts.
c. Lubricate couplings as required by the OEM.
d. Inspect belt drive and belt condition.
e. Maintain belt drive belt tension.
f. Verify the serviceability of belt drive sheaves and tensioners.
g. Lubricate belt drive sheave hubs as required by the OEM.

2.5.5.7 Emergency manual engine stop

Verify that the emergency manual engine stop switches (if equipped) are operational.

2.5.5.8 Fire and smoke detectors

Verify that the fire and smoke detectors (if equipped) are operational.

2.5.5.9 Engine exhaust system

a. Inspect attachment and condition of thermal blankets.
b. Remove blankets to inspect exhaust manifolds and stacks for traces that indicate exhaust leaks.
c. Inspect flexible joints for cracks.

d. Retorque manifold, flex joint and stack attachment hardware.
e. Drain condensate from the silencer.

2.5.5.10 Engine performance checks

a. Perform OEM proof of engine performance tests that may include electrical load testing or torque converter stall testing.
b. Check function of controls and control indicators.
c. Review fault logs to diagnose intermittent, recurring prime mover and transmission problems.
d. Check running noises.
e. Check for abnormal vibrations.
f. Monitor lubricating oil consumption.
g. Monitor the color and opacity of exhaust under load and no-load conditions.

2.5.5.11 Transmission/torque converter/reverse gear

a. Perform transmission and torque converter electrical control diagnostic checks and/or hydraulic control pressure checks.
b. Perform a chemical and spectrographic analysis of torque converter, transmission and reverse gear oil to determine oil condition and as an indication of unusual internal component wear.
c. Change oil based on chemical or spectrographic analysis of its condition.
d. Change oil filters.
e. Clean breathers.
f. Repair the source of transmission/torque converter/reverse gear oil leaks and pneumatic control air leaks.

   WARNING: Lubricating oil leaks are a fire hazard.

   NOTE: Stop the prime mover and investigate the source of oil leaks, oil accumulations or the smell of hot oil. Repair the source of the oil leak. Thoroughly clean oily residues before restarting the engine.

2.5.5.12 Engine and transmission oil, fuel and air filter change

Refer to OEM instructions and recommended practices for fluid and filter changes

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2.5.5.13 Engine valve lash adjustment

Refer to OEM engine service instructions and recommended practices for checking and setting engine valve lash.

2.5.5.14 Radiator/heat exchanger service

Remove engine cooling radiators and transmission heat exchangers; de-scale and degrease tubes, shells and headers; clean heat rejection surfaces; inspect heat rejection fin physical condition; and replace gaskets.

2.5.5.15 Engine/transmission mount service

Check engine and transmission resilient mounts.

2.5.5.16 Drive belt renewal, hose renewal

Replace drive belts with age-related checks and cracking. Replace aged cooling system hoses and flex connectors that are soft, bulging or that reveal torn or abraded reinforcing cord.

2.5.5.17 Engine pre-heating systems

Where equipped with a pre-heating device, check the operation of the engine mounted flame start device, cooling water heaters or block heaters, and check the associated diagnostic interface for faults.

2.5.5.18 Engine starting system

Check electric starter operation, battery capacity and engine firing speed.

2.6 Correction of deficiencies

Any deficiencies uncovered during the inspections required in Section 2.5 shall be corrected and documented in accordance with the RTS procedures and OEM specifications and recommendations.

3. References

- OEM Inspection and Maintenance Manuals
- Engine Manufacturers Association
- RTS procedures for diesel prime mover and drive systems inspection and maintenance procedures

4. Definitions

For the purposes of this standard, the following terms and definitions apply:

prime mover: An engine that provides mechanical power to drive the alternator/generator in diesel-electric vehicles or the hydraulic/mechanical transmission in diesel-hydraulic drive vehicles.

revenue vehicle: A rail transit vehicle designed, built and used for transporting passengers in routine revenue service.

NOTE: This standard specifically addresses diesel engine embodiments.

5. Abbreviations and acronyms

ANSI	American National Standards Institute
EMA	Engine Manufacturers Association
FAME	fatty acid methyl esters
OEM	original equipment manufacturer
RTS	rail transit system
ULSD	ultra-low sulfur diesel

Annex A (Informative): Lubricant, fluid, fuel, coolant and preservative specifications

A.1 General

Service life, operational reliability and the performance of prime movers and associated equipment are largely dependent on the fluids and lubricants used. Correct selection and handling of fluids and lubricants is therefore extremely important. Instructions are contained in the following sections for fluids and lubricants that rail transit systems may modify or supplement as required in accordance with OEM specifications.

Test standards for fluids and lubricants:

- DIN: Federal German Standards Institute
- EN: European Standards
- ISO: International Standards Organization
- ASTM: American Society for Testing and Materials
- IP: Institute of Petroleum

NOTE: The use of approved fluids and lubricants, either in accordance with the specified designation or with the stated specification, usually constitutes a component of the OEM warranty conditions for prime movers and associated equipment.

WARNING: Engine lubricants and coolants are considered hazardous waste and must be disposed of in accordance with the RTS's hazardous waste disposal procedures.

A.2 Lubricants

A.2.1 Engine oils

Requirements of engine oils for diesel engines:

- Engine oil is specified by the OEM.
- For synthetic oils, the RTS, in conjunction with the respective OEM, must consider engine size, load profile, performance, cost and other parameters to decide whether to use synthetic oils.

Viscosity class selection:

- Selection of a viscosity class is recommended by the OEM and based primarily on the ambient temperature at which the engine is to be started and operated. Taking into consideration the relevant performance criteria, engines can be operated with either single grade or multi-grade oils, depending on application.

Oil drain intervals for diesel engines:

- Engine oil drain intervals depend on the engine oil, quality, its conditioning, the operating conditions, operating hours and the fuel used.
- Limits for oil service life serve as guide values and are contained in the appropriate OEM maintenance schedules and operating instructions.
- The RTS must follow OEM requirements for an oil change when limit values are reached or exceeded.
- In addition to analytical limit values, the engine condition, its operating condition and any operational faults are the decision factors considered by the OEM with regard to engine oil changes.

Laboratory analysis to determine the service life of the engine oil:

- Engine oil analysis is usually performed by the OEM, oil analysis laboratories, oil manufacturers or using an RTS-approved OEM test kit. The oil sample must be taken in accordance with OEM specifications and instructions (including laboratories and manufacturers if used).

Results from each periodic laboratory analysis shall be charted to show the trend of each tested quantity (e.g. metallic ppm). The RTS, in conjunction with the diesel engine OEM, oil supplier and oil laboratory, shall determine the analytic limit values for each tested quantity. Engine oil samples must be analyzed in accordance with OEM recommendations. The test methods (e.g., ASTM D445 viscosity at 100 ºC maximum mm^2/s) and the limit values (15.0 maximum mm^2/s SAE 5W-30) that relate to individual oil samples for viscosity and other engine oil characteristics are determined by the OEM and indicate when the results of an individual oil sample analysis are to be regarded as abnormal.

Minimum requirements of operation monitoring:

- The oil analyses required by OEM maintenance schedules can usually be made using an OEM test kit that contains all of the required equipment and instructions. The following checks are performed:
  - determination of oil dispersancy (spot test)
  - determination of fuel content
  - determination of water content

A.2.2 Lubricating greases

Lubricating greases for diesel engines and associated equipment:

- Lubricating greases are specified by the OEM.

Lubricating greases for general purposes:

- Lithium saponified greases shall be used for all lubrication points with the exception of emergency air shutoff flaps installed between exhaust turbochargers and mechanical couplings.

Lubricating greases for applications at high temperatures:

- These greases shall be used for emergency air shutoff flaps that are located between turbochargers and intercoolers.

Lubricating greases for mechanical couplings:

- Lubricating greases for mechanical couplings are specified by the OEM.

A.2.3 Special purpose lubricants

Turbochargers:

- Turbine oils must be used in accordance with OEM specifications. Follow OEM recommendations.

Lubricants for gear couplings:

- The application of the respective lubricants and their service lives are specified in the OEM operating instructions and maintenance schedules.

A.3 Coolants

A.3.1 Requirements of coolants:

Coolants for use in prime mover engines shall be prepared from suitable fresh water and an OEM-approved coolant additive.

Conditions for coolant additive approval are OEM specified. They include:

- emulsifiable corrosion preventative oils;
- corrosion inhibiting antifreeze; and
- water-soluble corrosion inhibitors.

NOTE: Coolant manufacturers are usually informed in writing if their product is OEM approved.

A.3.2 Fresh water

For coolant preparation, use only clean, clear water in accordance with OEM specifications for:

- total alkaline earth metals (water hardness);
- pH value at 68 deg F;
- chloride ions; and
- anion total.

NOTE: The RTS must have its fresh water tested to ensure that it meets the specifications of the cooling system OEM.

A.3.3 Emulsifiable Corrosion Preventative Oils

Emulsions of OEM approved corrosion preventative oils (1.0% to 2.0% by volume) and suitable fresh water provides adequate corrosion protection.

A.3.4 Antifreezes with Corrosion Inhibiting Properties

To avoid long term engine damage the RTS should adhere to the OEM engine coolant specification that includes pH and dissolved solids limits. Antifreeze and corrosion inhibiter concentrations shall be determined together with the OEM based on the available water quality and the ambient temperatures.

A.3.5 Water Soluble Corrosion Inhibitors

Where water soluble corrosion inhibitors can be used, follow the OEM recommendations to ensure adequate protection with the correct concentrations. Water soluble corrosion inhibitors may be used in climates where there is no danger of freezing and are required for higher coolant temperatures and large temperature drops in heat exchangers.

NOTE: Coolant additives for aluminum-free engines must be used in accordance with the OEM recommendations.

A.3.6 Operational Monitoring

Careful controls must be implemented to ensure that coolants (different manufacturers and different types) are not mixed and that coolants are replaced or tested and treated with OEM approved additive boosters when indicated by testing at the OEM recommended interval. Frequent coolant mixture checks are important features for trouble free engine operation and can be performed using OEM test kits that contain the required equipment, chemicals, and instructions for the determination of the following:

- pH value
- Corrosion preventative oil content
- Antifreeze corrosion inhibiting concentration
- Water-soluble corrosion inhibitor content.

In the event of a sudden drop in coolant additive concentration or if the additive is no longer absorbed, change the coolant. Clean the engine coolant system in accordance with OEM specifications.

A.4 Fuels

The properties and limit values specified by the OEM will achieve optimum engine performance, long engine service life, and levels of acceptable exhaust emissions levels.

Annex B (Informative) provides a sample specification for fuel. Prior to implementing a fuel testing program, the RTS should develop the pass-fail requirements in conjunction with the diesel engine OEM and fuel supplier.

NOTE: The designation “sulfur free” applies to diesel fuels with a sulfur content of maximum 10 ppm.

A.4.1 Biodiesel

NOTE: The standard general term “FAME” (fatty acid methyl esters) is generally used to designate biodiesel fuels.

It is intended that future OEM engine series will be approved for operation with FAME. The RTS must verify with the engine OEM as to whether their engines are approved or not approved for operation with FAME in compliance with EN 14214.

A.5 Preservatives

A.5.1 Types of Preservatives

Preservatives are OEM specified. They include:

- Corrosion inhibiting oils for internal preservation of the fuel system
- Corrosion inhibitors for external preservation
- Initial operating oils and corrosion inhibiting oils for internal preservation

A.5.2 Requirements

Preservation and represervation shall be carried out on:

- New or overhauled engines, gearboxes, and couplings after the initial successful test stand run typically carried out at the OEM facility.
- Engines, transmissions and couplings that are to be taken out of service longer than an OEM specified period.

For an overview of the types of preservation periods, tasks, and form sheets, refer to the OEM specifications.

A.5.3 Corrosion Preventive Oils for Internal Preservation of Oil Coated Components of Engines and Gearboxes

OEM approved viscosity class corrosion preventive oils shall be used.

A.5.4 Corrosion Inhibitors for External Preservation of all Non-Painted Parts

OEM approved corrosion inhibitors shall be used.

A.5.6 Corrosion Preventive Oils for Cooling, Lubrication, and Fuel System Internal Preservation

OEM approved corrosion preventative oils shall be used.

A.5.7 Depreservation

Follow OEM specifications and put the engine into operation in accordance with OEM engine documents and recommendations.

A.6 Flushing and Cleaning Engine Coolant Systems

Flushing and cleaning procedures for engine coolant systems must be performed in accordance with OEM specifications.

Annex B (Informative): Physical and chemical properties for North American ultra-low sulfur diesel fuel

Engine manufacturers support the introduction and use of ultra-low sulfur diesel (ULSD) fuels having uniform properties. Specifically, the Engine Manufacturers Association (EMA) recommends that all ULSD fuel distributed in North America meet the requirements of ASTM D975 and the following additional performance requirements that are included in **Table 4** below.

1. Lubricity: Based on testing conducted on ULSD fuels in accordance with ASTM D6079, fuel injection manufacturers require a maximum wear scar diameter of 460 micrometers for ULSD.
2. Cetane: To improve the sociability aspects of diesel fuel performance such as white smoke, engine starting and engine combustion noise, ASTM D613 requires a minimum cetane number of 43 for ULSD.

TABLE 4 - Performance Requirements for ULSD

Property	ASTM Test Method or (other)	General Reference Fuel Specification
Sulfur, microg/g	D5453	15 max
Lubricity, HFRR at 60 deg F, micrometers	D6079 EMA	520 460
Aromatic HC, vol %	D5186-96	10% max
Polycyclic aromatic HC, wt %	D5186-96	3.5 max
Nitrogen content, ppm	D4629-96	10 max
Natural cetane number	D975 D613-84 and EMA	40 min 43 min
Gravity, API	D287-82	33-39
Viscosity at 40 deg C, mm^2/s	D445-83	1.9 to 4.1
Flash point, deg F	D93-80	130 min
Distillation, deg F	D86-96	
IBP		340-420
10% Rec		400-490
50% Rec		470-560
90% Rec		540-640
EP		580-660
Ash, wt %	D482	0.01 max
Carbon residue, 10% Btms, wt %	D524	0.35 max
Copper (Cu) strip corrosion, 3 hours at 122 deg F, rating	D130 and EN590	1A
Stability, mg/m^3	D2274	10 max

When considering ULSD fuel properties, it is important to recognize the need to maintain the cleanliness of ULSD fuel from the time that it leaves the refinery until it is delivered to the vehicle. The use of a smaller than 5 micrometer filter at the point where the fuel is dispensed into the vehicle is recommended.

