Specialized Lubricant Evaluations

- Mercedes-Benz M111 Black Sludge (CEC L-53-T-95)
- Mercedes-Benz M111 Fuel Economy (CEC L-54-T-96)
- Peugeot TU5 JP+L4 High-Temperature Deposits, Ring Sticking andOil Thickening (CEC L-88-X-01)
- Peugeot TU3M Valve Train Scuffing Wear (CEC L-38-A-94)
- Peugeot DV4TD Medium Temperature Dispersivity (CEC-L-93-04)
- Nissan TD25 Detergency (JASO M336:1998)
- Volkswagen T4 Viscosity Increase, TBN, and Piston Cleanliness (VW PV 1449)
- Volkswagen Turbocharged DI Diesel Piston Cleanliness and Ring Sticking (CEC L-78-T-99)
- Mitsubishi 4D34T4 Valve Train Wear (JASO M354:1999)

Mercedes-Benz M111 Black Sludge (CEC L-53-T-95)

Specifications

ACEA 2002:
A1-02 A2-96 Issue 3 A3-02 A5-02

ACEA 2004:
A1/B1-04 A3/B3-04 A3/B4-04 A5/B5-04
C1-04 C2-04 C3-04

Objective

To evaluate the ability of an automotive crankcase lubricant to inhibit the deposition of sludge and prevent wear in gasoline engines when operated on a fuel that is prone to generate such problems.

Field Service Simulated

Typical European service in urban, rural and autobahn driving applications.

Procedure Fixture

An engine dynamometer procedure stand with a 2.0 liter Mercedes-Benz M111 E20 gasoline engine, four-cylinder, sliding follower, overhead camshaft, port fuel-injected, water-cooled rocker cover.

Procedure Parameters

A 257-hour procedure comprised of four different phases, each with different operating cycles, and using an oil charge of 4350 g.

Procedure Phase	1	2	3	4
Procedure Hours	0-48	48-49	49-124	124-257
Description	Cold section	Engine quality section	Full load section	Alternating section
Procedure Cycle	14-step, 6-hour cycle repeated 8 times	10-step, 1-hour section	2-step, 5-minute cycle repeated 900 times	10-step, 1-hour cycle repeated 133 times
Engine Speeds (rpm)	0-1950 varying loads	1500-6000 full throttle	3750 and 3850 full throttle	0-5500 varying loads

Procedure Parts Evaluation

Inspect sludge deposits on cylinder head, cylinder head front cover, oil sump, timing cover and rocker cover. Evaluate pistons for cleanliness and ring sticking. Measure cam lobe, follower, and piston ring wear.

Used Lubricant Analysis

- Kinematic viscosity at 40ºC and 100ºC
- Fuel dilution
- Total base number
- Sulfated ash
- Total solids
- Wear metals

Pass/Fail Criteria

ACEA 2002	A1-02	A2-96 Issue 3	A3-02	A5-02
ACEA 2004	A1/B1-04	A3/B3-04	A3/B4-04	A5/B5-04
		C1-04	C2-04	C3-04
Engine Sludge, avg.	≥ RL140	≥ RL140	≥ RL140	≥ RL140

Mercedes-Benz M111 Fuel Economy (CEC L-54-T-96)

Specifications
ACEA 2002:
A1-02 A5-02 B1-02 B5-02

ACEA 2004:
A1/B1-04 A3/B3-04 A3/B4-04 A5/B5-04
C1-04 C2-04 C3-04

Objective
To measure the effect of engine oil on the fuel economy of gasoline engine passenger cars.

Field Service Simulated
Based on European emissions Procedure performed on a chassis dynamometer.

Procedure Fixture
An engine dynamometer procedure stand with a 2.0 liter Mercedes-Benz M111 E20 gasoline engine, four- cylinder, sliding follower, overhead camshaft, port fuel-injected, with a "flying flush" system for changing oils without an engine shutdown.

Procedure Parameters
A 24-hour procedure comprised of running the procedure cycle with baseline reference oil, performing a "flying flush" to candidate oil then running the procedure cycle three times on candidate oil. The portion of the procedure conducted on candidate oil incorporates steady-state aging of the oil charge. The procedure cycle has two parts and eight stages, varying speeds, loads and coolant and oil temperatures over a period of 2 hours, 24 minutes, 10 seconds. Fuel consumption is measured under cyclic conditions over the two-part cycle. The remainder of total procedure time consists of a stabilization period between procedure cycles and flushing between reference and candidate runs.

Procedure Parts Evaluation
None. Procedure results are expressed as a percent change in total fuel consumption of the candidate oil relative to the reference oil.

Used Lubricant Analysis
None.

Pass/Fail Criteria

ACEA 2002	A1-02	A5-02	B1-02	B5-02
Fuel Economy Improvement vs. RL 191	≥ 2.5 %	≥ 2.5 %	≥ 2.5 %	≥ 2.5 %

ACEA 2004	A1/B1-04	A3/B3-04	A3/B4-04	A5/B5-04
Fuel Economy Improvement vs. RL 191	≥ 2.5 %	--	--	≥ 2.5 %

ACEA 2004	C1-04	C2-04	C3-04
Fuel Economy Improvement vs. RL 191	≥ 2.5 %	≥ 2.5 %	≥1.0 (for Xw30 grades)

Peugeot TU5 JP+L4 High Temperature Deposits, Ring Sticking and Oil Thickening (CEC L-88-T-02)

Specifications
ACEA 2002:
A1-02 A2-96 Issue 3 A3-02 A5-02

ACEA 2004:
A1/B1-04 A3/B3-04 A3/B4-04 A5/B5-04
C1-04 C2-04 C3-04

Objective
The objective of this procedure is to evaluate oil thickening, high temperature deposits and ring sticking in a modern engine with controlled ignition.

Field Service Simulated
High speed, European highway driving is simulated in this procedure.

Procedure Fixture
Peugeot TU5 JP+L4 1.5-liter inline four-cylinder engine with a modified oil sump, mounted on a procedure stand with a dynamometer.

Procedure Parameters
The procedure runs six, 12-hour two-phase cycles, for a total procedure duration of 72 hours. Phase 1 (11 hours 50 minutes) is at wide open throttle, 5600 rpm, 150□C and 110□C oil and coolant temperatures. Phase 2 is at idle for 10 minutes.

Procedure Parts Evaluated
The pistons are rated for lacquer, carbon, and ring sticking.

Used Lubricant Analysis
Kinematic viscosity at 40□C is measured at 12, 24, 48, 60 and 72 procedure hours and compared to new oil.

Pass/fail criteria

ACEA 2002	A1-02	A2-96 Issue 3	A3-02	A5-02
Ring sticking	≥ 9.0	≥ 9.0	≥ 9.0	≥ 9.0
Piston varnish	≥ RL216	≥ RL216	≥ RL216	≥ RL216
Viscosity increase	≤ RL216	≤ (1.5 × RL216)	≤ (0.8 × RL216)	≤ (0.8 × RL216)

ACEA 2004	A1/B1-04	A3/B3-04	A3/B4-04	A5/B5-04
		C1-04	C2-04	C3-04
Ring sticking	≥ 9.0	≥ 9.0	≥ 9.0	≥ 9.0
Piston varnish	≥ RL216	≥ RL216	≥ RL216	≥ RL216
Viscosity increase	≤ RL216	≤ (0.8 × RL216)	≤ (0.8 × RL216)	≤ (0.8 × RL216)

Peugeot TU3M Valve Train Scuffing Wear (CEC L-38-A-94)

Specifications
ACEA 2002:
A1-02 A2-96 Issue 3 A3-02 A5-02

ACEA 2004:
A1/B1-04 A3/B3-04 A3/B4-04 A5/B5-04
C1-04 C2-04 C3-04

Objective
To evaluate a lubricant's performance in protecting an engine's valve train components.

Field Service Simulated
Low speed/low temperature and medium speed/high temperature conditions to simulate typical short duration city driving.

Procedure Fixture
Peugeot TU3M/KDX 1.3-liter inline four-cylinder engine mounted on a procedure stand with a dynamometer.

Procedure Parameters
The procedure runs a 40-hour step at 1500 rpm with oil and coolant temperatures of 40□C and 45□C, then a 60- hour step at 3000 rpm with oil and coolant temperatures of 100□C and 90□C.

Procedure Parts Evaluated
The rocker pads are rated for scuffing and the camshaft lobes are measured for wear.

Used Lubricant Analysis
The oil is sampled and checked at 0, 40, and 100 hrs for iron content and fuel dilution.

Pass/Fail Criteria

ACEA 2002	A1-02	A2-96 Issue 3	A3-02	A5-02
ACEA 2004	A1/B1-04	A3/B3-04	A3/B4-04	A5/B5-04
		C1-04	C2-04	C3-04
Avg. Cam Wear, μm	≤ 10	≤ 10	≤ 10	≤ 10
Max. Cam Wear, μm	≤ 15	≤ 15	≤ 15	≤ 15
Average Pad Merit	≥ 7.5	≥ 7.5	≥ 7.5	≥ 7.5

Peugeot DV4TD Medium Temperature Dispersivity (CEC L-93-04)

Specifications
ACEA 2004:
A1/B1-04 A3/B3-04 A3/B4-04 A5/B5-04
C1-04 C2-04 C3-04

Objective
The objective of this procedure is to evaluate the effect of combustion soot on engine oil viscosity increase and piston cleanliness.

Field Service Simulated
This procedure simulates high-speed highway service in a diesel-powered passenger car.

Procedure Fixture
The procedure fixture is an engine dynamometer procedure stand with a Peugeot DV4 TD/L4 four-cylinder, in-line, common rail diesel engine installed.

Procedure Parameters
The engine undergoes a ten-hour run-in and is then operated continuously for 120 hours. The 240 cycle procedure consists of the following 2 phases:

Procedure phase	1	2
Duration, min	2	27
Ramp between phase, sec	30	30
Engine speed, rpm	1,100	4,000
Engine power, kW	---	> 40
Engine oil temperature, °C	---	120
Coolant temperature, °C	---	100

Procedure Parts Evaluated
Pistons and rings are rated for lacquer deposits and ring sticking.

Used Lubricant Analysis
Kinematic viscosity at 100 °C, soot content and iron content in the used oil are evaluated at 24-hour intervals during the procedure. The final oil drain is used in conjunction with the intermediate samples to interpolate the absolute viscosity increase at 6% soot.

Pass/Fail Criteria

ACEA 2004 limits under definition.

Nissan TD25 Detergency (JASO M336: 1998)

Specification
For JASO DH-1, DL-1.

Objective
The objective of this procedure is to evaluate the detergency of automobile diesel oils under high temperature and high load.

Field Service Simulated
This procedure simulates high-speed highway service in a diesel-powered passenger car or light truck.

Text Fixture
The procedure fixture is an engine dynamometer procedure stand with a Nissan 2.5L four-cylinder, in-line diesel engine installed.

Procedure Parameters
The engine is run continuously for 200 hours with the exception of a complete oil change at 100 hours. Engine operating conditions are as follows:

Engine speed, rpm	4,300
Engine torque, N-m	Max.
Engine oil temperature, °C	120
Coolant temperature, °C	90

Procedure Parts Evaluated
Pistons and rings are evaluated for lacquer deposits, wear, and ring sticking. Oil rings are rated for clogging and cylinder liners are evaluated for deposits and wear. Cylinder heads are rated for combustion chamber deposits and oil-contact surfaces in the engine are rated for sludge formation. In addition, many engine components are evaluated visually and dimensionally for wear.

Used Lubricant Analysis
Kinematic viscosity, soot content, sulfated ash, total acid number, total base number, insolubles, water, fuel dilution, and wear metals.

Pass/Fail Criteria
DD6 Reference oil acceptance limits are:

39.3 – 64.6 % Top Groove Fill

7.47 – 8.42 Average Piston Merit

Candidate oils must be equal to or better than the testing laboratory's DD6 reference procedure result.

Volkswagen T4 Viscosity Increase, TBN, and Piston Cleanliness (VW PV 1449)

Specification
For Volkswagen factory-fill or service engine oil in spark-ignition engines with extended oil-change intervals (502, 503, 504, 507).

Objective
The objective of this procedure is to evaluate a crankcase lubricant's performance in combating viscosity increase, total base number depletion, and piston deposits.

Field Service Simulated
Passenger vehicles driven at high speed, high-temperature conditions at full and part loads, along with periods of prolonged idle.

Text Fixture
The procedure fixture is an engine dynamometer procedure stand with a Volkswagen 2.0L four-cylinder, in-line gasoline engine installed.

Procedure Parameters
Procedure is conducted for 248 hours in two phases.
Phase 1 = 0 - 192 hours

PNK Stage	1	2	3
Time, min	120	72	48
Engine Speed, rpm	4,300	4,300	idle
Engine Torque, N-m	Max	75	--
Engine oil temperature, °C	133	130	40
Coolant temperature, °C	100	100	30

Phase 2 = 192 - 248 procedure hours, held constant at PNK Stage 2 conditions above.

Procedure Parts Evaluated
Piston rings are evaluated for sticking, and pistons are evaluated for cleanliness. Cylinders, cam lobes, cam followers and seals containing elastomer materials are evaluated visually.

Used Lubricant Analysis
Kinematic viscosity, total base number and iron, chrome and copper content is evaluated on the 248-hour oil drain.

Pass/Fail Criteria
Candidate oils are judged against procedure laboratory's adjusted performance on reference oil 76409. Determining criteria is absolute viscosity, viscosity increase, TBN level, TBN depletion, and piston cleanliness at 248 hours.

Volkswagen Turbocharged DI Diesel Piston Cleanliness and Ring Sticking (CEC L-78-T-99)

Specifications
ACEA 2002: B4-02 B5-02

ACEA 2004: A3/B4-04 A5/B5-04
C1-04 C2-04 C3-04

Global DLD-1, DLD-2 and DLD-3

Objective
To evaluate engine oil performance with regard to piston cleanliness and tendency to piston ring sticking.

Field Service Simulated
European high-speed operation, followed by idling, is simulated.

Procedure Fixture
Volkswagen 1.9 liter, inline, four-cylinder, turbocharged, direct injection automotive diesel engine (VW TDi) mounted on an engine dynamometer stand.

Procedure Parameters
The 54-hour, two-phase procedure cycle alternates between idle (30 minutes with 40°C oil sump) and 4150 rpm, full power (150 minutes with 145°C oil sump). No oil top-ups are allowed during the procedure.

Procedure Parts Evaluated
Pistons are rated for carbon, lacquer deposits, and groove carbon filling. Piston rings are evaluated for ring sticking.

Used Oil Analysis
New and used oil samples are tested for kinematic viscosity at 40°C and 100°C and total base number. Oil samples are also tested for iron (Fe), chromium (Cr), copper (Cu) and soot content.

Pass/Fail Criteria

ACEA 2002	B4-02	B5-02
Avg. Piston Merit	≥ (RL206 – 3.0)	≥ RL206
Avg. Ring Sticking, ASF	≤ 1.2	≤ 1.2
Max. Ring Sticking, ASF	NA	NA
Max. 1st Ring Sticking, ASF	≤ 2.5	≤ 2.5
Max. 2nd Ring Sticking, ASF	≤ 0.0	≤ 0.0

(continued)

ACEA 2004	A3/B4-04	A5/B5-04	C1-04	C2-04	C3-04
Piston Cleanliness	≥ (RL206 – 3.0)	≥ RL206	≥ RL206	≥ RL206	≥ (RL206 – 3.0)
Avg. Ring Sticking, ASF	≤ 1.2	≤ 1.2	≤ 1.2	≤ 1.2	≤ 1.2
Max. 1st Ring Sticking, ASF	≤ 2.5	≤ 2.5	≤ 2.5	≤ 2.5	≤ 2.5
Max. 2nd Ring Sticking, ASF	≤ 0.0	≤ 0.0	≤ 0.0	≤ 0.0	≤ 0.0

Mitsubishi 4D34T4 (JASO M354:1999)

Specification
For JASO DH-1, Global DLD-1, DLD-2 and DLD-3.

Objective
This procedure evaluates the ability of a crankcase oil, when subject to elevated soot generation, to prevent valve train wear in a commercial diesel engine.

Field Service Simulated
Steady, full-load operation at maximum power and high temperature is simulated.

Text Fixture
The procedure fixture is an engine dynamometer stand with a Mitsubishi 4.0 liter, four-cylinder, in-line direct injection diesel engine and 6-speed manual transmission, locked in 5th gear, installed.

Procedure Parameters
The engine is operated continuously for 160 hours with stoppages at 20-hour intervals for oil top-ups.

Engine speed, rpm	3,200
Engine torque, N-m	Max.
Engine oil temperature, °C	105
Coolant temperature, °C	90

Procedure Parts Evaluated
The camshaft, lifters and cylinder bores are measured for wear, and piston rings and crankshaft bearings are measured for weight loss. Other engine parts are visually observed for corrosion and abrasive wear.

Used Lubricant Analysis
Kinematic viscosity, viscosity index, carbon residue soot content, sulfated ash, total acid number, total base number, insolubles, water, fuel dilution, and wear metals are quantified at 20 hour intervals.

Pass/Fail Criteria
Candidate oils must demonstrate a corrected camshaft wear of less than 95 µm. The correction is calculated as a function of the oil carbon residue content at the end of procedure, normalized to 4.5%.