

Low ash technology for heavy duty off-highway and biodiesel applications — field test results & solutions



Oronite

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2. Off highway: challenges, field test data, solutions
3. Bio-diesel: challenges, field test data, conclusions
4. Summary



Low ash technology in heavy duty application

Increasing in off-highway and bio-diesel service

- **Drivers**

- Emission regulations
- Use of advanced aftertreatment system

- **Impact**

Unique set of performance challenges for the lubricant additive

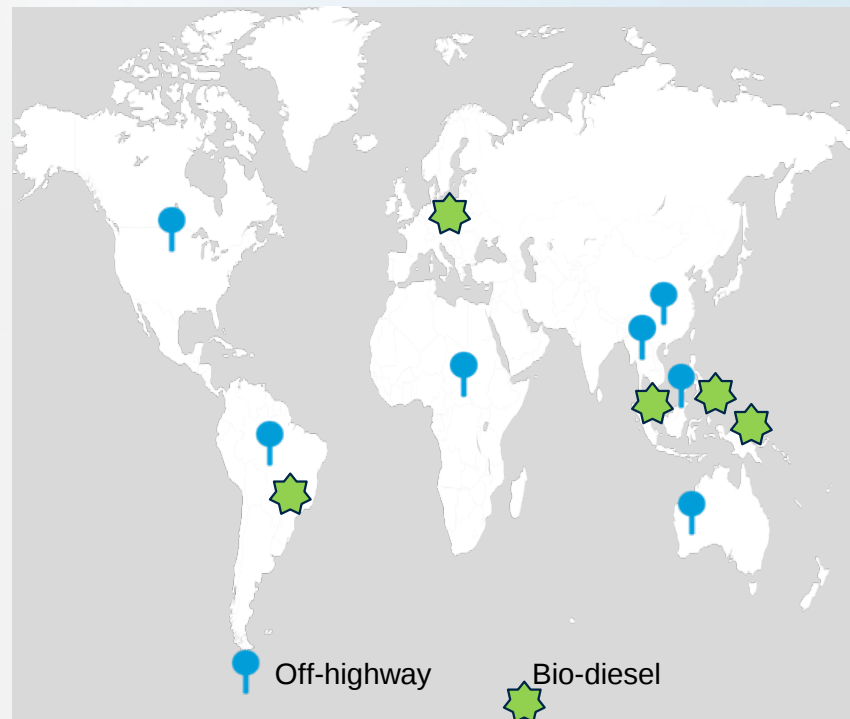
- **Off-highway**

Increasing in Americas, China, Australia, Indonesia, Africa

- **Bio-diesel**

increased adoption in Thailand, Indonesia, Malaysia, Europe

- **These applications require fully formulated additives with right base oil combination and demonstrated field test data**



Low ash additive solutions for off highway application

Demonstrated through a field
test in Cummins 12L engines in
China



China off-highway — fleet and mining environment



Mining service

Very demanding, involves high and transient engine loads, severe operating conditions, with high level of dust/ particles and require trouble free running for the fleets

Location

Xin Jiang, China

Temperature

varies significantly from -20°C in winter to 35°C or higher in summer

Fleet Application

Coal excavation

Lubricant performance expectations:

- Robust technology
- Field-proven, no-harm performance with extended oil drain

China- Off highway mining field test with API CK-4 (1% ash) and PC-12 (0.9% ash) products



**ODI has been extended
to 750-1000hours (long ODI)**
demonstrating excellent field
performance in off-road mining
application

Field test location

Xin Jiang, China

Application

Off-road mining

Fleets

SDLG Cummins 12L and 15 L engines

Fuel

Low Sulfur Diesel

Products

PC-12, CK-4

Viscosity grade

15W-40

Duration

Started in Q1, 2025

Completed 12L engines field test

15L engines – by 1Q 2027

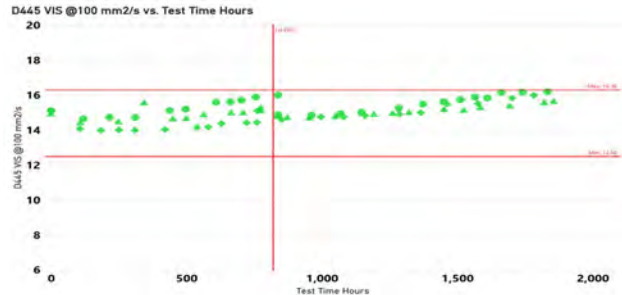
Hours covered

2000 hours (total)

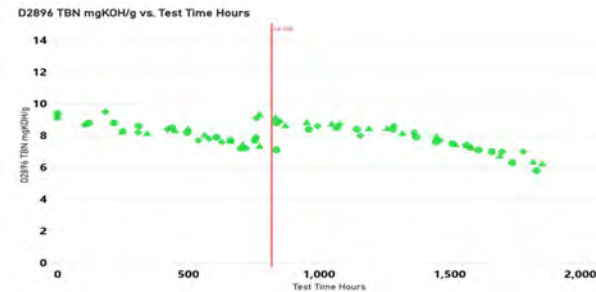
Used oil analysis (1 of 2)

CK-4 product – excellent test results

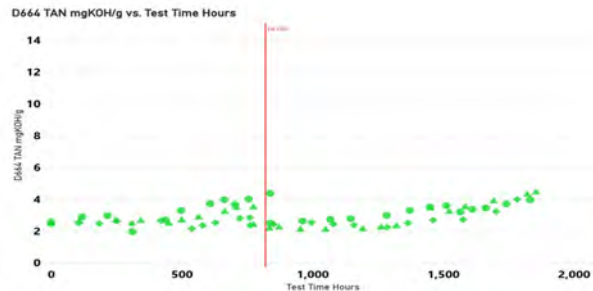
Stable vis control



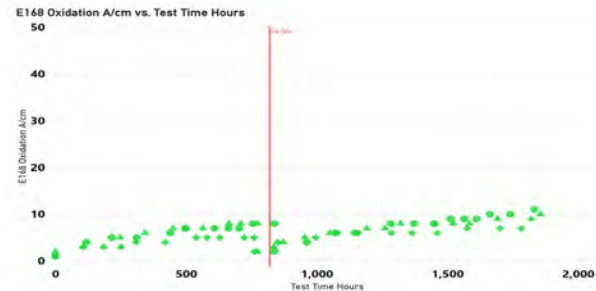
Excellent TBN retention



Minor TAN increase



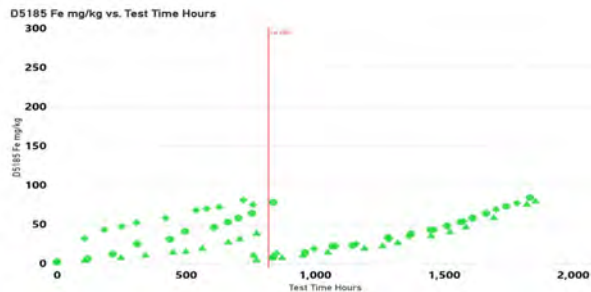
Oxidation: Max. 11 A/cm



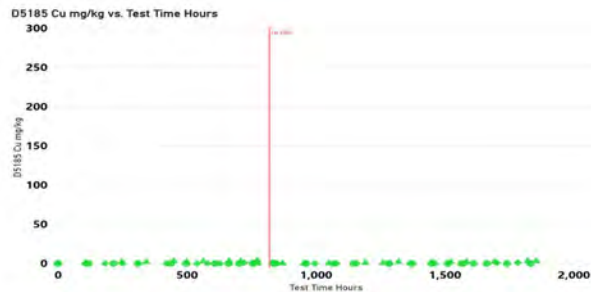
Used oil analysis (2 of 2)

CK-4 product– excellent test results

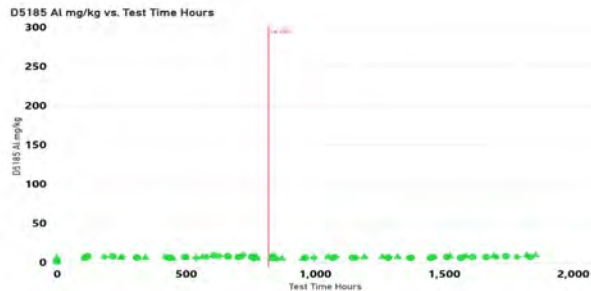
Fe content: Max 84 ppm (below 100 ppm max)



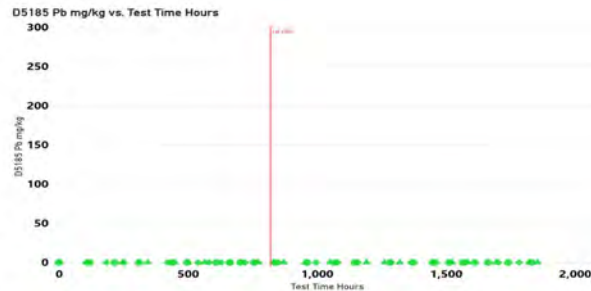
Almost no Cu content



Al content: Max 9 ppm

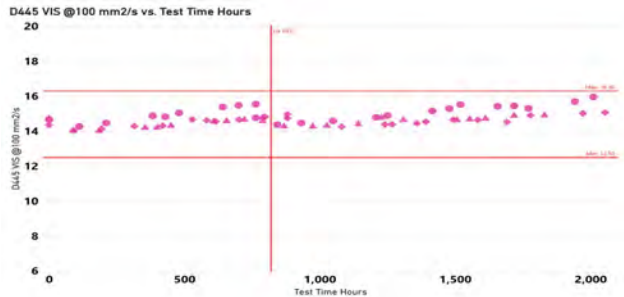


No Pb content

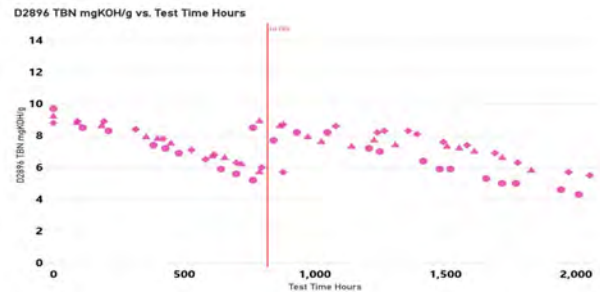


PC-12 product– excellent test results

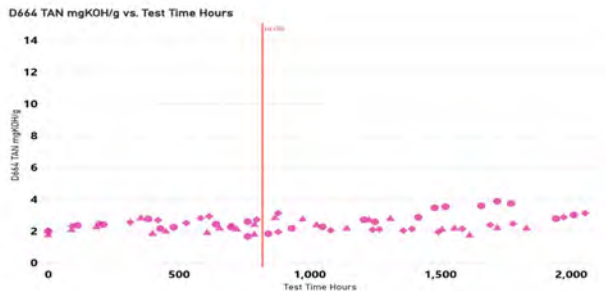
Stable vis control



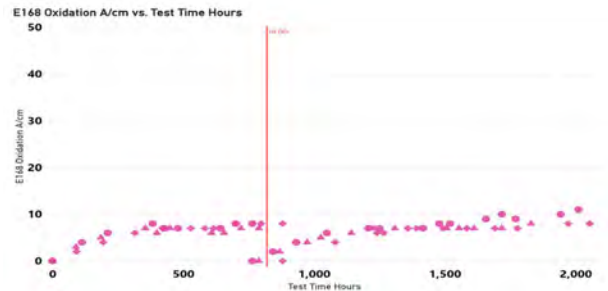
Excellent TBN retention



Minor TAN increase

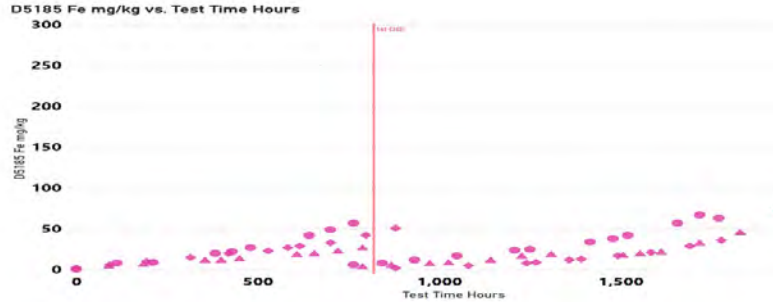


Oxidation: Max. 11 A/cm

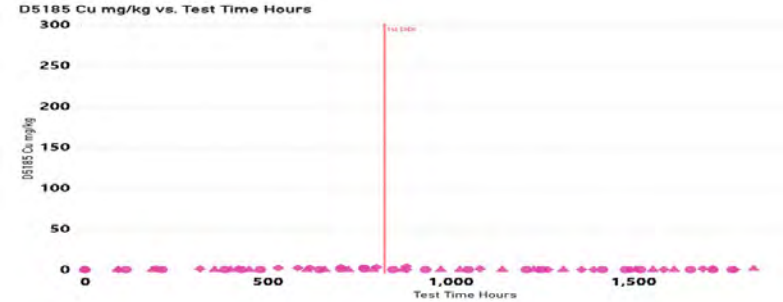


PC-12 product– excellent test results

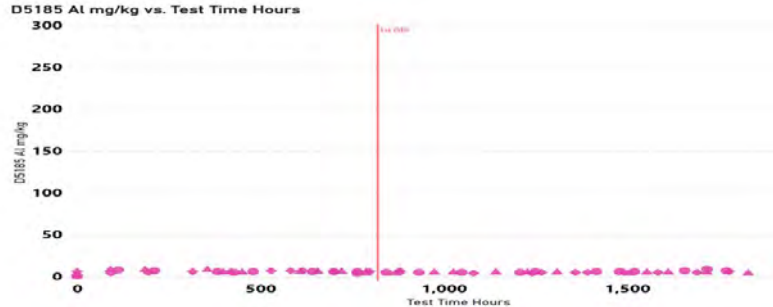
Fe content: Max 86 ppm (below 100 ppm max)



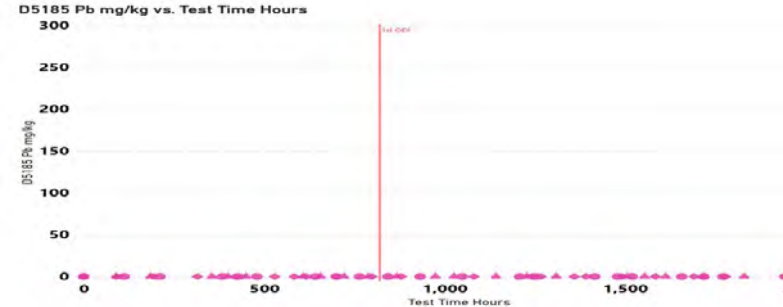
Almost no Cu content copper



Al content: Max 9 ppm



No Pb content



Field test inspection

Excellent parts condition



Piston



Piston under-crown



Cylinder liner



Piston ring

**Good deposit control
in pistons**

**Good condition of
piston rings and liners**

Benefits:

Reduced engine knocking and bore polishing. Minimized: fuel & oil consumption increase and exhaust emission deterioration

Off highway field test summary

with CK-4 (1% ash) and PC-12 (0.9% ash) products

Parameter	CK-4,PC-12 formulation	Remarks
KV100		Stable vis control
TBN (D2896)		Excellent TBN retention
TAN		Minor TAN increase
Oxidation (A/cm)		Max. 11 A/cm
Fe content (mg/kg)		Max. 86 ppm
Cu content (mg/kg)		Almost no copper
Al content (mg/kg)		Max. 9 ppm
Pb content (mg/kg)		No Lead
Drain intervals	Delivered long ODI of 750-1000 hrs	
Lower ash technologies tested in off highway	Supports emission reduction, after treatment system protection while delivering excellent oil performance with extended drain	

Low ash additive solutions for bio-diesel application

Demonstrated through
a field test in one ton
pickup truck in Thailand



Key challenges in 1 Ton pick-up Euro V low ash technology application with bio-diesel

Severe real-world operation

- Stop, start urban driving
- High idling
- Wide variability in duty cycles

Emission system constraints (Euro V)

- DPF durability
- Frequent regeneration can amplify fuel dilution (in presence of bio-diesel)

Biodiesel-driven stress

- High fuel dilution
- High viscosity loss and wear
- Higher oxidation

Low ash additive formulations need a fine balance of after-treatment system protection and engine durability in a high bio-diesel fuel environment

Bio-diesel field tests conducted in multiple technologies with lower ash in different fleets

Markets	Biodiesel content	Application	Products tested	Status
Thailand	B20	1 ton Pick up trucks Euro V Fleets: 1. Toyota and 2. Isuzu	CK-4 (1% ash) PC-12 (0.9% ash) C2/C3 (0.8% ash)	CK-4- Completed PC-12: In progress C2/C3: In progress

Fueling facility



B20 storage tank
with pump and meter

B20 biodiesel
used for this
field testing
**is blended
specifically for
this purpose**

Bio-diesel - B20 field test with API CK-4 (1% ash) product



**ODI has been extended
to 15,000-20,000km (long ODI)**
through 2 oil drain intervals,
demonstrating good
field performance in light duty
pick-up trucks B20 application

Field test location

Bangkok, Thailand

Application

Light duty trucks

Fleets

Isuzu & Toyota 1-ton pick-up trucks

Euro V engines with DPF

Fuel

20% bio-diesel (B20)

Product

API CK-4 with OEM claims

Viscosity grade

10W-30 & 15W-40

Duration

8 months in 2025 completed

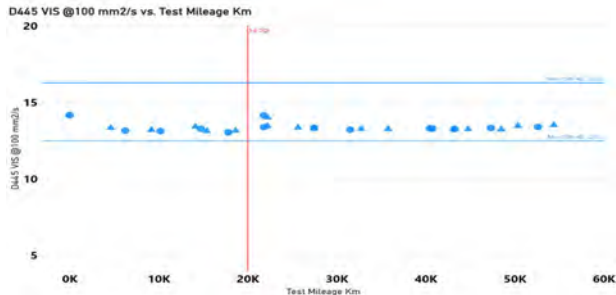
Mileages covered

40,000km ~ 50,000km

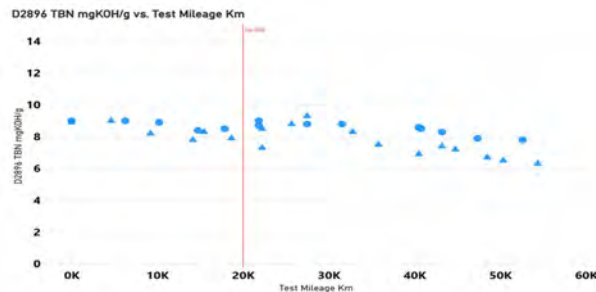
Used oil analysis (1 of 2)

Toyota – excellent test results

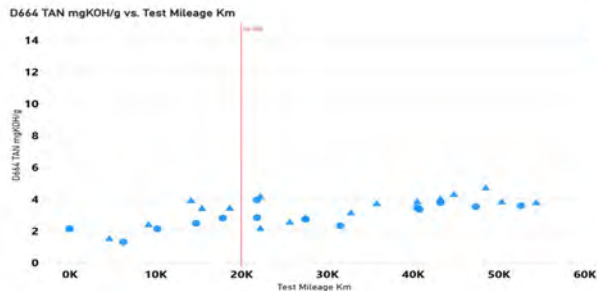
Stable vis control



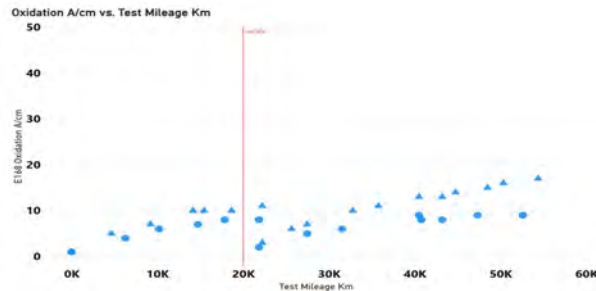
Excellent TBN retention



Minor TAN increase



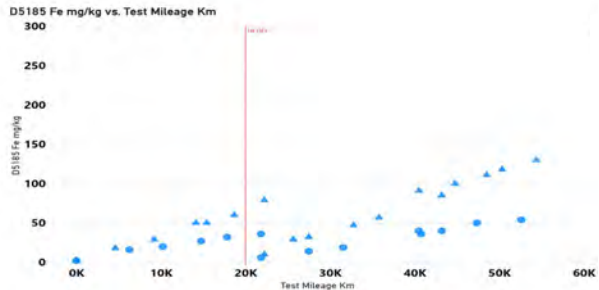
Oxidation: Max. 17 A/cm



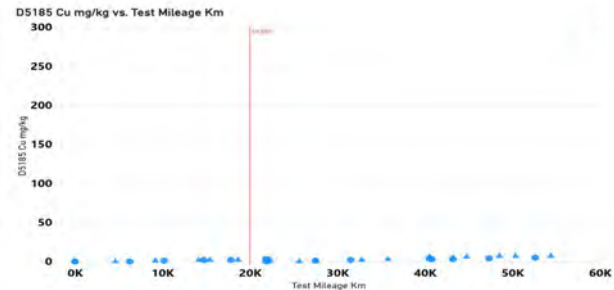
Used oil analysis (2 of 2)

Toyota – excellent test results

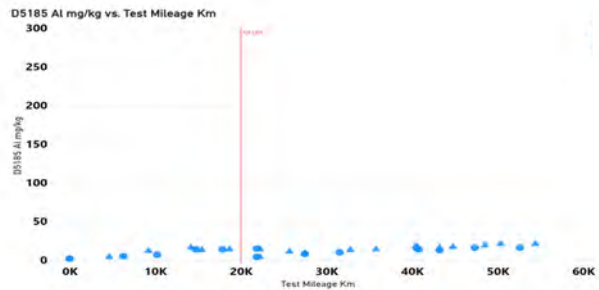
Fe content: Max. 130 ppm



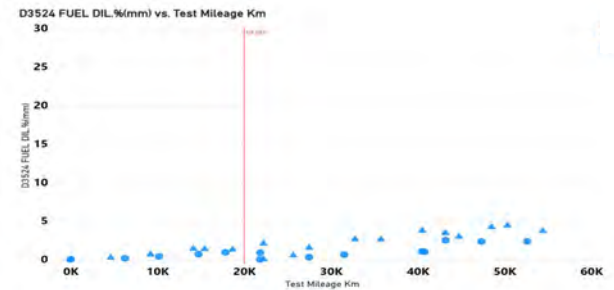
Cu content: Max. 7 ppm



Al content: Max. 21 ppm



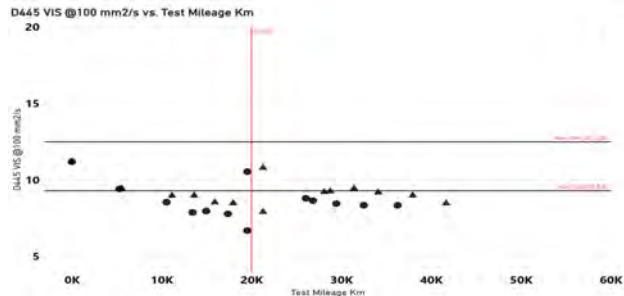
Fuel Dilution <5%



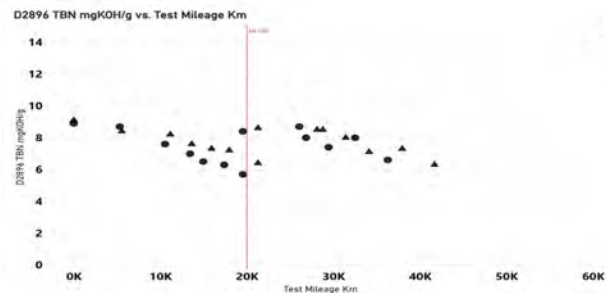
Used oil analysis (1 of 2)

Isuzu – Good TBN,TAN,Oxidation; Decrease in viscosity

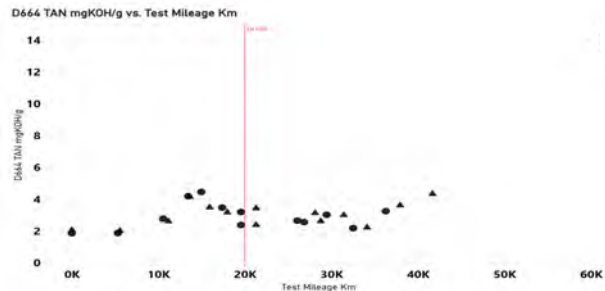
Vis decreasing due to high Fuel Dilution



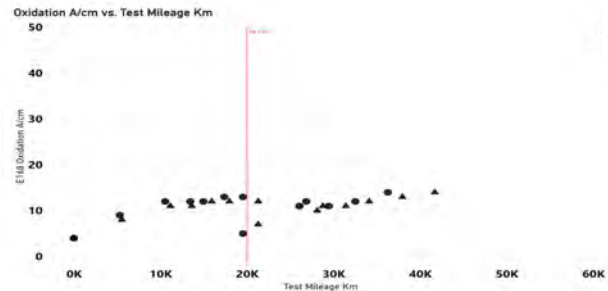
Excellent TBN retention



Minor TAN increase



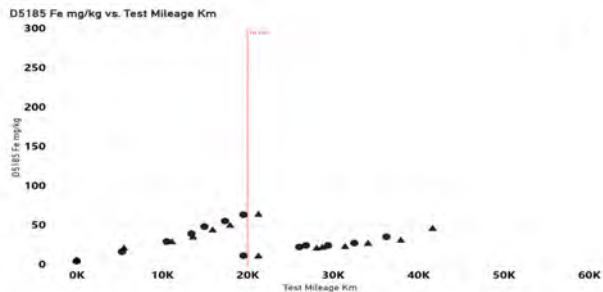
Oxidation: Max. 14 A/cm



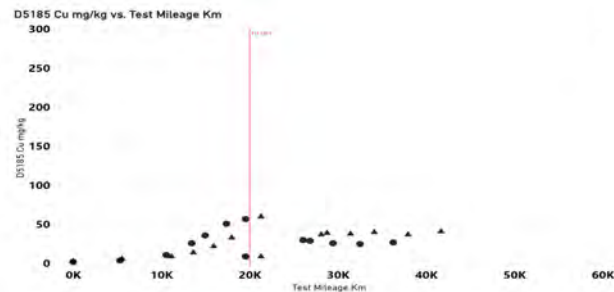
Used oil analysis (2 of 2)

Isuzu – Good wear metals control, High fuel dilution

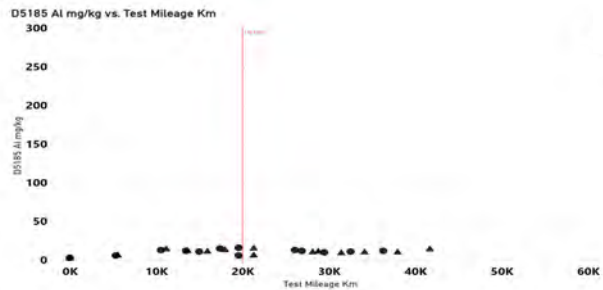
Fe content: Max. 63 ppm



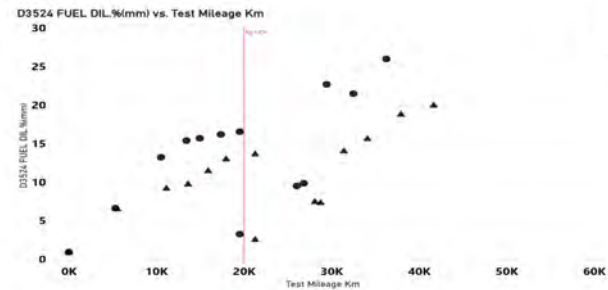
Cu content: Max. 60 ppm



Al content: Max. 15 ppm



High Fuel Dilution (Max. 26%)



Field test inspection

Toyota and Isuzu – Excellent parts condition

Toyota



Piston under-crown, cylinder head and
Conrod bearings

Isuzu



Piston under-crown, cylinder head and
Conrod bearings

Clean piston
under-crown area

Excellent
sludge control

Conrod bearings:
Toyota- No scratch, no
scuffing

Isuzu- Overlay was
observed

Bio-diesel field test summary

with CK-4 (1% ash) in Toyota and Isuzu one ton pick up trucks

Parameter	CK-4 formulation	Toyota	Isuzu
KV100		Stable vis control	Drops due to Fuel dilution
TBN (D2896)		Excellent TBN retention	
TAN		Minor TAN increase	
Oxidation (A/cm)		Max. 17 A/cm	Max. 14 A/cm
Fe content (mg/kg)		Max. 130 ppm	Max. 63 ppm
Cu content (mg/kg)		Max. 7 ppm	Max. 60 ppm
Al content (mg/kg)		Max. 21 ppm	Max. 15 ppm
Fuel dilution		< 5%	Max 26%
Drain intervals (recommended 10KKms)		Extended up to 20-25KKms	Could extend only up to 15KKms (due to high fuel dilution)

Summary



Summary



- **Low ash technology in heavy duty application is increasing in off highway and bio-diesel service**, driven by emission regulations and advanced aftertreatment system
- **These applications require fully formulated additives with right base oil combination and field proven test data**
- **Chevron Oronite's field test data demonstrate:**
 - **Off highway mining: oxidation and wear metals** are critical parameters, **delivering extended oil drain intervals** while **maintaining durability** and performance
 - **Bio-diesel (B20): fuel dilution and viscosity control** are key parameters, **delivering extended oil drain intervals. However, High fuel dilution in specific engine fleets reduce extended oil drain capability** and needs to be **factored in the real-world usage**
- **Chevron Oronite is continuing with further field tests with lower ash technologies and will share more findings in the future**

Thank you

