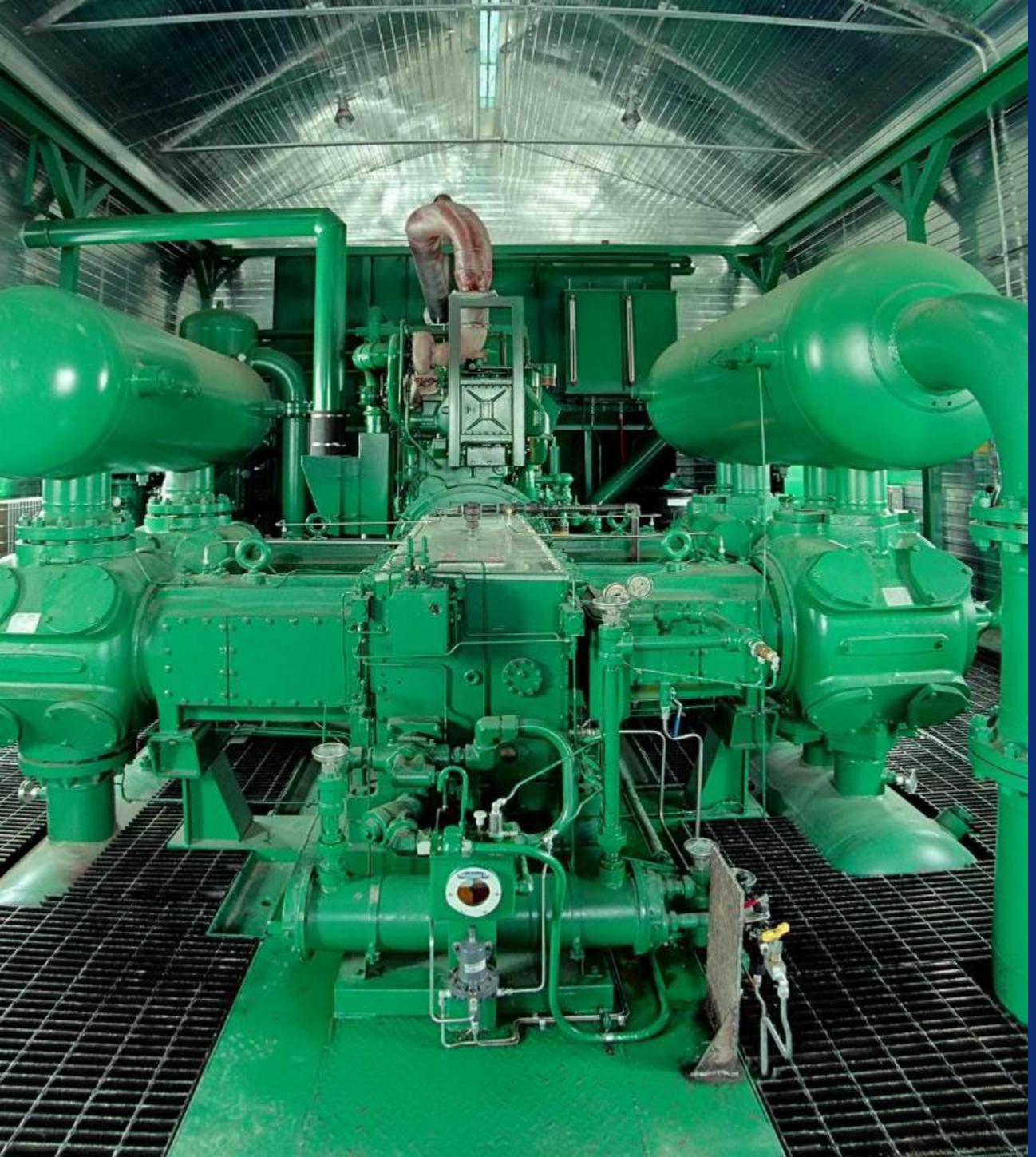


Introducing HDAX® 9500 Gas Engine Oil

Proof of Performance

Achieve full land fill and biogas engine potential

Revised November 2022

the human energy company™

Overview

Natural gas engine markets are evolving rapidly.

Primary growth segment is power generation.

Applications include four-stroke cycle engines running on landfill gas, biogas, digester gas and sour gas.

Regulations to reduce emissions drive the need to reduce oil consumption of the engine.

Global HDAX®
product family architecture

To achieve their full potential, today's high-BMEP engines need lubricants that can perform under the most punishing conditions. Today's extreme operating conditions require outstanding and innovative formulations, so, product recommendations should be from the top tier down. Not all products found in the global HDAX product family architecture are available in every region. Consult region customer experience teams or region product line managers for local product offering. For an editable spreadsheet, click here.

Product Family	Architecture		Application														Equipment and Customer Challenges					
																	Equipment and operating efficiency	Equipment reliability and durability	Extreme operating conditions	Oil life and contamination	OEM requirements	Environmental, Social & Governance (ESG)
																	Product Attributes					
Product Name	Tier	Level	Piston Type		Industries		Four-stroke Cycle Engine	Two-stroke Cycle Engine	Ashless	Low Ash	Medium Ash	Dual Fuel	Landfill/ Biogas	Natural Gas	SAE 15W-40 and/or SAE 30 Viscosity Grades[2]	Reciprocating Compressor Frame	System efficiency	Wear protection	Long lubricant life	Deposit control	OEM approvals	Energy efficiency and lower carbon
																	Increase equipment uptime	Optimized component and equipment life	Reduce oxidation, nitration, viscosity increase, corrosion and acid rise	Sludge and varnish control	The latest OEM approvals have been obtained	Longer oil drain intervals, deposit control, equipment efficiency
																	Customer Benefits					
																	Operational efficiency	Equipment durability	Oil integrity	Equipment durability	Equipment warranty	Operational efficiency
																	Commercial Insights					
																	Lower operating expenses	Increase equipment uptime, productivity and efficiency	Lower operating costs and maintenance expenses	Increase equipment uptime, productivity and efficiency	Products are formulated to meet OEM equipment requirements	Governmental regulation compliance for lower emissions; increased energy efficiency
HDAX 9700[1]	1	Best	Aluminum		Power Generation	Inland and Coastal Marine	●					●					✓✓✓	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓
HDAX 9500				High BMEP Steel			●						●	●			✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
HDAX 9300							●				●			●			✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
HDAX 9200							●			●				●			✓✓	✓✓✓	✓✓	✓✓	✓✓✓	✓✓✓
HDAX 6500	2	Better				Oil and Gas Petro-chemical Agriculture	●						●	●	●			✓✓	✓✓	✓✓	✓✓	
HDAX 5300							●				●			●				✓✓	✓✓	✓✓	✓✓	
HDAX 5200 EF[3]							●			●				●		●		✓✓	✓✓	✓✓	✓✓	
HDAX 5200					Power Generation		●			●		●		●	●	●		✓✓	✓✓	✓✓	✓✓	
HDAX 5100								●	●					●	●			✓✓	✓	✓✓✓	✓	
HDAX 3200	3	Good					●			●				●	●	●		✓✓	✓	✓	✓	
HDAX 3100							●	●	●					●	●			✓✓	✓	✓	✓	

[1] Chevron HDAX 9700 is the first lubricant to gain time-unrestricted approval for use with MAN Energy Solutions' four-stroke engines running on either liquefied natural gas (LNG) or distillate fuels (with a sulfur content of up to 0.10%). It offers simplicity for operators switching between the two fuels, meaning that they can use just one lubricants, rather than having to change lubricants.
[2] For frequent start/stop operation or colder climate.
[3] EF = Emulsion Free

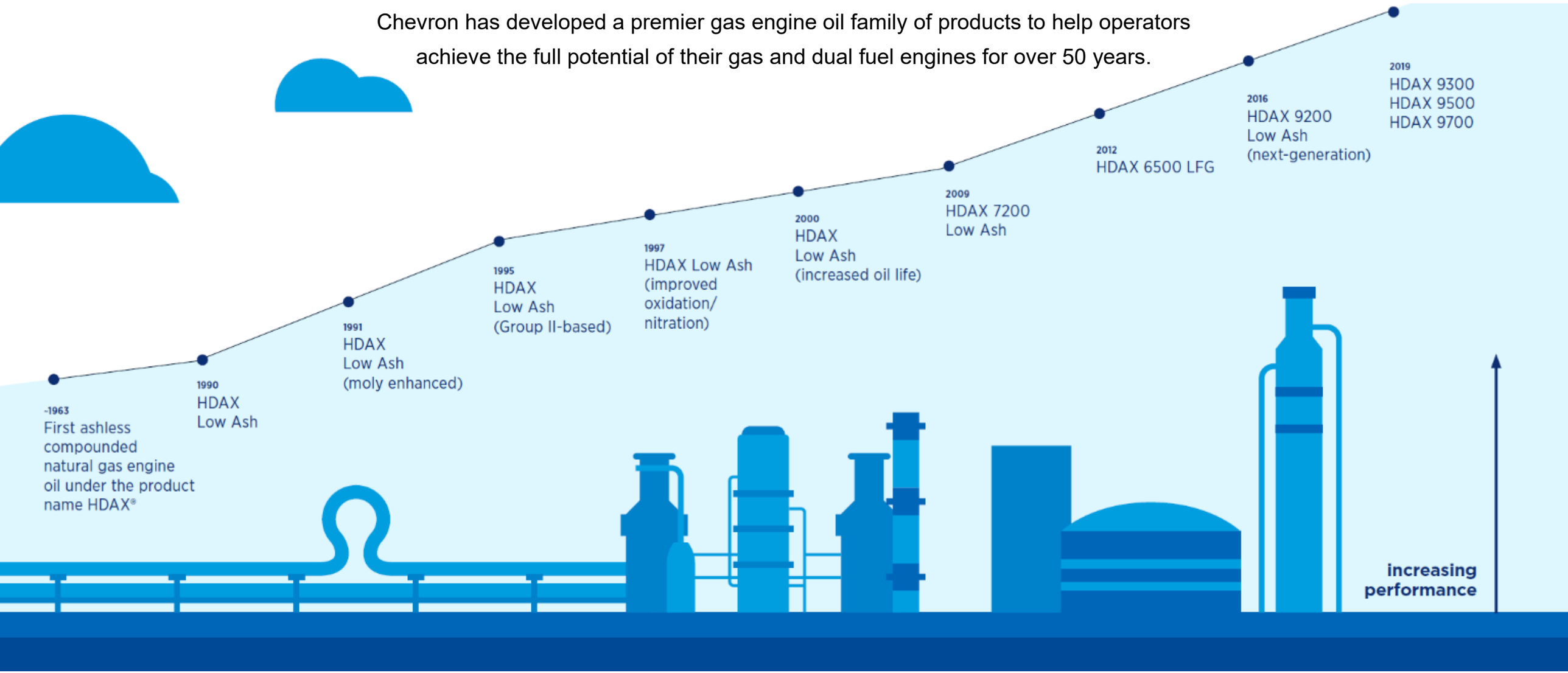
100 series = Ashless | 200 series = Low Ash | 300 series = Medium Ash
500 series = LFG/Biogas | 700 series = Dual Fuel
3000 series = Tier 3 standard products | 6000 and 5000 series = Tier 2 offers high performance products developed to meet the needs of most engine technology | 9000 series = Tier 1 is the highest performance product line developed to meet the latest engine technology

✓ = Good ✓✓ = Better ✓✓✓ = Best

Our Family of Brands

HDAX® path of innovation

Chevron has developed a premier gas engine oil family of products to help operators achieve the full potential of their gas and dual fuel engines for over 50 years.



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Formulated to protect four-stroke cycle engines with aluminum pistons running on landfill gas, biogas, digester gas and sour gas

Equipment and operational efficiency	**Increased equipment uptime.** Formulated for reliable valve recession control and to help prevent potential pre-ignition. Low phosphorus additive design allows use with catalyst systems.
Equipment reliability and durability	**Optimizes component and equipment life.** Outstanding piston deposit control, providing scuffing protection to the cylinder liners. Protects against abrasive wear.
Extreme operating conditions	**Extreme oil conditions.** Reduce oxidation, nitration, viscosity increase, corrosion and acid rise.
Oil life and contamination	**Provides sludge and varnish control.** Oxidation/nitration resistance and base number retention characteristics enable extended drain capability, even in engines designed for very low oil consumption.
OEM requirements	A strong set of OEM approvals have been obtained.
Environmental, Social & Governance	Longer oil drain intervals, deposit control and equipment efficiency

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HDAX® 9500 scope of testing

HDAX 9500 SAE 40 is a gas engine oil for landfill gas, biogas, digester gas and sour gas applications.

Chevron conducted proprietary and industry standard bench tests in the laboratory to collect performance data.

The product is exclusive to Chevron and developed for premium performance.

The testing results demonstrate improved performance of Chevron HDAX 9500 SAE 40 compared to HDAX 6500 SAE 40.

Achieve full gas engine potential

2010 Chevron Image Library. Biogas Condensate Separator.

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Gas engine original equipment manufacturers (OEMs)

HDAX® 9500 SAE 40 is optimized for use in catalyst systems.

MAN

Approved for use with natural gas, sewage gas, biogas, wood gas or landfill gas fuels in applications with after-treatment devices in the following engine:

- MAN E3268

Obtained approval:

- MAN M 3721-5

INNIO Jenbacher

Approved for use with biogas, sewage and landfill gas in the following engines:

- Type 2 & 3
- Type 4, Versions A & B/D
- Type 6, Versions C/E

Caterpillar Inc.

Demonstrated performance in the following engine:

- Caterpillar G3520

HDAX® 9500 finished oil characteristics compared to HDAX 6500

Characteristic	HDAX 9500	HDAX 6500
Sulfated Ash, D874, %	0.6	0.55
TBN, D2896, mgKOH/g	5.4	4.5
Viscosity @ 40°C, mm^2/s	116	124.3
Viscosity @ 100°C, mm^2/s	13.4	13.5
Viscosity Index, D2270	107	106
Color, D1500	<2.5	<5
Nitrogen, ppm	490	380
Calcium, ppm	1649	1524
Phosphorous, ppm	230	267
Sulfur, ppm	1263	2178
Silicon, ppm	8	4
Zinc, ppm	278	320

Select the right lubricants

Proper lubricant selection can help extend oil life until the next planned maintenance.

Bench test results

HDAX® 9500 compared to HDAX 6500

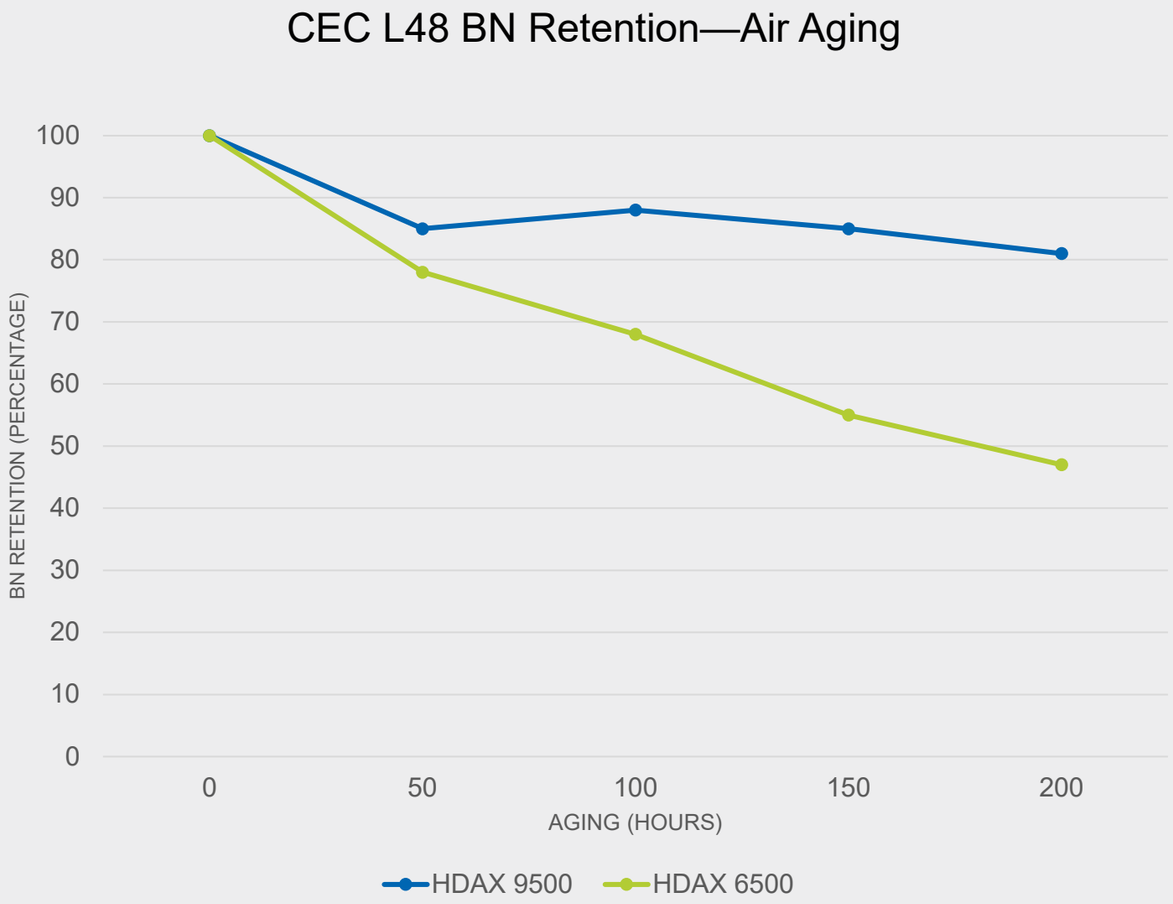
Characteristic	HDAX 9500	HDAX 6500
Oxygen-rich (lean burn environment)		
Average Oxidation, DIR	11.02	11.8
Average Nitration, DIR	7.78	16.7
Average Viscosity Increase, %	3.41	3.35
Oxidation Test, time to 1L O_2 uptake, hours	24.42	14.56
4-Ball Scuff, incipient seizure load, kg	65	72.5
Copper Strip, D130	1A	1B

Select the right lubricants

Gas engine oils must be formulated to **counter oxidation**, nitration, deposits and wear.

HDAX® 9500 gas engine oil demonstrates strong oxidation stability to help prevent deposits.

Base number (BN) retention test results



Thwart gas engine attacks

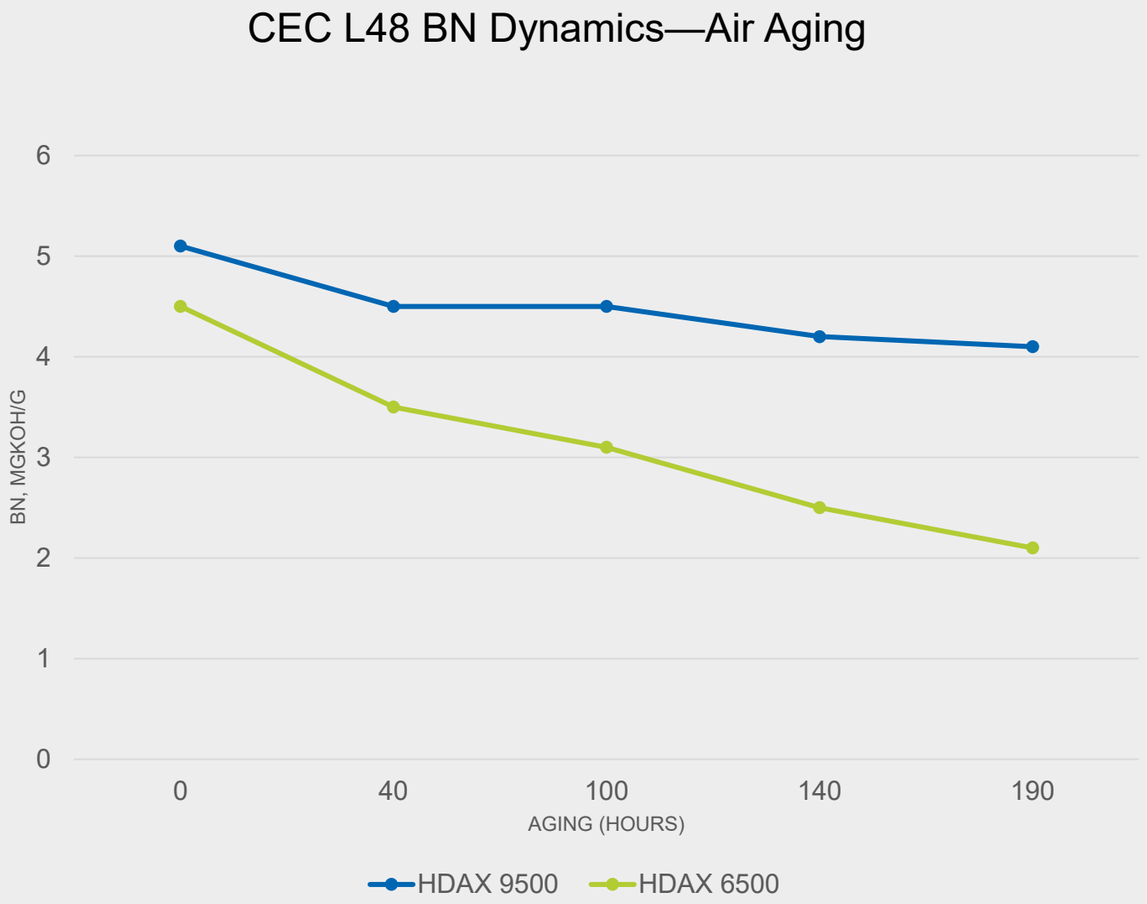
Oxidation, nitration, acids and deposits are infiltrating gas engines and inflicting damage.

HDAX® 9500 gas engine oil demonstrates improved base number (BN) retention compared to HDAX 6500.

Oxidation leads to the formation of acids, which cause damage to the engine. The presence of sulfur in fuel can lead to acid formation. To neutralize acids, base is required.

CEC L48 Test measures oxidation stability of lubricating oils by artificially aging the oil.

Base number (BN) retention test results



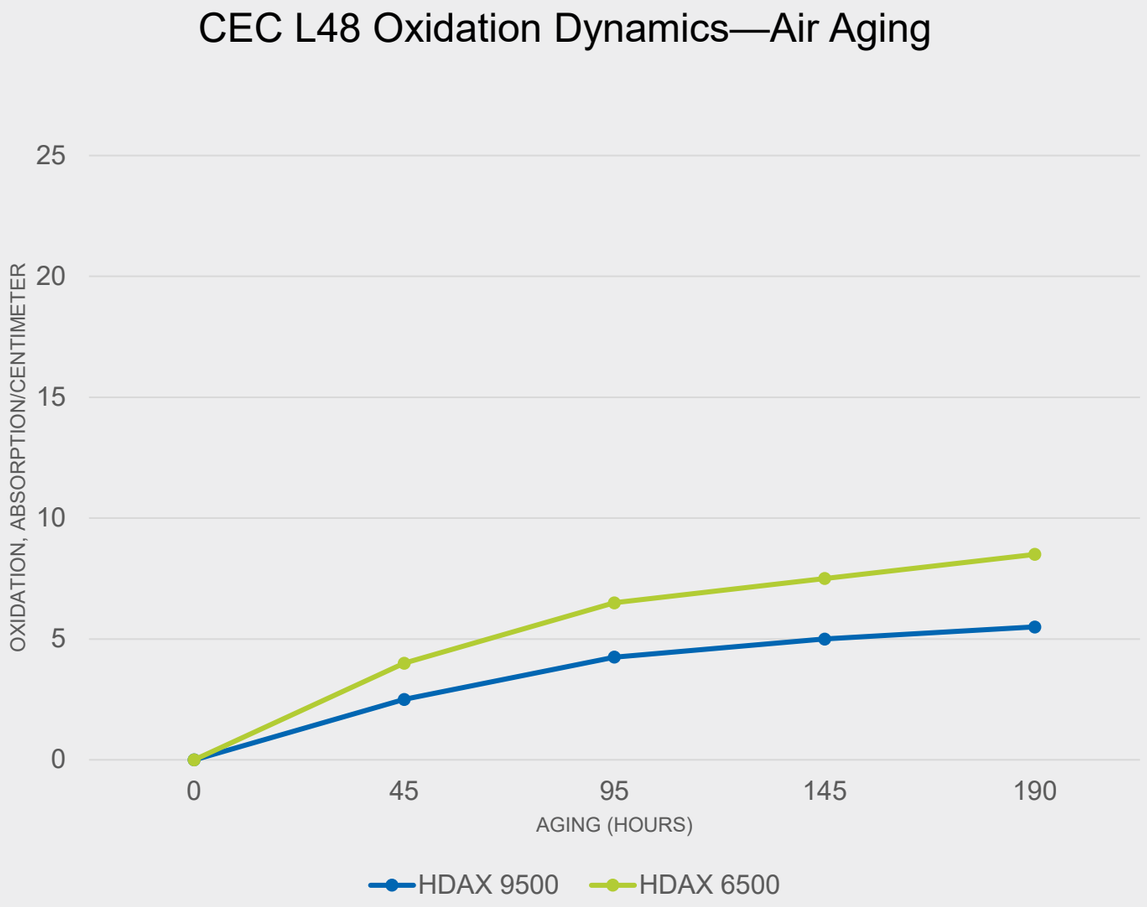
Thwart gas engine attacks

Oxidation, nitration, acids and deposits are infiltrating gas engines and inflicting damage.

HDAX® 9500 gas engine oil demonstrates improved base number (BN) retention compared to HDAX 6500.

CEC L48 Test measures oxidation stability of lubricating oils by artificially aging the oil.

Oxidation test results



Thwart gas engine attacks

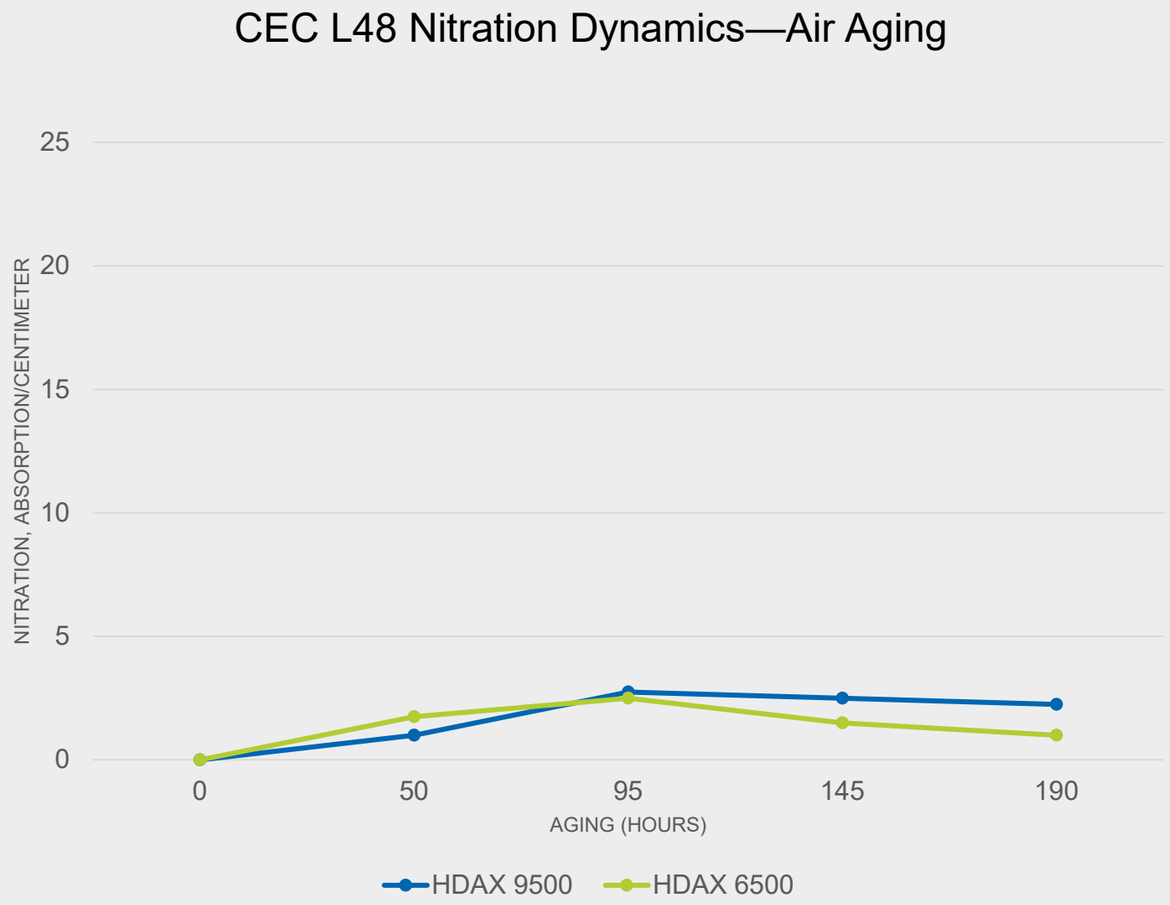
Oxidation, nitration, acids and deposits are infiltrating gas engines and inflicting damage.

HDAX® 9500 gas engine oil demonstrates a lower oxidation rate compared to HDAX 6500. It is formulated to resist oxidation to minimize deposits and sludge and varnish formation.

Oxidation is a key mechanism that degrades engine oil. It results in oil thickening, formation of sludge and deposits and depletion of additives.

CEC L48 Test measures oxidation stability of lubricating oils by artificially aging the oil.

Nitration test results



Thwart gas engine attacks

Oxidation, nitration, acids and deposits are infiltrating gas engines and inflicting damage.

HDAX® 9500 gas engine oil demonstrates a similar nitration resistance performance compared to HDAX 6500.

HDAX® 9500 and 6500 gas engine oil demonstrate strong nitration resistance resulting in low NOx emissions.

Nitration is degradation of an engine oil in a reduced oxygen environment.

CEC L48 Test measures oxidation stability of lubricating oils by artificially aging the oil.

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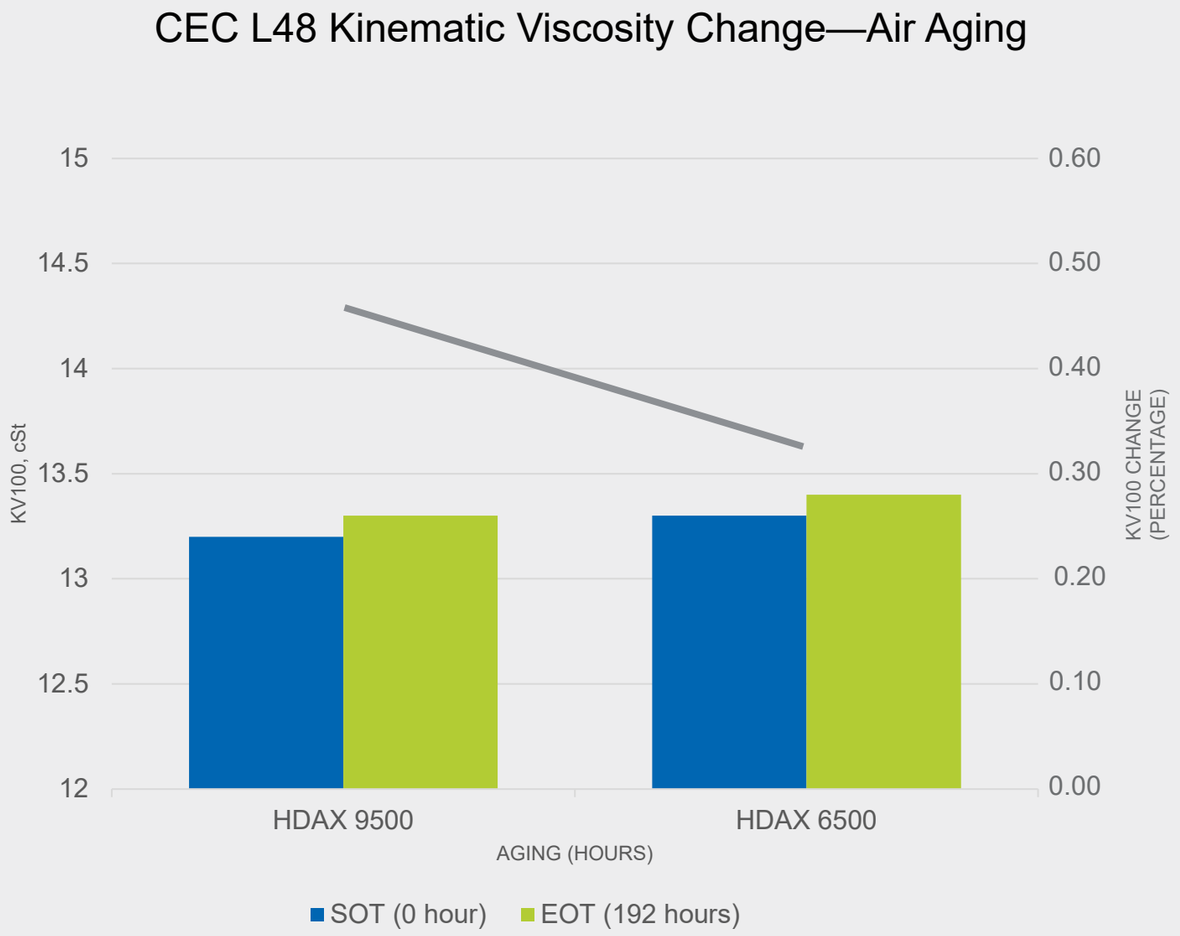
Viscosity change test results



Thwart gas engine attacks

Oxidation, nitration, acids and deposits are infiltrating gas engines and inflicting damage.

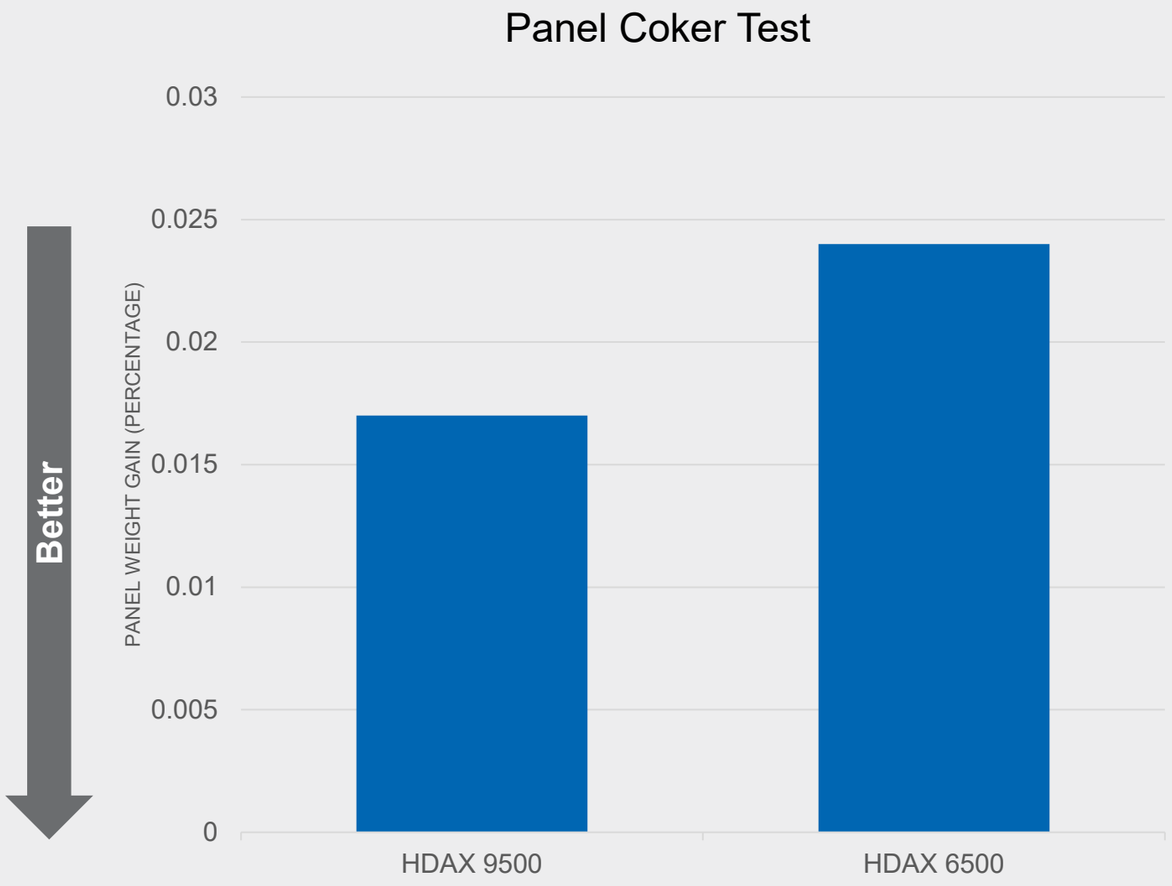
HDAX® 9500 and HDAX 6500 gas engine oils demonstrates strong viscosity retention performance.

HDAX® 9500 and HDAX 6500 gas engine oils demonstrates ability to maintain proper operational viscosity.

An engine oil's viscosity should be designed to operate in an engine's operating conditions without increasing beyond its SAE viscosity grade.

CEC L48 Test measures oxidation stability of lubricating oils by artificially aging the oil.

Tendency for deposit formation test results



Defeat deposits

Controlling deposits can help prevent piston ring sticking, valve failure and premature replacement of components.

HDAX® 9500 gas engine oil demonstrates the ability to reduce formation of deposits better than HDAX 6500.

The Panel Coker Test evaluates the tendency for deposits to form.

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Field test results

INNIO Jenbacher using HDAX® 9500

GE Jenbacher J-420 engine field test parameters

Engine	Site	Oil Consumption
GE Jenbacher Type J-420	Landfill gas application	0.2 g/kWh (as reported by the customer)

Start of Test	Intermediate Inspection	End of Test
November 2016	April 2017 ~4,000 hours	March 2018 **~10,000 hours**

16 months

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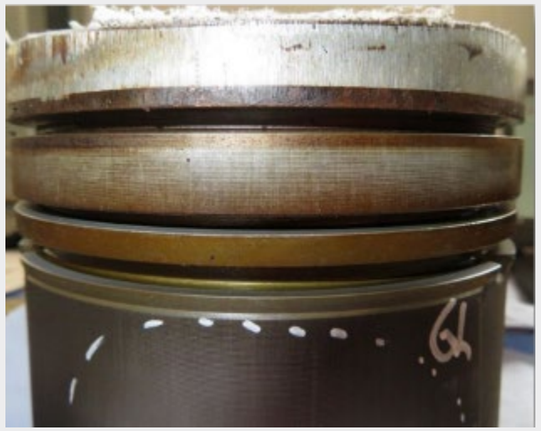
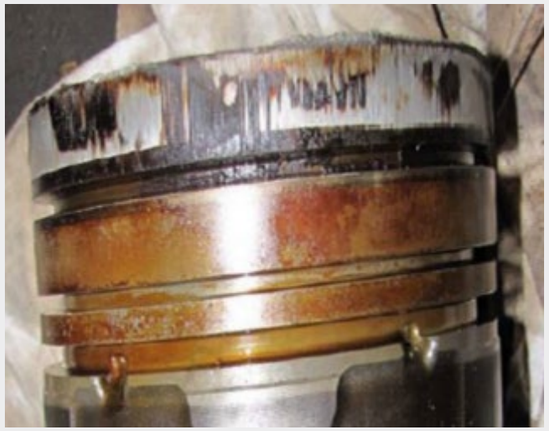
GE Jenbacher J-420 engine field test results

	HDAX® 9500	Competitor
Pistons		
Piston Liners		

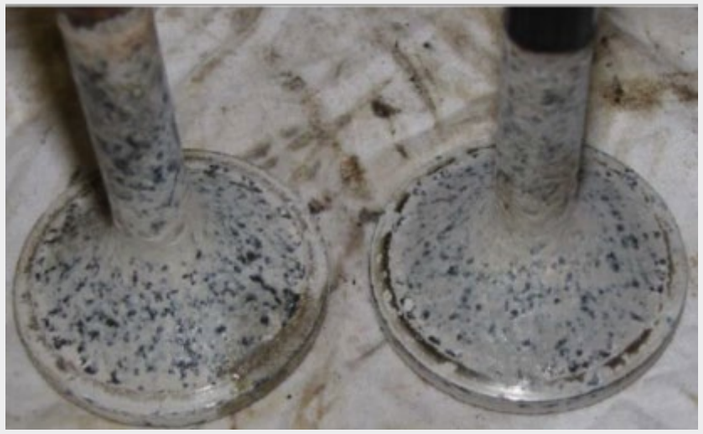
Defeat deposits

Varnish and deposits can destroy pistons and trigger immediate engine shutdown.

HDAX® 9500 gas engine oil can reduce deposit formation that cause piston and cylinder wear.

Photos are from the ~10,000-hour end of test engine inspection

GE Jenbacher J-420 engine field test results

	HDAX® 9500	Competitor
Valves		
		

Defeat deposits

Controlling deposits help prevent valve failure and premature replacement of components.

HDAX® 9500 gas engine oil shows lower overall deposit formation which provides longer component life.

Photos are from the ~10,000-hour end of test engine inspection

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Proof of Performance demonstration results

Caterpillar 3520C
HDAX® 9500 vs HDAX 6500

Caterpillar 3520C field engine proof of performance demonstration results

Characteristics	HDAX® 9500	HDAX 6500
AN/BN cross-over point	~1,000 hours	~600 hours
Acid number below condemning limit	✓	✓
Oxidation and nitration controlled	✓	✓
Kinematic viscosity within grade	✓	✓
Silicon estimated approach to 325 ppm condemning limit	~1,300 hours	~1,000 hours
Typical wear metals at oil change		
Iron	<15ppm	<20ppm
Lead	<20ppm	<15ppm
Copper	<10ppm	<5ppm

Select the right lubricants

Gas engine oils must be formulated to **counter oxidation**, nitration, deposits and wear.

HDAX 9500 gas engine oil demonstrates strong performance for acid control, oxidation and nitration control while maintaining viscosity to help prevent deposits.

Proof of Performance demonstration results

INNIO Jenbacher JGS 320 GS-L.L engine
HDAX® 9500 vs HDAX 6500

Field Test in INNIO Jenbacher JGS 320 GS-L.L engine

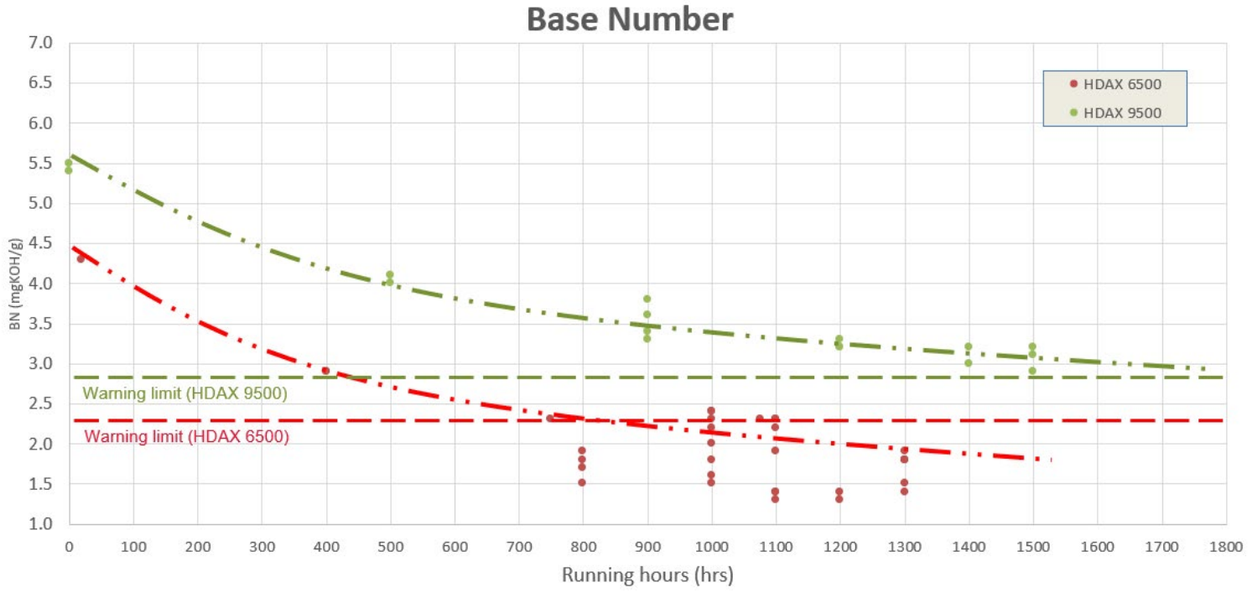
- **Customer**:
  - An environmental engineering services company in Shenzhen China

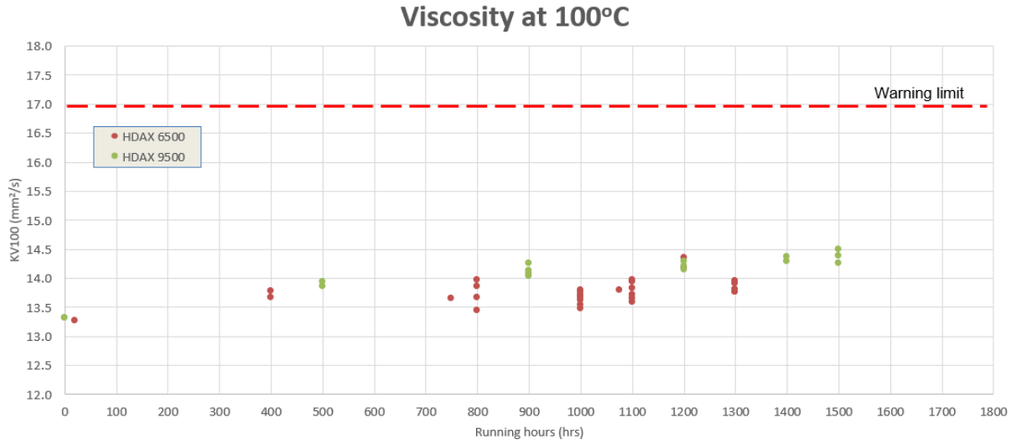
- **Engines**:
  - Model: INNIO Jenbacher 320GS LL, Engine No #6, #7

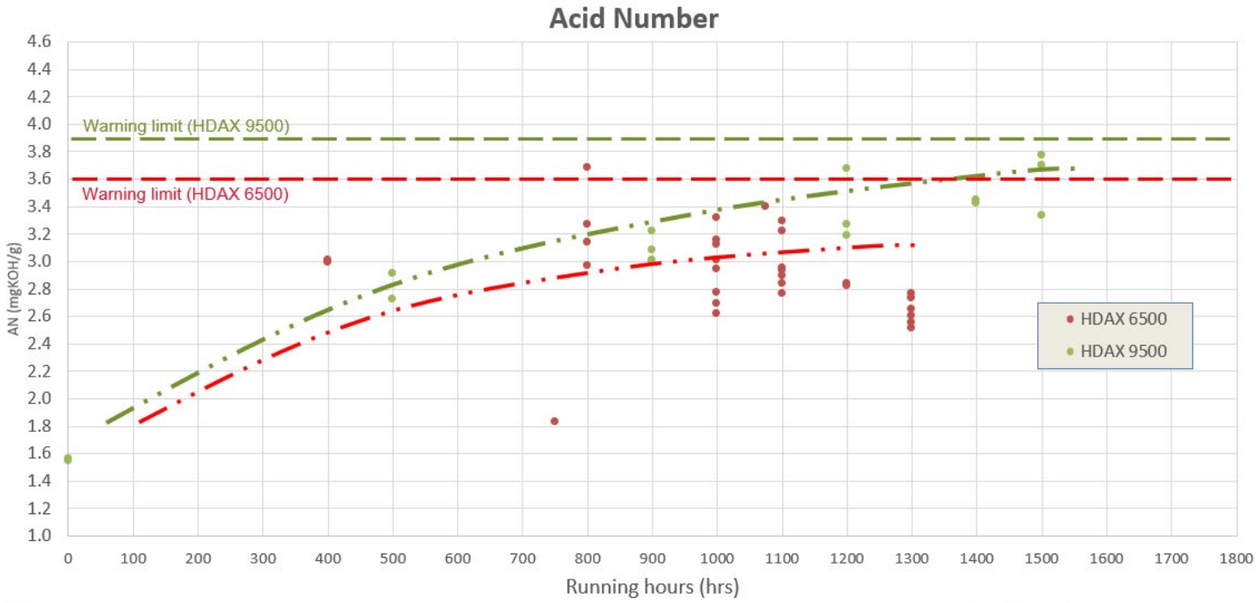
- **Oil drain interval (ODI)**
  - HDAX 6500 LFG: 800-1100 hrs
- **Gas type**
  - Landfill gas: Class C
  - Hydrogen sulfide (H_2S) : 10~50ppm

Oil drain interval extended from 800-1100 hours (HDAX 6500) to ~1700 hours

Field Test in INNIO Jenbacher JGS 320 GS-L.L engine

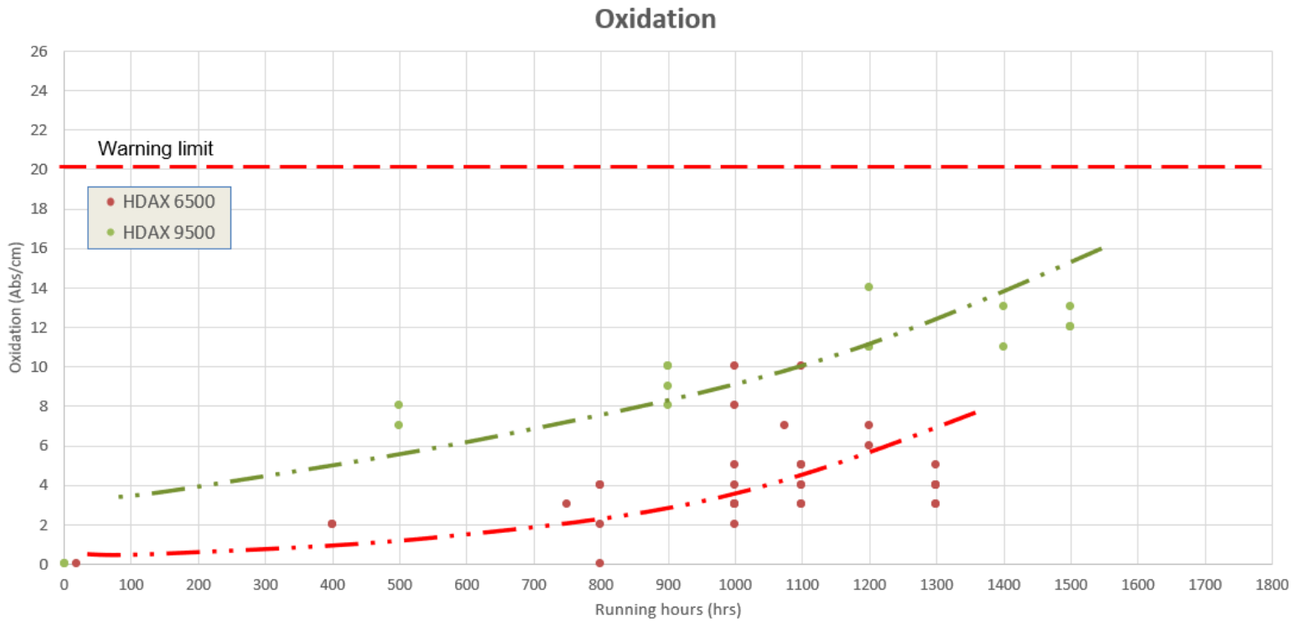




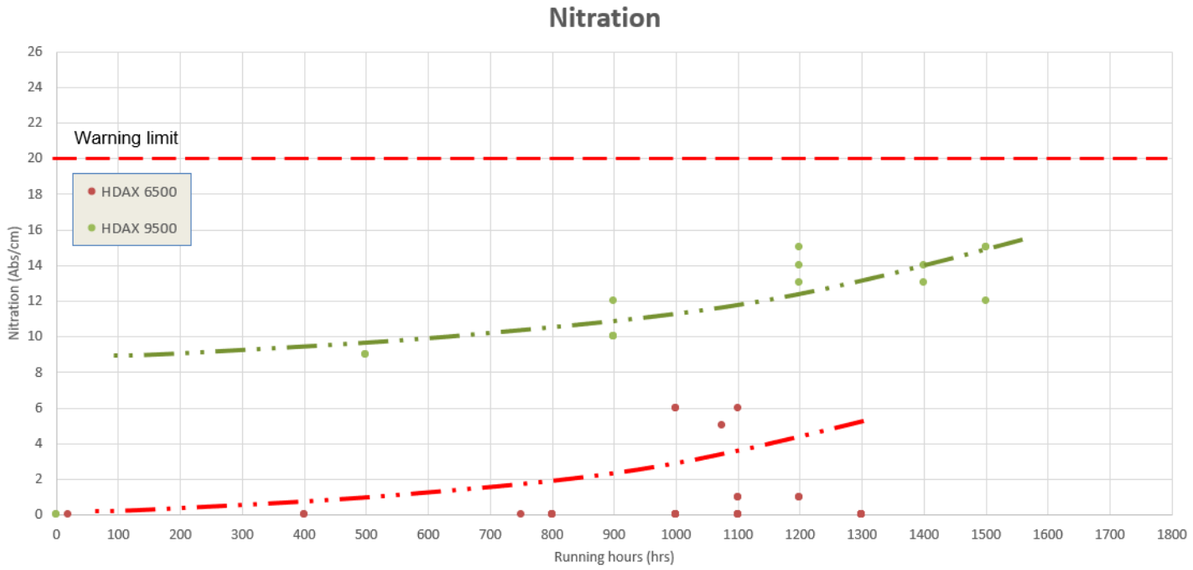


Excellent BN retention
Improved oxidation stability over HDAX 6500

Field Test in INNIO Jenbacher JGS 320 GS-L.L engine



Excellent nitration/ oxidation performance when used with landfill gas



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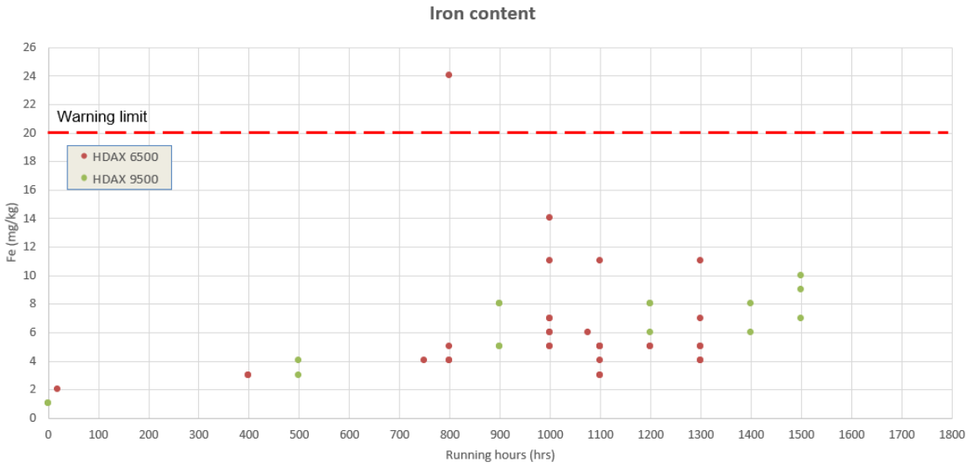
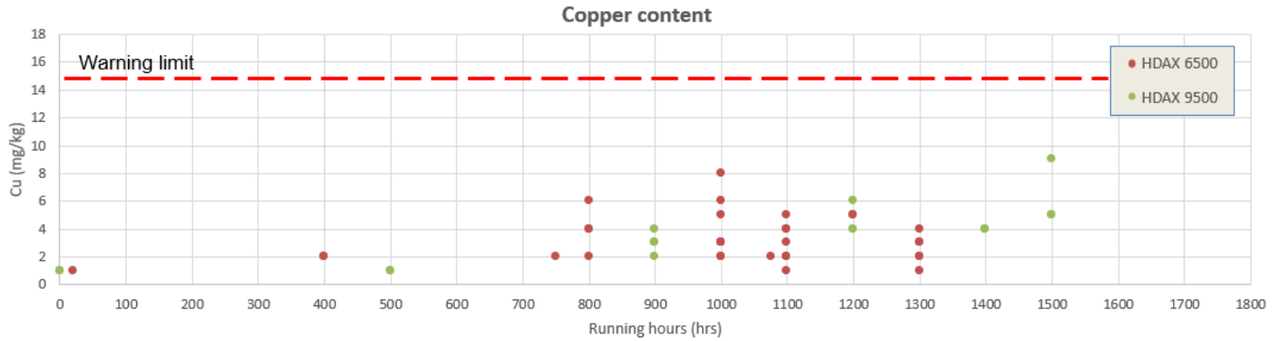
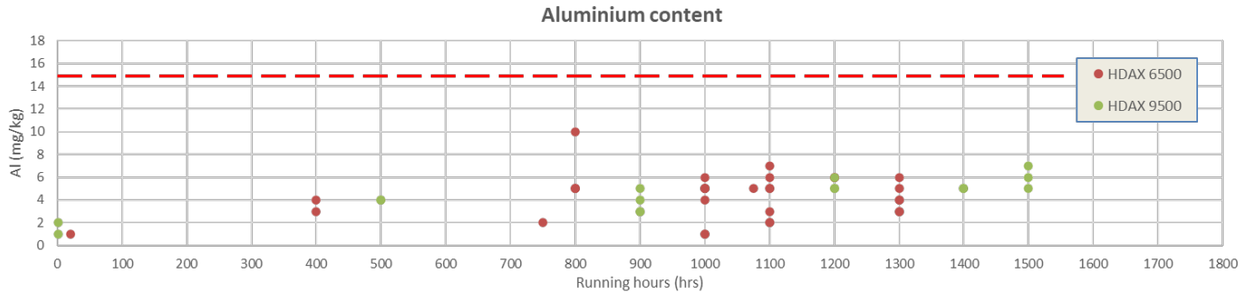
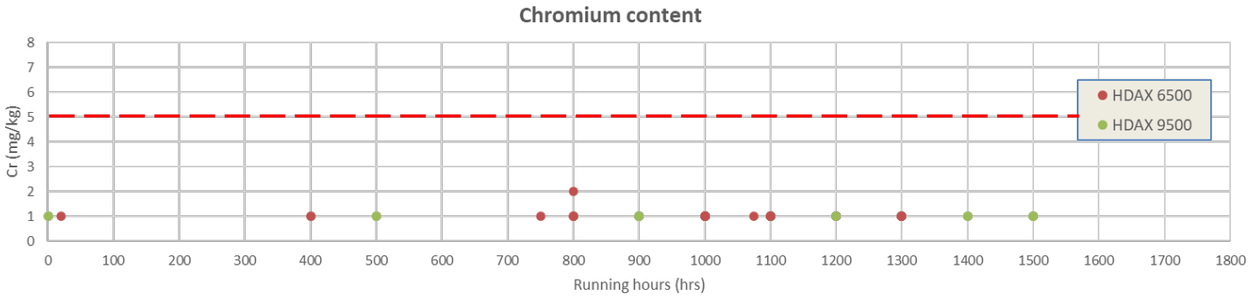
Field Test in INNIO Jenbacher JGS 320 GS-L.L engine

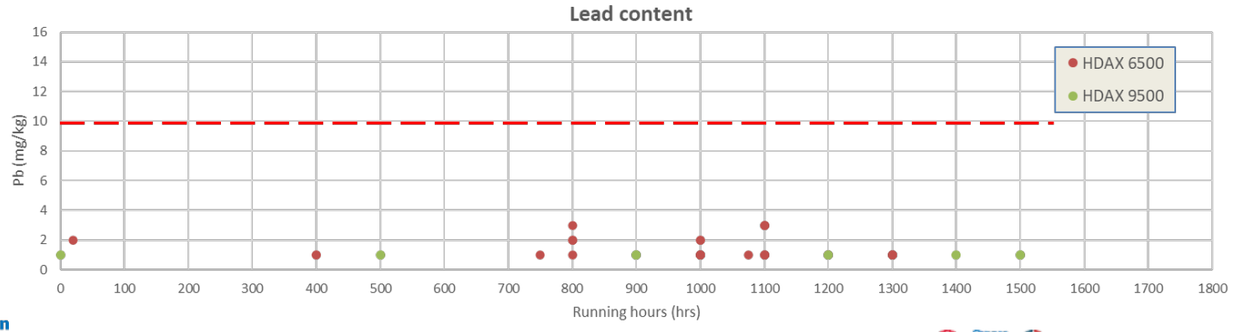




Outstanding wear protection







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Proof of Performance demonstration results

INNIO Jenbacher JGS 320 GS-L.L engine
HDAX® 9500 vs HDAX 6500

Field Test in INNIO Jenbacher JGS 320 GS-L.L engine

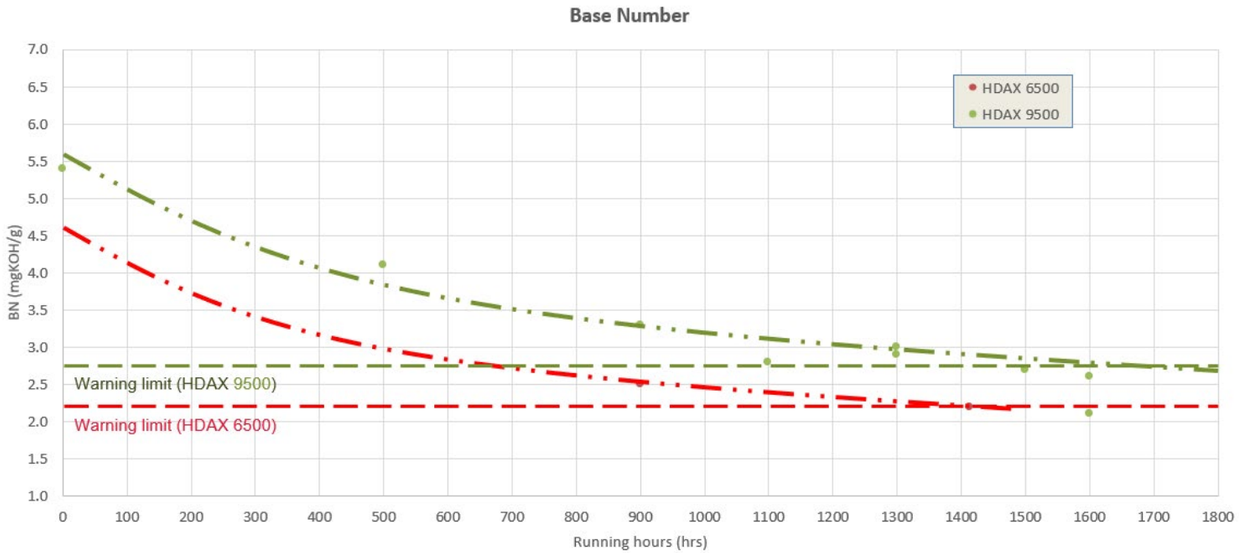
- **Customer**:
  - Environment Technology Company in Yingde China
- **Engine**:
  - Model: INNIO Jenbacher 320GS LL, Engine No #3

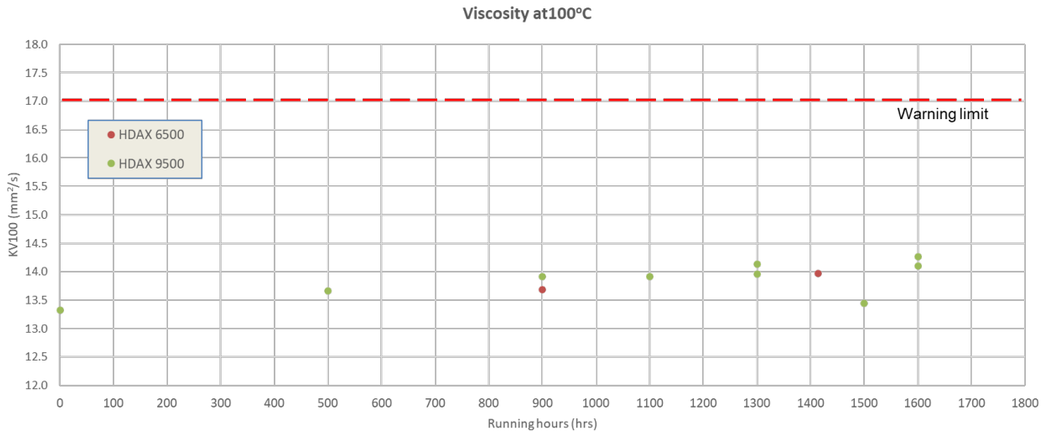
- **Oil drain interval (ODI)**
  - HDAX 6500 LFG: 1400 hrs
- **Gas type**
  - Landfill gas: Class C
  - Hydrogen sulfide (H_2S) : 10~30ppm

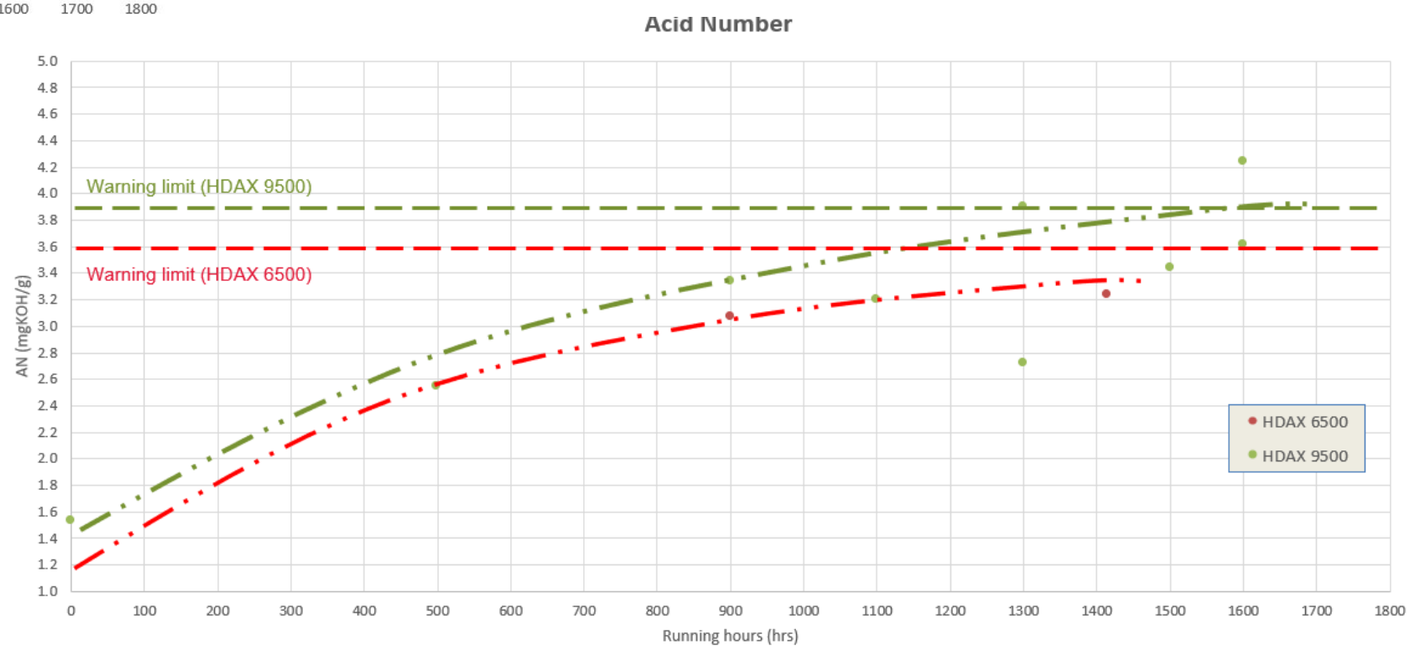
Oil drain interval extended from 1400 hours (HDAX 6500) to ~1600 hours*

* Oil drain could be higher, but intercooler blockage reported at the customer

Field Test in INNIO Jenbacher JGS 320 GS-L.L engine

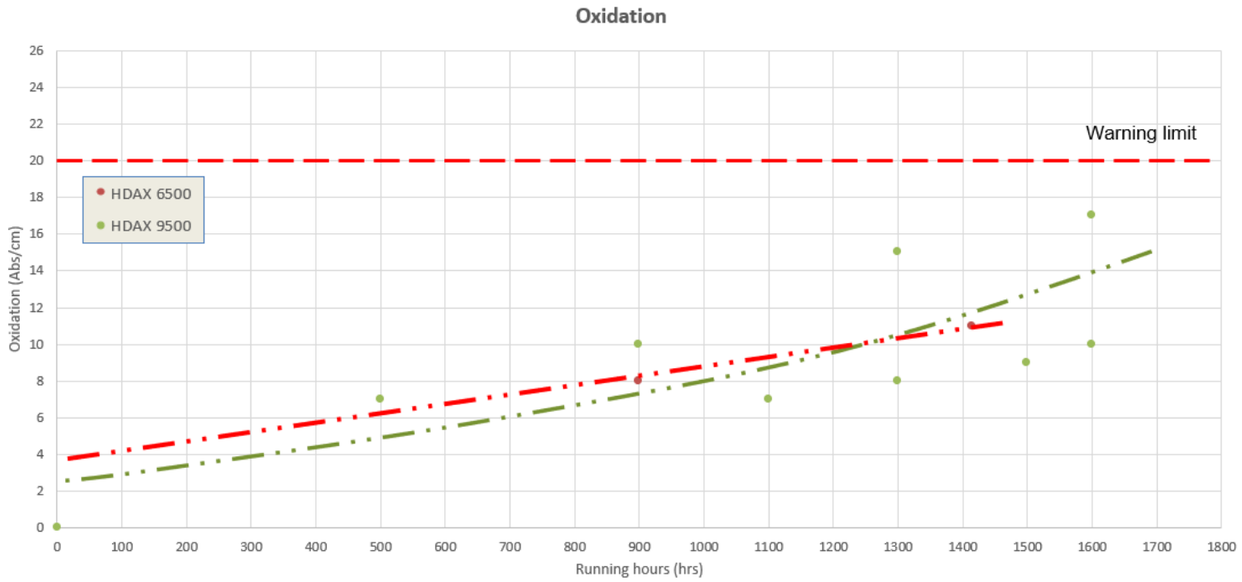




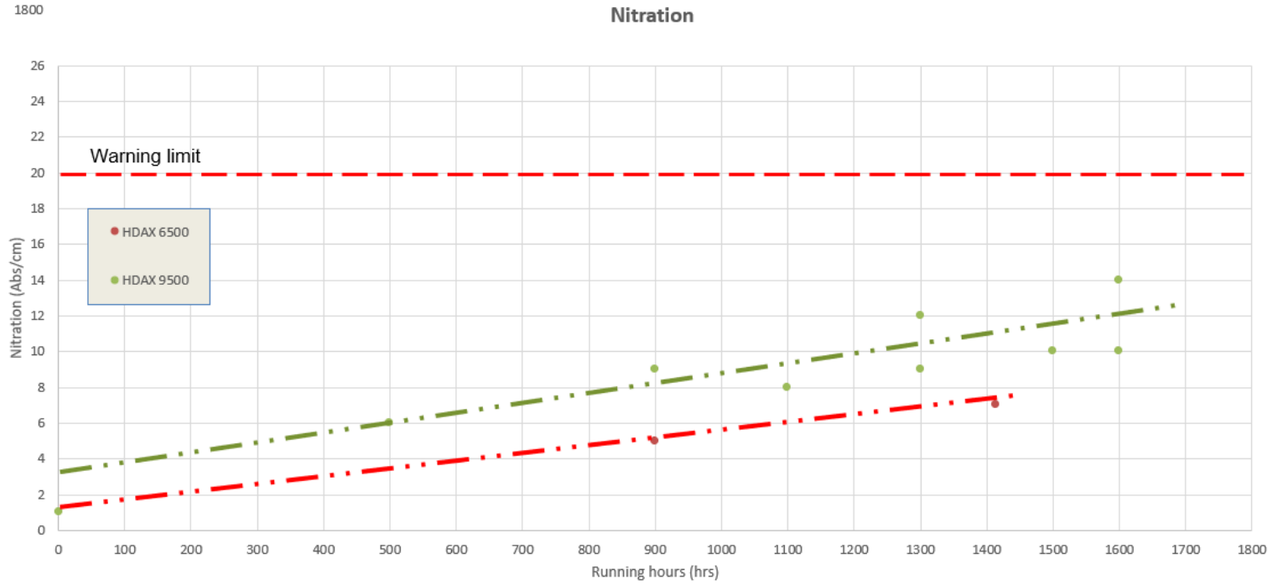


Better BN retention
Improved oxidation stability over HDAX 6500

Field Test in INNIO Jenbacher JGS 320 GS-L.L engine



Excellent nitration/ oxidation performance when used with landfill gas



Our Family of Brands

HDAX® 9500 gas engine oil promotes engine cleanliness and extended component life

	Product attributes	Customer benefits
	Equipment and operational efficiency	Increased equipment uptime.
	Equipment reliability and durability	Optimized component and equipment life.
	Oil life and compatibility	Improved sludge and varnish control.
	Extreme operating conditions	Reduced corrosion, oxidation and wear; minimized acid number (AN) increase and improved base number (BN) retention.
	Original Equipment Manufacturer (OEM) requirements	Increased confidence that products are formulated to meet OEM requirements.
	Environmental, social & governance (ESG) requirements	Improved operational efficiency and compliance.

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