PC-12 Update:
The Next Generation of Heavy Duty Diesel Engine Oils

The webinar will begin in less than 10 minutes.

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PC-12 Update:
The Next Generation of Heavy Duty Diesel Engine Oils

The webinar will begin in less than 5 minutes.

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TEST YOUR KNOWLEDGE

Which of the following factors primarily influences oil drain intervals in heavy-duty trucks?

- Engine Type and Operating Conditions
- Tire Size and Brake Type
- Truck Color and Driver Experience
- Fuel Type Only

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TEST YOUR KNOWLEDGE

CITGARD 700 Synthetic Blend 10W-30 engine oil helps extend oil drain intervals by providing enhanced wear protection and increased oxidation resistance.

True

False

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TEST YOUR KNOWLEDGE

Why is cylinder wall honing important?

- Helps Create the Perfect Engine Sound
- Helps Retain Engine Oil in the Cylinder Wall to Lubricate the Piston Rings
- It's Not Important
- Creates Friction Energy That is Used to Charge Batteries

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PC-12 Update:
The Next Generation of Heavy Duty Diesel Engine Oils

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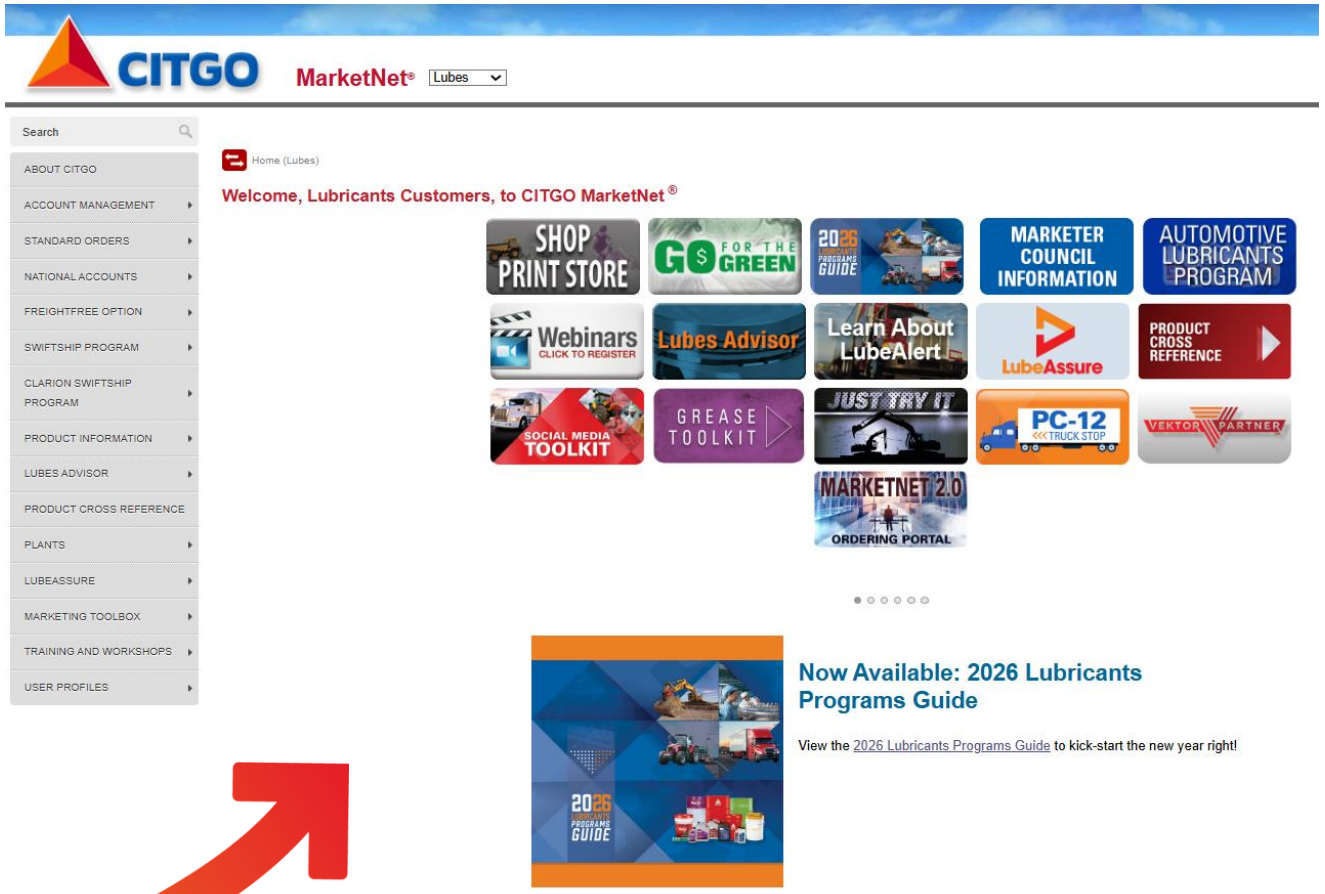
Amber Fessler - NLGI CLGS; STLE CLS & OMA-I

- CITGO Senior Sector Manager
- Materials Engineer
- 14 Years of Experience in Lubricants
- STLE Certified
  - Certified Lubrication Specialist
  - Oil Monitoring Analyst I
- NLGI Certified
  - Certified Lubricating Grease Specialist

Want Resources?

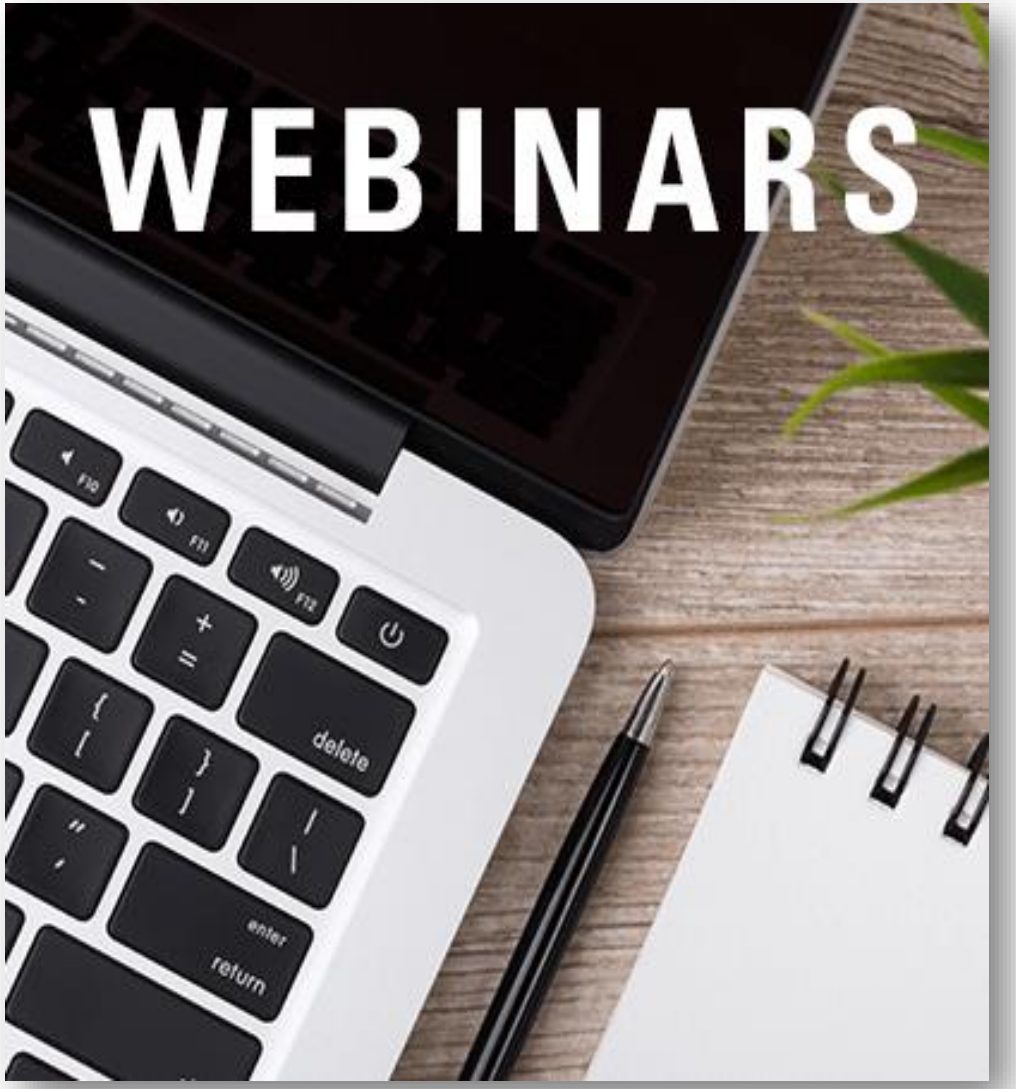
- 2026 Programs Guide
- Support Literature
- Social Media Toolkit
- Webinars



Future Webinars & Tech Talks

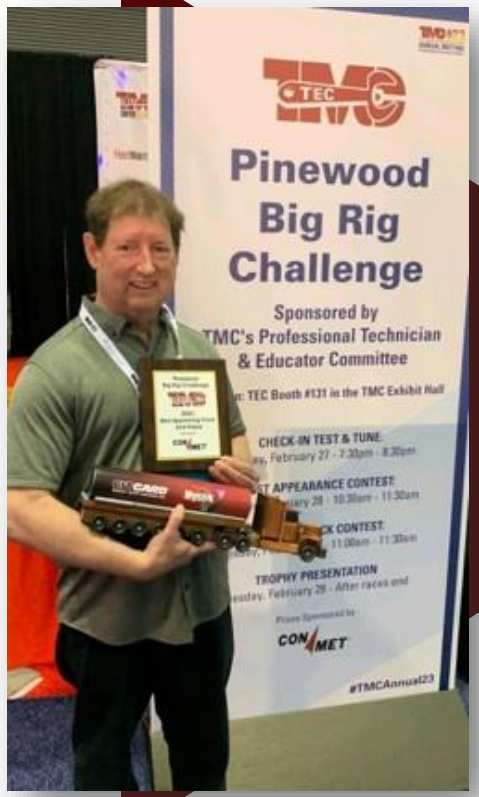
April 20: Tech Talk: Bearing Grease, Bearing Failures and Troubleshooting

May 18: The Future is Cool: Trends and Technologies in AI Data Center Cooling



Steven Bowles – STLE CLS & OMA-I

- CITGO Sr. Product Specialist
- B.S. Zoology & M.S. Environmental Science
- 21 Years of Experience in Lubricants
- 16 Years of Experience in Laboratory Supervision/Analytical Chemistry



Brandon Thompson

- CITGO Product Manager
- B.S. Chemistry
- 20 Years of Experience in Lubricants including:
  - QC Lab Technician
  - QC Laboratory Manager
  - Product Specialist
  - Sr. Lubes Compliance Specialist

Agenda

- Heavy Duty Specifications
- PC-12 Market Implications

HD Specifications

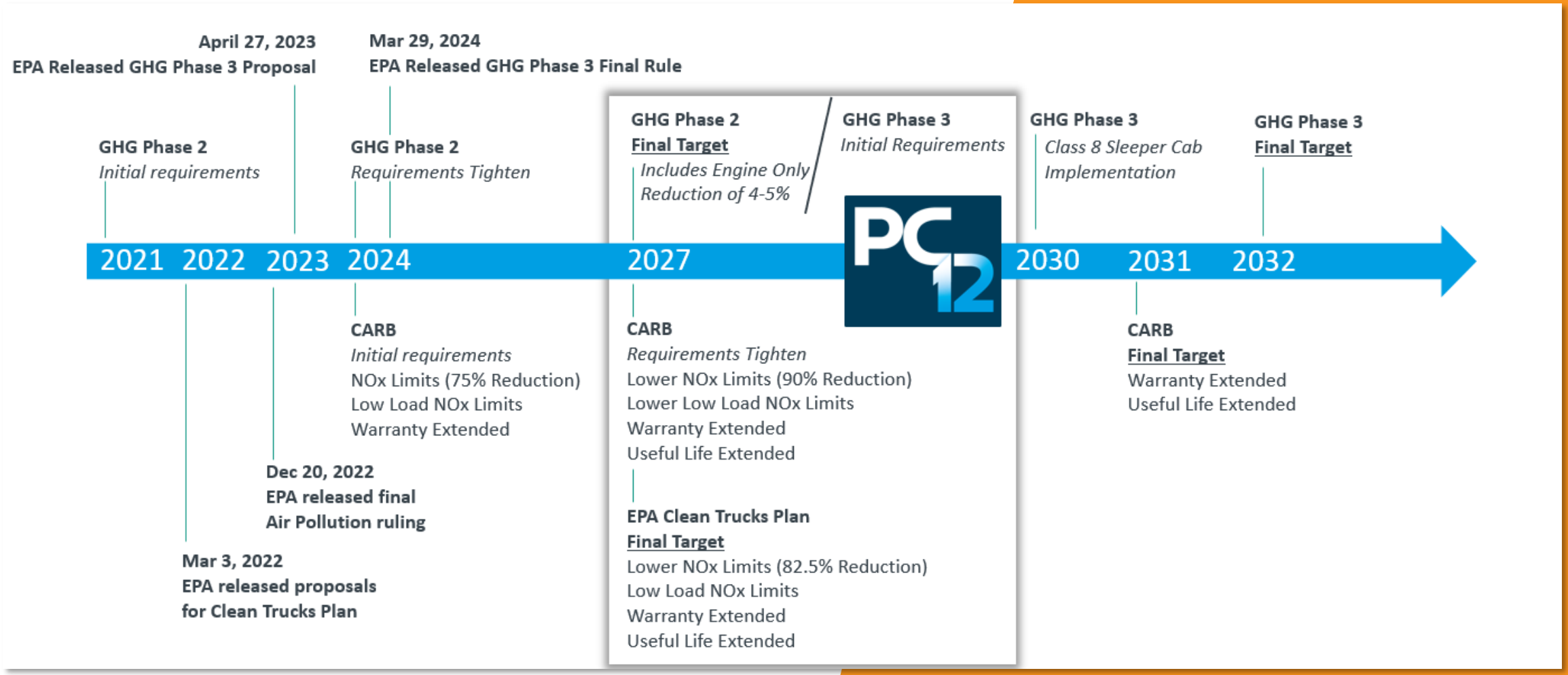
PC-11 & PC-12

HD Specifications

Regulation Leads to Specifications

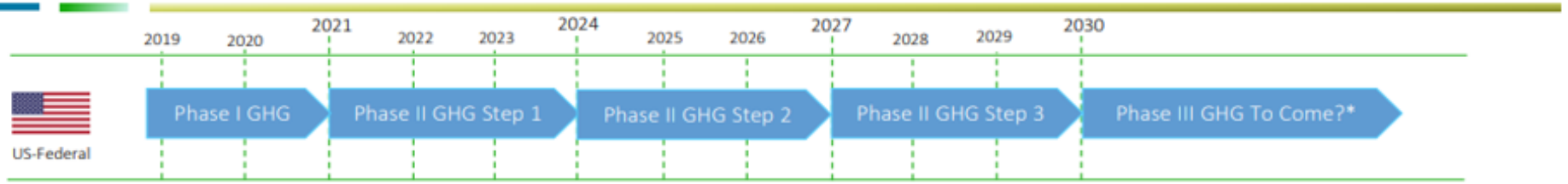
	Emissions Regulation			Specification	Status
Year Phased In	Particulate Emissions (g/bhp-hr)	NOx Emissions (g/bhp-hr)	CO_2 Emissions		
1988	0.60	10.7		1985 - API CE	Obsolete
1990-91	0.25	6.0 -> 5.0		1990 - API CF-4	Obsolete
1994	0.10	5.0		1995 - API CG-4	Obsolete
1998	0.10	4.0		1998 - API CH-4	Active
2002	0.10	2.0		2002 - API CI-4/CI-4 PLUS	Active
2007, 2010	0.01	1.2 -> 0.2		2006 - API CJ-4	Active
2014-2018			GHG Phase 1	2016 - API CK-4 / API FA-4	Active (PC-11)
2021-2027			GHG Phase 2	2027 - New API Categories Have Been Requested (PC-12)	Under Development (PC-12)
2024-2031	0.005	CARB (0.05 - 0.02)			
2027	0.005	EPA (0.035)			
2027-2032			GHG Phase 3		

HD Specifications



HD Specifications

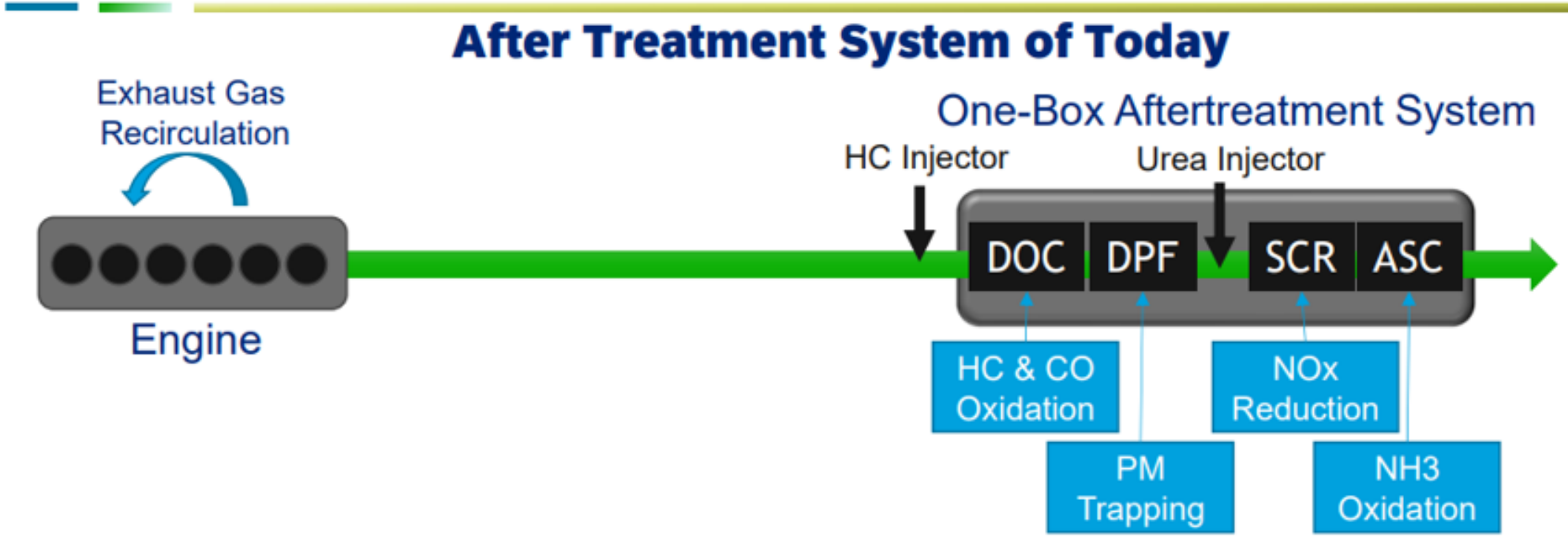
Green House Gas Phase 2 (GHG2) Emissions Phase-In
Green House Gas Phase 3 (GHG3) on the Horizon



Reduction in Fuel Consumption and GHG Emissions compared to MY 2017 Baseline	MY 2021	MY 2024	MY 2027
Combination Tractors*	13%	20%	25%
Trailers	5%	7%	9%
Heavy Duty Pickup Trucks and Vans	2.5%	10%	16%
Vocational Vehicles*	12%	20%	24%
*Separate Engine Standards (tractor, vocational)			4-5%

HD Specifications

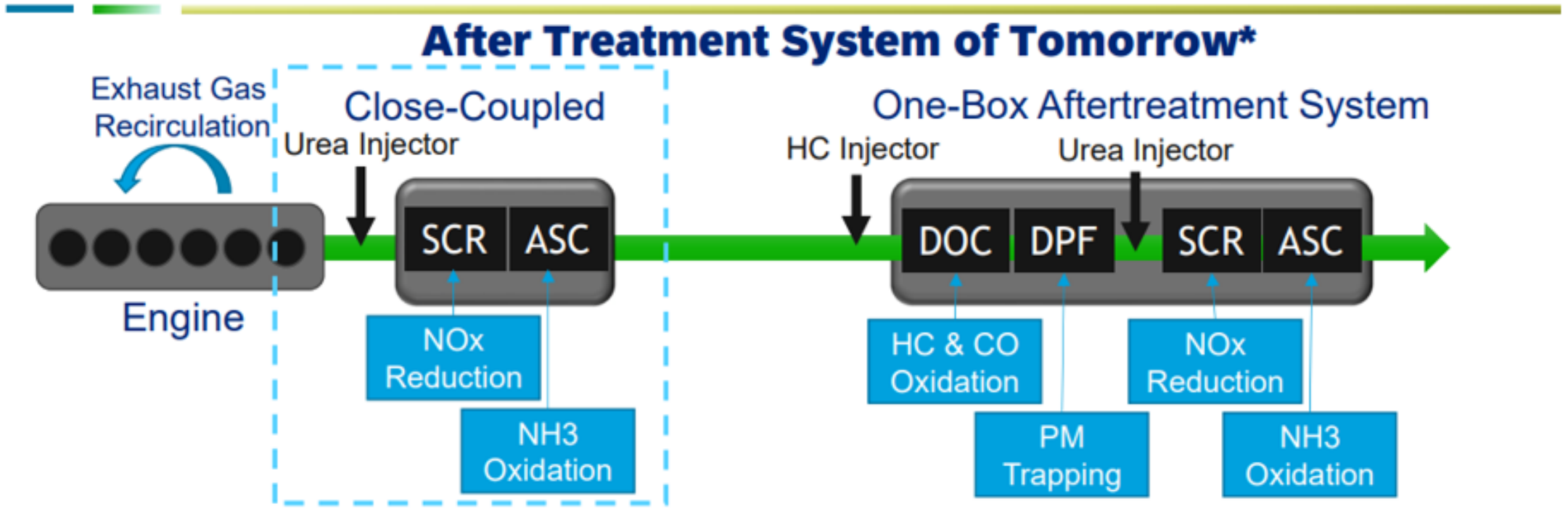
More complex aftertreatment systems are required



DOC – Diesel Oxidation Catalyst
DPF – Diesel Particulate Filter
DEF – Diesel Exhaust Fluid (Urea)
SCR – Select Catalytic Reduction
ASC – Ammonia “Slip” Catalyst

HD Specifications

More complex aftertreatment systems are required



DOC – Diesel Oxidation Catalyst
DPF – Diesel Particulate Filter
DEF – Diesel Exhaust Fluid (Urea)
SCR – Select Catalytic Reduction
ASC – Ammonia "Slip" Catalyst

*Based on possible solution for Class 8 Truck proposed by CARB/EPA research

HD Specifications

Longer warranties and useful life for engines and aftertreatment systems

Warranty periods and useful life periods for heavy-duty engines						
	Warranty period			Aftertreatment system useful life periods		
	Miles	Years	Hours	Miles	Years	Hours
Current	100,000	5	–	435,000	10	22,000
MY 2027 and later	450,000	10	22,000	650,000	11	32,000

PC-11

API CK-4 & FA-4: Why Two API Oil Categories?

API CK-4

More Robust API CJ-4
Recommended by all OEMs
Full backward compatibility

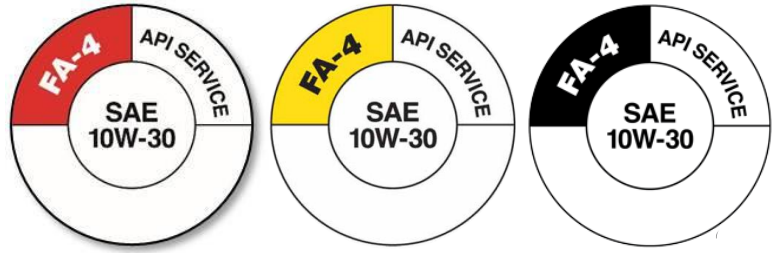
SAE xW-30 and xW-40
HTHSV > 3.5 mPa•s
API CK-4, ACEA E

API FA-4

Robust CJ-4 at lower viscosity
Some OEM's opted out
Not backward serviceable

SAE xW-30
HTHSV: 2.9 – 3.2 mPa•s
API FA-4, New ACEA F

API CK-4 has the same durability requirements as API FA-4 to minimize risks associated with the new lower viscosity fuel economy grades



Combination of New and Carry forward tests from **API CJ-4**

PC-11

API CK-4 & FA-4: Test Requirements

	Test	Performance Parameters	Fuel Sulfur
Legacy Tests	Caterpillar C13	Piston Deposits, Oil Consumption	15 ppm
	Caterpillar 1N	Aluminum Piston Deposits, Oil Consumption	500 ppm
	Cummins ISB	Valve Train Wear	15 ppm
	Cummins ISM	Valve Train Wear, Filter Plugging, Sludge	500 ppm
	Roller Follower Wear Test	Roller Follower Pin Wear	500 ppm
	Mack T-11	Soot Induced Viscosity Increase	500 ppm
	Mack T-11A	Sooted Oil Low Temperature Pumpability	500 ppm
	Mack T-12	Ring/Liner Wear parameters only	15 ppm
New	**Volvo T-13**	**Oxidation**	**15 ppm**
	Caterpillar C13 Oil Aeration Test (COAT)	**Oil Aeration**	**15 ppm**

PC-11

API CK-4 & FA-4: Improving Oxidation

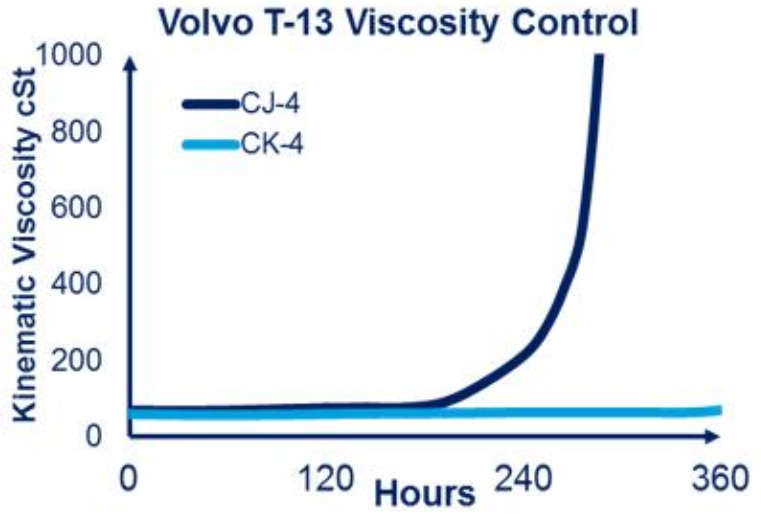
ASTM D8048 (Volvo T-13 Oxidation Test)

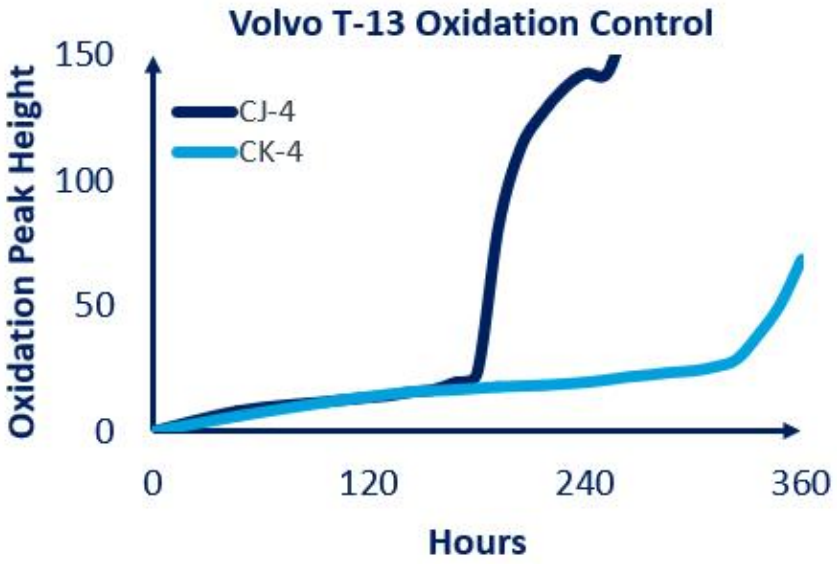
- 13L Mack MP8 diesel engine
- 360 hours steady-state test
- Oil temperatures:
  - 130°C main gallery
  - 140°C sump

API CK-4 & FA-4 Limits:

- T-13 FTIR Oxidation Peak Height: 125 max
- KV 40C % increase (300-360 hr): 75% max

- **Drove more anti-oxidants into oil**
- **Largest increase of any API oil category!**



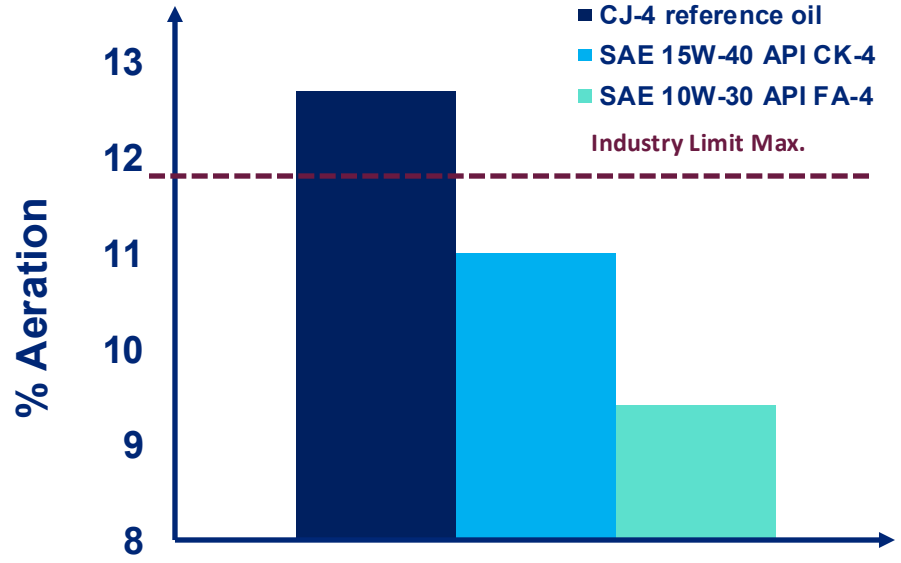


PC-11

API CK-4 & FA-4: Improving Aeration

ASTM D8047
(Caterpillar-C13 Oil Aeration Test)

- 13 L diesel engine
- 50 hours duration
- Aeration is measured real time via a Micromotion meter which measures oil density



API CK-4 & FA-4 Limits:

- Average % aeration 40-50 hrs: 11.8% max

- **Drove rebalance of additives, promotes lighter SAE viscosity grades**

PC-12 – Category Proposal

	2023		2024		2025		2026		2027
	1H	2H	1H	2H	1H	2H	1H	2H	1H
INDUSTRY	NCDT				Tech Demo + Limit Setting		Mandatory Waiting Period		First Allowable Use January 1, 2027

PC-12 Timeline

PC-12

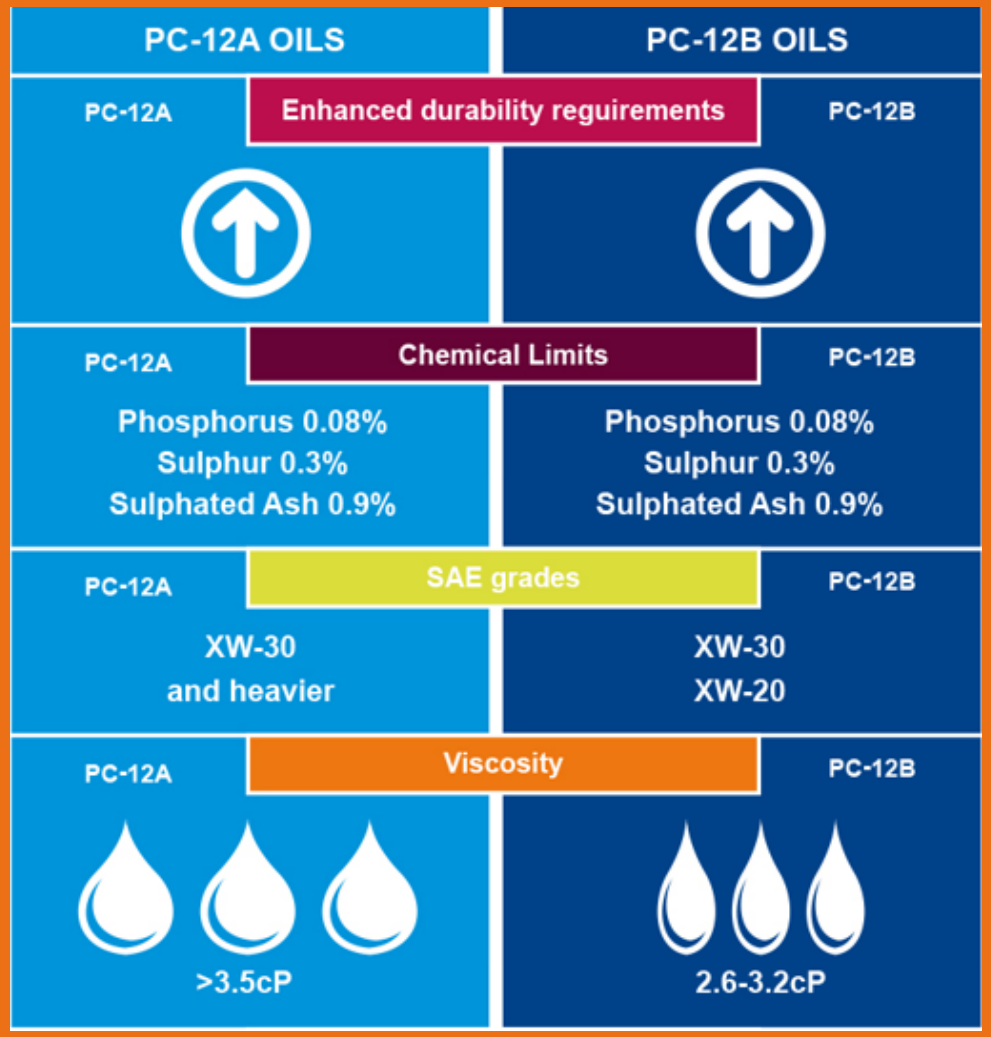
Tests Included in PC-12

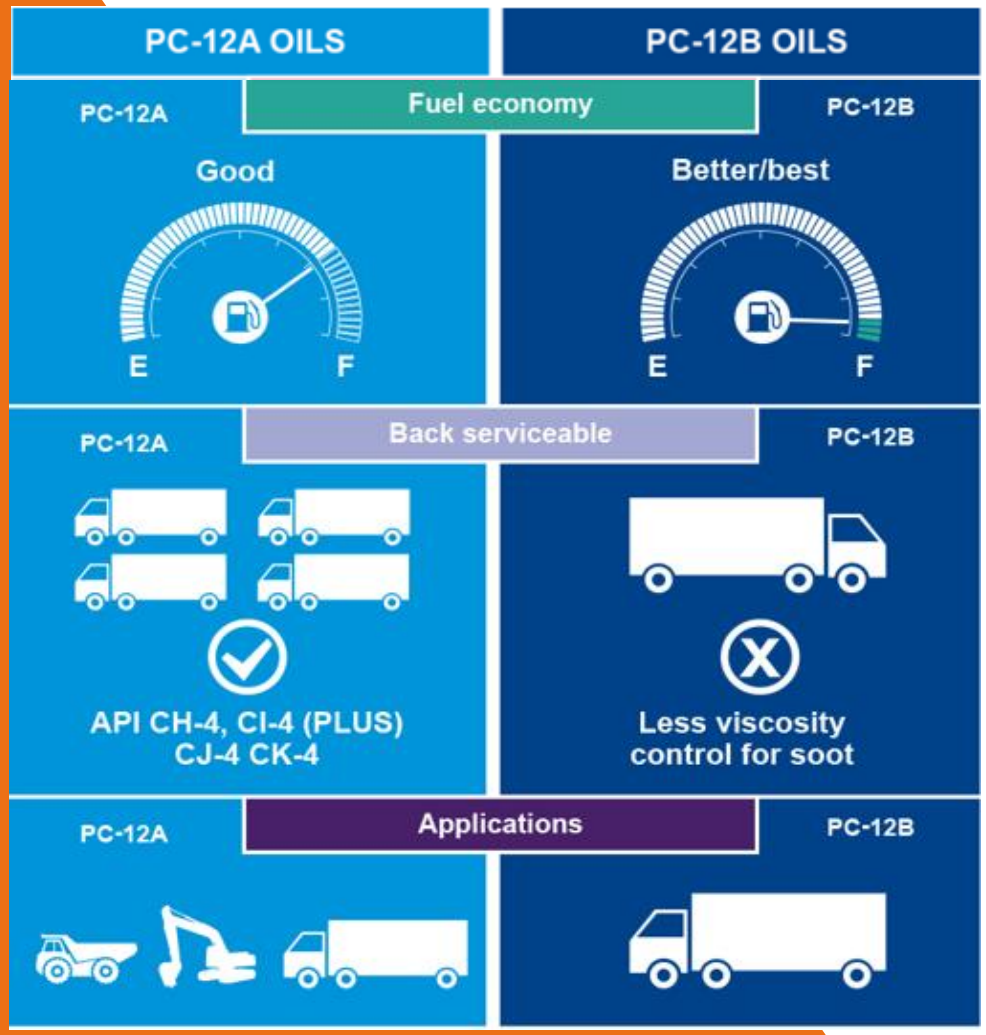
	Characteristic	Test that measures parameter	Upgraded/ changed for PC-12	Limits	
				PC-12a	PC-12b
Bench tests	High Temperature / High Shear Limit (Fresh Oil)	HTHS	X	CK-4	2.6 – 3.2 cP
	High Temperature / High Shear Limit (After Shear Oil)	HTHS	X	CK-4	TBD
	Mass fraction of sulphated ash	ASTM D874	X	0.9% max	
	Mass fraction of phosphorus	ASTM D5185/D4951	X	0.08% max	
	Mass fraction of sulfur	ASTM D5185/D4951	X	0.3% max	
	Elastomer Compatibility	ASTM D7216	X	Additional material added (HNBR)	
	Used Oil Viscometrics (Low Temp)	MRV (Cummins ISB Viscosity)	X	CK-4	TBD
	High Temperature Corrosion	HTCBT		CK-4	FA-4
	Shear Stability	ASTM D7109	X	CK-4	TBD
	Volatility	NOACK		CK-4	FA-4
	Foaming	ASTM D892		CK-4	FA-4
Engine tests	Soot / EGR Valvetrain Wear Valve Stem / Guide Wear Filter Plugging / Sludge	ISM		CK-4	FA-4
	Piston Deposits, Fe and Oil Consumption	C13		CK-4	FA-4
	Soot Valvetrain Wear (Sliding Wear)	ISB		CK-4	FA-4
	Thermal Stability (Oxidation)	T-13	X	Targeting FTIR Peak ≤ 80, KV40 Inc. % ≤ 50	
	Oil Aeration	COAT		CK-4	FA-4
	Soot Viscosity in EGR Engines	Cummins ISB Viscosity	X	CK-4	Targeting 12 cSt at 4.8% Soot
	Piston / Liner Scuffing Wear (Adhesive)	DD13	X	Targeting 31 hrs to scuff	

New test development New test added Existing test new limits

PC-12

Anticipated Changes for PC-12





HD Specifications

Current Category OEM Specifications and Recommendations

OEM	API CK-4	API FA-4
Cummins	CES 20086	CES 20087
Detroit Diesel	DFS 93K222	DFS 93K223
Mack	Mack EOS-4.5	Mack EOS-5
Volvo	Volvo VDS-4.5	Volvo VDS-5
Caterpillar	API CK-4	
Navistar	API CK-4	API FA-4
PACCAR	API CK-4	
GM (Duramax 6.6L)	API CK-4	
Ford (Power Stroke 6.7L)	WSS M2C171-F1	
Ford (Power Stroke 3.0L)		WSS M2C214-B1

HD Specifications

Expected Category OEM Specifications for PC-12

OEM	Specification	Chemical Limits
Cummins	Updated "C" Category (CES 20086+)	0.08% max P 0.3% max S 0.9% max SASH
	Updated "F" Category (CES 20087+)	
Detroit Diesel Corporation	Market General Updated "C" Category (DFS 93K222+)	0.08% max P 0.3% max S 0.9% max SASH
	Market General Updated "F" Category (DFS 93K223+)	
	Extended ODI Updated "C" Category (DFS 93K222+)	0.08% max P 0.3% max S 0.9% max SASH
	Extended ODI Updated "F" Category (DFS 93K223+)	
Volvo	VDS-4.5 for "C" Category Oil (Not Upgrading for 2027)	0.12% max P 0.4% max S 1.0% max SASH
	New VDS Specification	0.08% max P 0.3% max S 0.9% max SASH

OEM	Specification	Chemical Limits
Navistar	CL-4, FB-4	
PACCAR	CL-4, (FB-4 TBD)	
Ford	WSS M2C171-F1 (Not upgrading for 2027)	0.12% max P 0.4% max S 1.0% max SASH

HD Specifications

Current OEM Oil Drain Intervals

	<5.0 MPG	5.0-5.5 MPG	5.5-6.0 MPG	6.0-6.5 MPG	6.5-7.0 MPG	>7.0 MPG	> 7.5 MPG
Cummins X15	25k miles	50k miles		60k miles		75k miles (up to 100k with Oil Guard)	
Detroit DD15	35k miles	45k miles		60k miles		75k miles	
Detroit DD13	35k miles	40k miles		55k miles		65k miles	
Navistar A26	20k miles		30k miles		50k (up to 70k with oil sampling)		
Mack MP7/MP8	35k miles* / 30k miles	45k miles* / 40k miles		60k miles* / 55k miles			
Volvo D11/D13	35k miles**/ 30k miles	45k miles**/ 40k miles		60k miles**/ 55k miles			75k miles**/ 55k miles

	Severe / Vocational	Normal / Line Haul, >20% Idle	Normal / Line Haul, < 20% Idle
PACCAR MX-11/MX13	25k miles	50k miles	60k miles

* Using Genuine Mack EOS-4.5 Premium Oil
** Using Volvo Premium Motor Oil VDS-5

Severe
Short Haul / Heavy
Long Haul / Normal
Efficient Long Haul / Light / Economy

PC-12 Market Implications

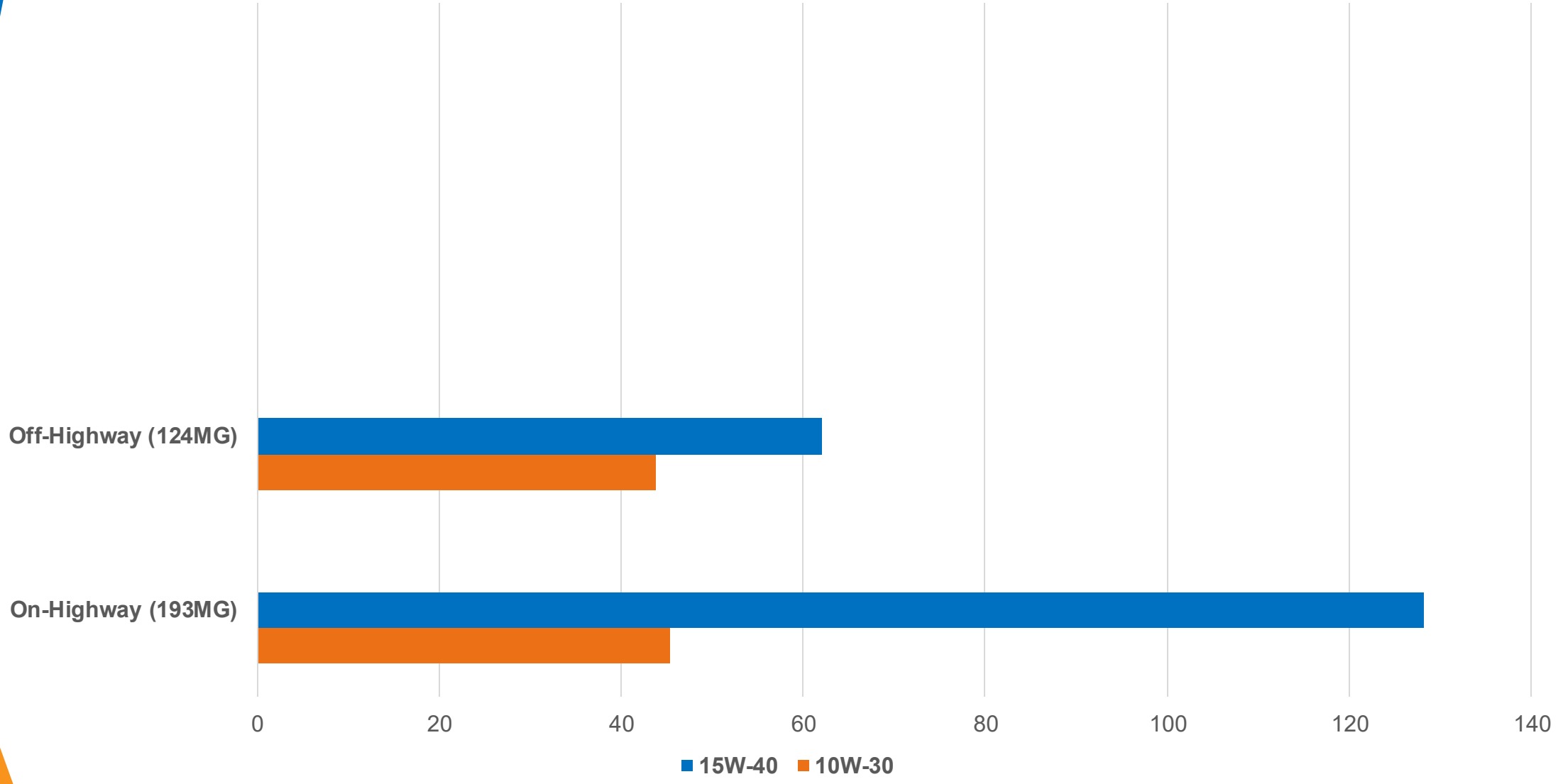
Structure, Pacing & Transition

From Specification
to Market Implication

- API CL-4 and FB-4 targeted for 2027
- OEM alignment progressing
- **Adoption will be shaped by market structure, not just category launch timing.**

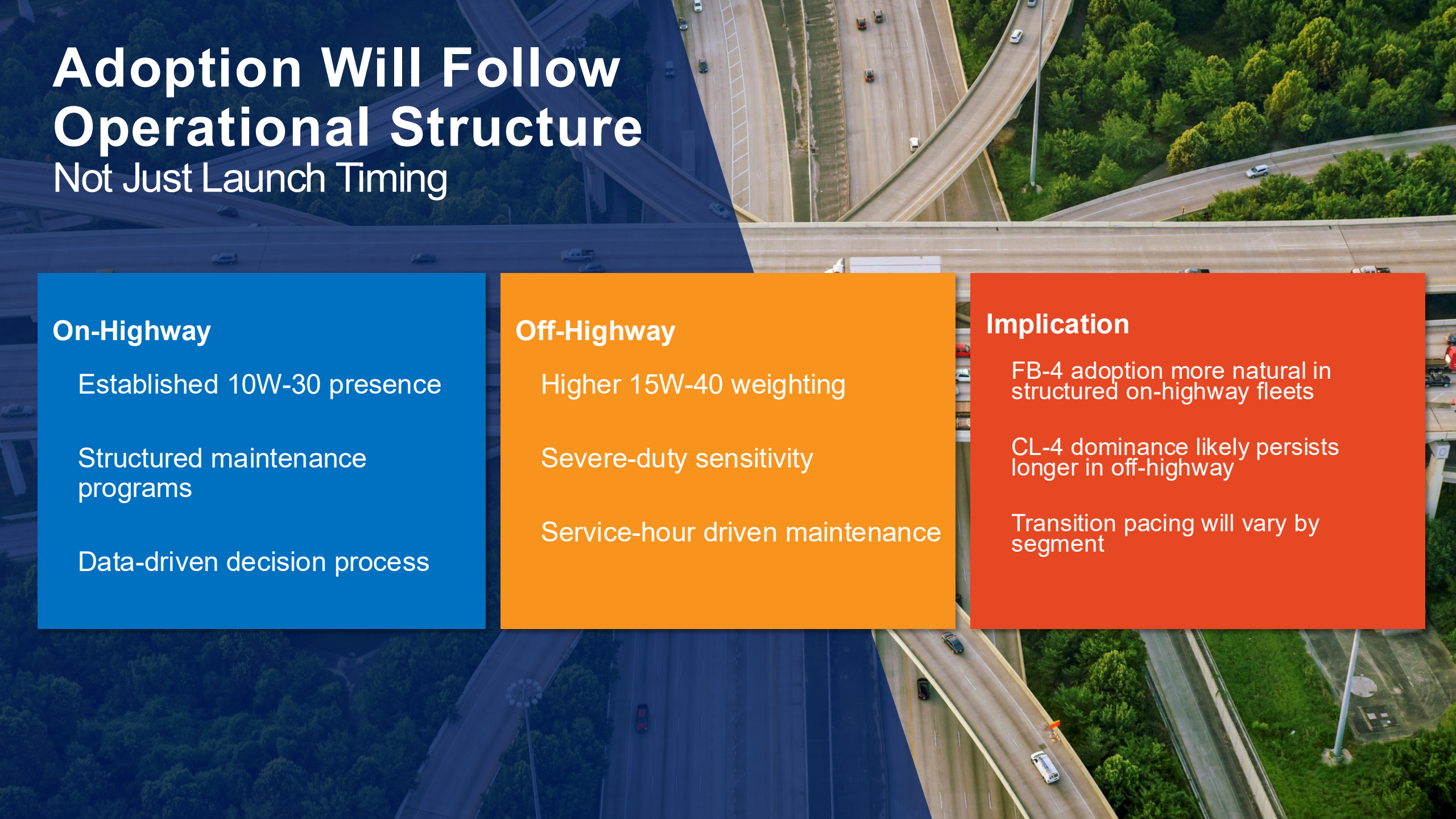
Visual horizontal timeline:
2025–2026 → OEM approvals & communication
2027 → First allowable use
2028+ → Phased fleet transition

2025 HDMO Viscosity Demand by Segment
(Million Gallons)



Adoption Will Follow Operational Structure

Not Just Launch Timing



On-Highway

- Established 10W-30 presence
- Structured maintenance programs
- Data-driven decision process

Off-Highway

- Higher 15W-40 weighting
- Severe-duty sensitivity
- Service-hour driven maintenance

Implication

- FB-4 adoption more natural in structured on-highway fleets
- CL-4 dominance likely persists longer in off-highway
- Transition pacing will vary by segment

Maintenance & Purchasing Structure

Influence Transition Pace

On-Highway

- 40,000 mile oil intervals
- Oil analysis commonly utilized
- Structured maintenance programs
- Centralized / contract-based purchasing common in larger fleets

Off-Highway

- 250–500 hour intervals (construction/mining)
- 500–600 hour intervals (agriculture)
- Service-hour driven maintenance
- Purchasing more fragmented, OEM/dealer influence stronger

Transition Becomes Feasible

When Fleet Mix Aligns

Mixed Fleet Reality

- Fleets operate equipment from multiple model years simultaneously
- New engines enter service gradually
- Older units remain in operation for extended periods

Operational Constraint

- Changes must be implemented across diverse equipment
- Maintenance programs evolve deliberately
- Inventory decisions tied to fleet composition

Implication

- Migration likely phased rather than immediate
- API CK-4 and CL-4 overlap expected
- Timing varies by fleet structure and segment

CK-4 and CL-4:
Coexistence During Transition

What Coexistence Means

CK-4 does not disappear in 2027

CL-4 introduction does not require immediate replacement

Both categories may be present during transition

What it Does NOT Mean

Automatic drain interval extension

Universal FB-4 applicability

Immediate SKU elimination

Messaging Discipline

Align with OEM guidance

Avoid overstatement

Set realistic expectations

Where Decision Pressure
is Likely to Happen

Inventory & Portfolio Strategy

- When to reduce CK-4 exposure?
- How long to support dual categories?
- Balancing simplification with service risk

Compatibility Interpretation

- Clarifying backward compatibility scope
- Avoiding assumptions across mixed applications
- Separating CL-4 from FB-4 positioning

Drain Interval Expectations

- Category update does not automatically extend drains
- OEM guidance remains primary
- Validation precedes interval changes

How Different Decision Makers

Will Evaluate CL-4 and FB-4

Maintenance Leader

- Uptime and reliability
- Validation through oil analysis
- Alignment with OEM recommendations

Fleet Operations / Management

- Risk mitigation
- Warranty compliance
- Implementation timing

Procurement / Supply Chain

- SKU rationalization
- Inventory complexity
- Contract and pricing stability

Off-Highway Equipment / Operations Manager

- Durability under load
- Proven field performance
- Conservative adoption bias

Signals to Monitor

Between Now and 2027

OEM Approvals & Specifications

- Formal CL-4 and FB-4 approvals
- Positioning within OEM service literature
- On-highway vs off-highway alignment

Inventory Behavior

- Distributor stocking adjustments
- CK-4 rationalization timing
- Regional variation in demand

Fleet Communication Shifts

- Procurement inquiries about transition timing
- Questions around SKU simplification
- Drain interval assumption trends

Contract & Maintenance Cycles

- Renewal timing in larger fleets
- PM standardization discussions
- Oil analysis program updates

CL-4 and FB-4:

An Evolution, Not a Disruption

The Market Is Structured

- Viscosity demand differs by segment
- Maintenance cadence varies
- Purchasing behavior is not uniform

Friction Will Be Operational

- Inventory management
- Compatibility interpretation
- Drain interval expectations

Transition Will Be Phased

- Adoption aligned with fleet readiness
- Equipment lifecycle influences timing
- Coexistence expected

Clarity Drives Credibility

- Discipline in messaging
- Alignment with OEM guidance
- Avoid overstatement

Questions?

Please post your questions using the Q&A function.

For technical inquiries or issues:
Lubes Answer Line 800-248-4684
lubeshelp@citgo.com

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Thank You!

See you next time