



Small engine lubricants

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September 10th, 2026

The small engine market

Chainsaws & Garden Equipment



Motorcycles & Mopeds



Snowmobiles



Personal Water Crafts



Outboards



Overview for today's discussion

1

Overview of 2T and 4T engines and applications

2

2T and 4T Lubricant Needs

3

Specifications:

- **Snowmobiles**
- **Leisure Marine**
 - 2T Outboard Engine Oils- NMMA TC-W3® Outboard Oils
 - 4T Marine Engine Oils -NMMA FC-W® and FC-W Catalyst Compatible®
- **Motorcycles and Mopeds**
 - 4T Motorcycle oils JASO T903 Specification
- **Garden Equipment and Generators**
 - 2T Low Ash Oils JASO M345 2T standard

Both four stroke and two stroke engines are commonly used in small engine applications

Emission regulations have driven technology towards 4T engines and electrification, but many 2T engines are still in use.

	In North America:
Outboards	Essentially all new engines are 4T, but a large population of 2T remains
Motorcycles	Population and sales are virtually all 4T
Snowmobiles	Mix of 2T and 4T new engines. Large 2T population base still exists
PWCs	All new engines are 4T, but still a significant 2T segment
Chainsaws	Still mainly 2T, but 4T options are available
String trimmers	Still mainly 2T, but 4T options are available
Leaf blowers	Still mainly 2T, but 4T options are available
Lawn mowers	Population and sales are virtually all 4T

Descriptions are used interchangeably
for small engines

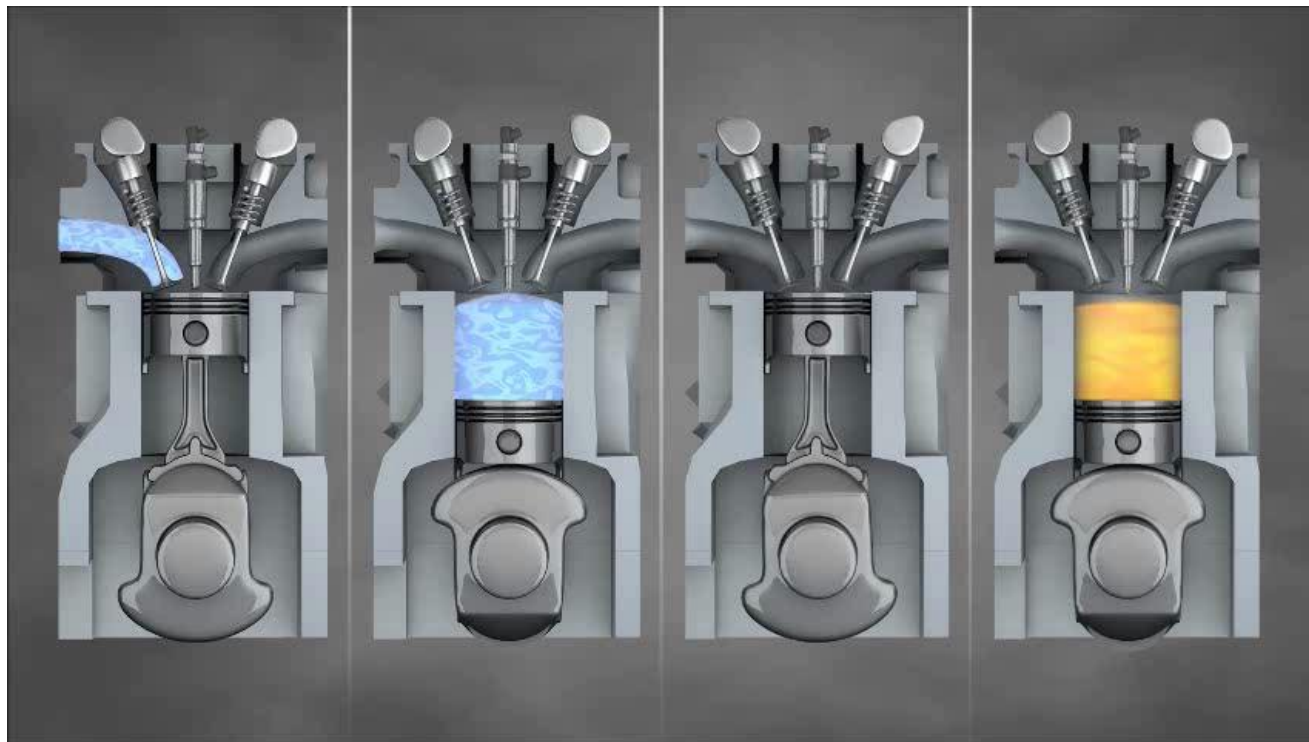
Four stroke cycle
Four stroke
Four cycle
4T

Two stroke cycle
Two stroke
Two cycle
2T

“**T**” in 4T & 2T comes from the French term “***temps***”
meaning “**time**” or “**stroke**”
(the translation is not precise)

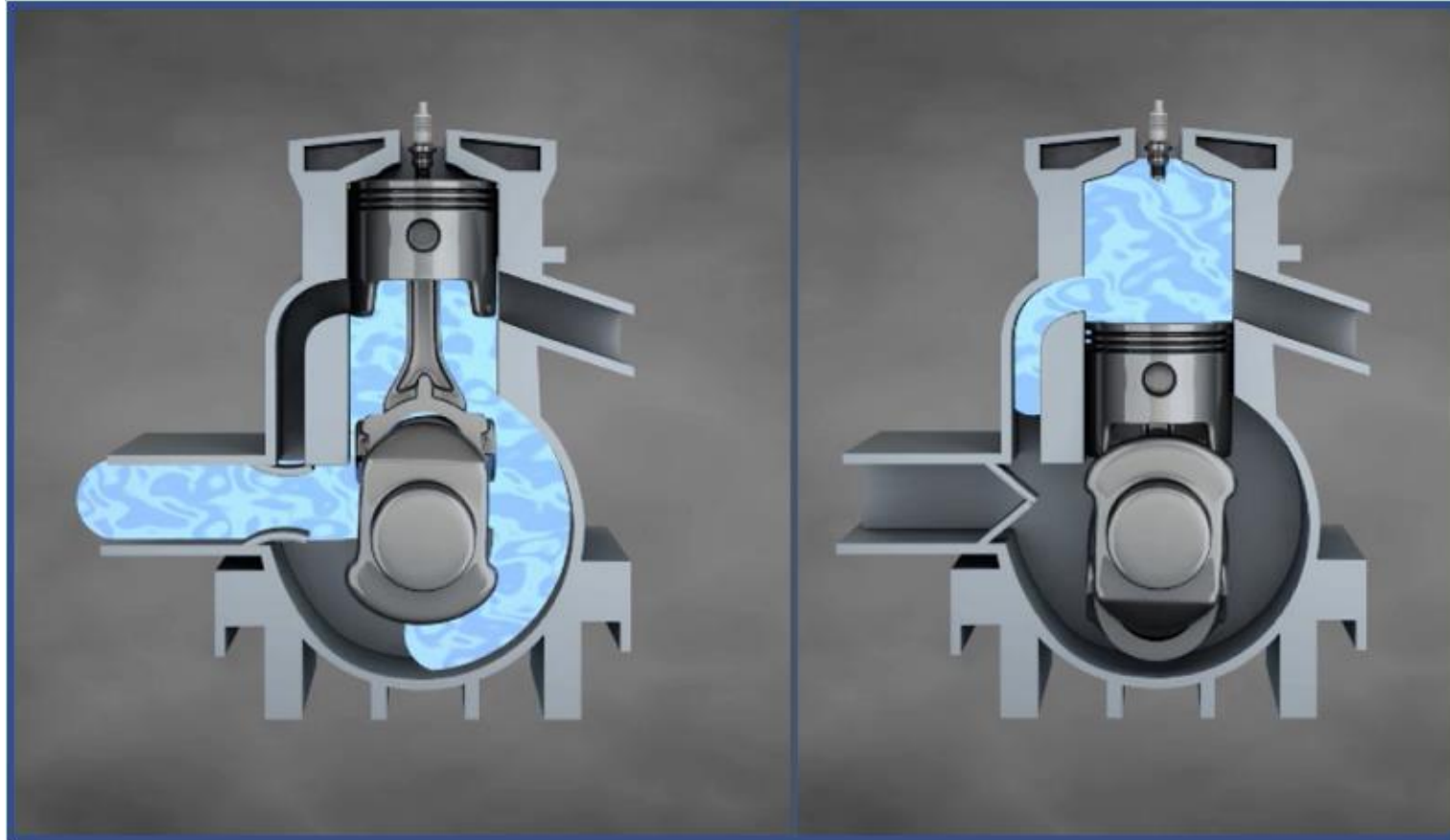
Traditional four stroke engine

Four-stroke Cycle = Four-stroke = Four Cycle = 4T



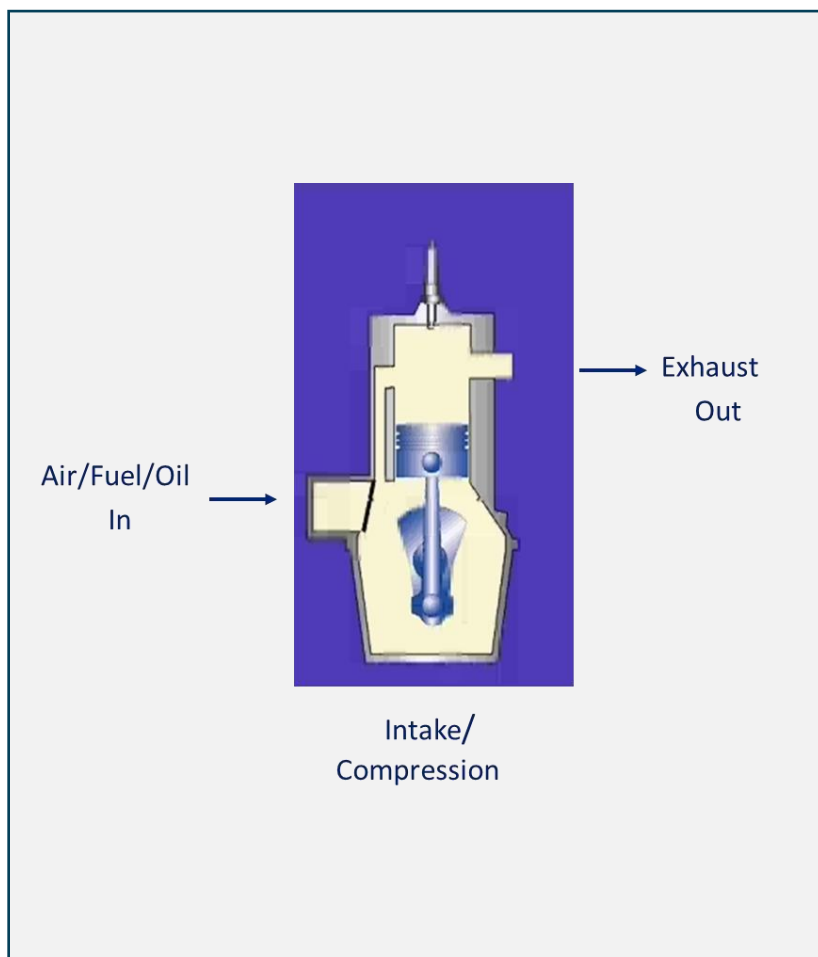
- The sump is oil filled and the oil recirculates
- Inherently low emissions

Traditional two stroke engine



- More power / less weight
- Two stroke engines mix oil with the fuel and consume the oil

How two stroke engines are lubricated



- **Oil is mixed in the fuel (usually at 50:1)**
 - Traditionally, oil would be mixed in the fuel tank
 - In modern engines the oil is injected into fuel line
- **Evaporation of the fuel** deposits oil on the cylinder walls and bearings to lubricate them
- Fuel and oil in the combustion chamber are **ignited by the spark plug**
- **Replacement oil** is delivered with fresh fuel/air
- Traditional over-fueling design causes **high emissions**

Both two stroke and four stroke engines have advantages

Two stroke

Advantages:

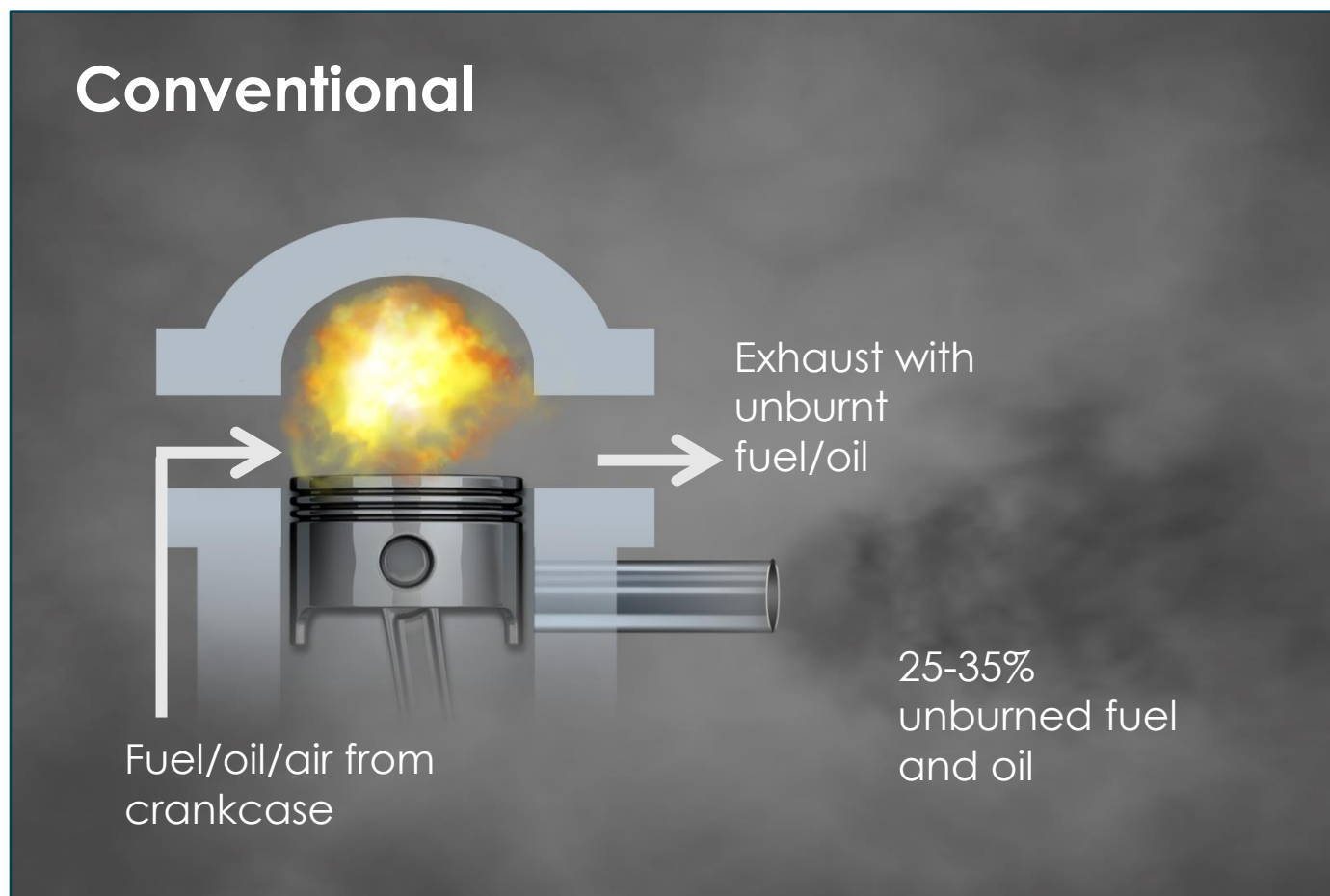
- Two-stroke Engines have an excellent Power to Weight Ratio
- Fewer Parts than a Four Stroke Engine
- Small, Compact Engines
- Low Cost
- Low Nitrogen Oxides (NOx) Emissions
- Less Engine Weight

Four stroke

Advantages:

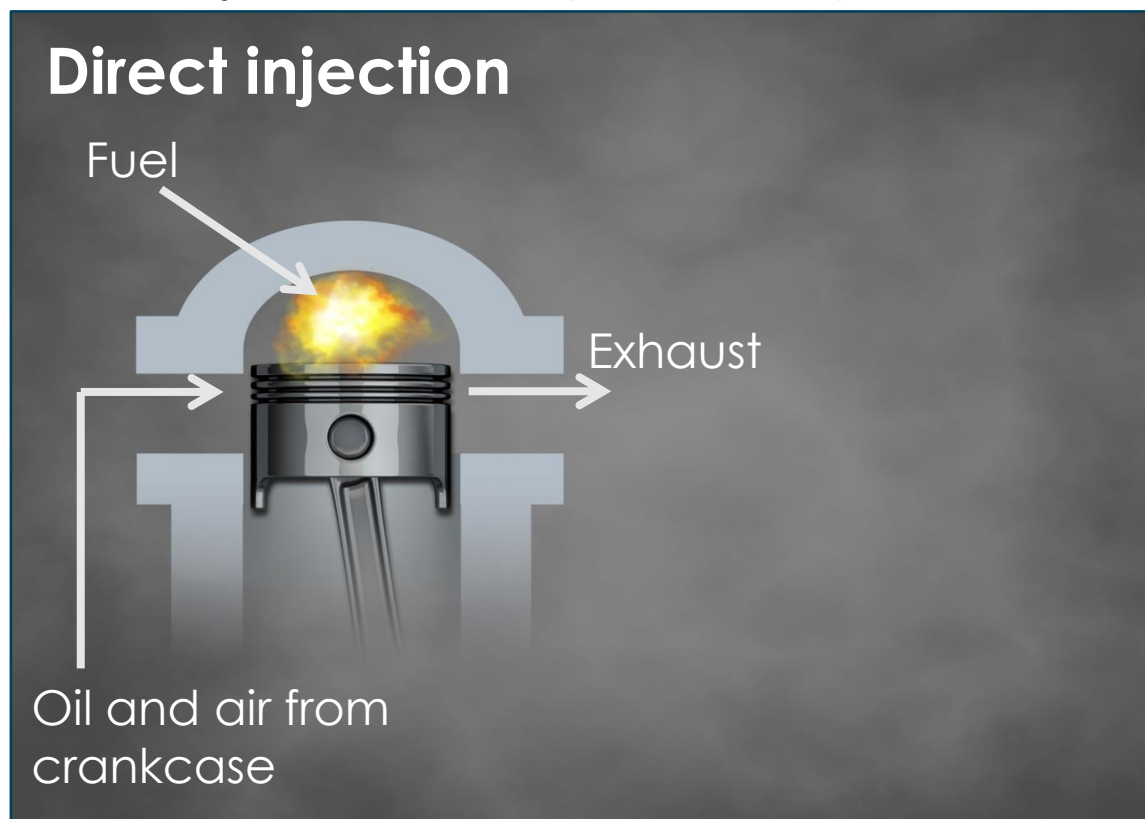
- 20-40 % Better Fuel Economy
- Smooth and Quiet Operation
- Low Hydrocarbon (HC) and Carbon Monoxide (CO) Emissions

Conventional 2T engines have high hydrocarbons emissions due to unburned fuel



2T direct fuel injection (DFI) is a way to address emissions

Fuel is injected when piston is top dead



Notice: Exhaust port is blocked, therefore reduced emissions

DFI makes 2T outboard engine service more severe

Higher temperatures

- In traditional 2T engines, fuel vaporizes in the crankcase, cooling the engine
- In DFI, fuel bypasses the crankcase, **raises engine temperature by 50°C**

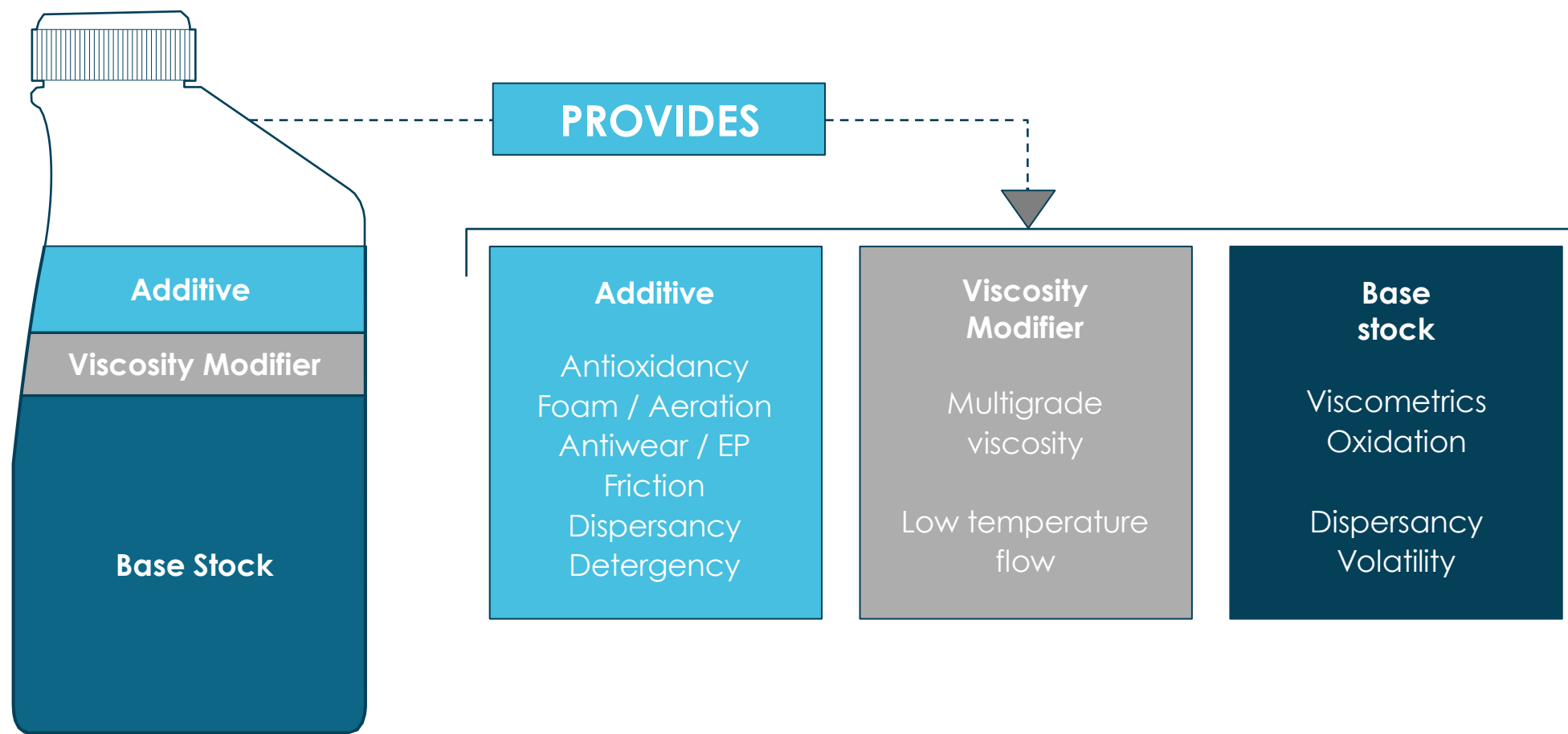
Less oil delivered to critical surfaces

- In DFI, air alone carries the oil, which is less efficient
- Oil must often be pumped to the cylinders for extra lubrication
- Oil flow is reduced, touted as an advantage for the consumer

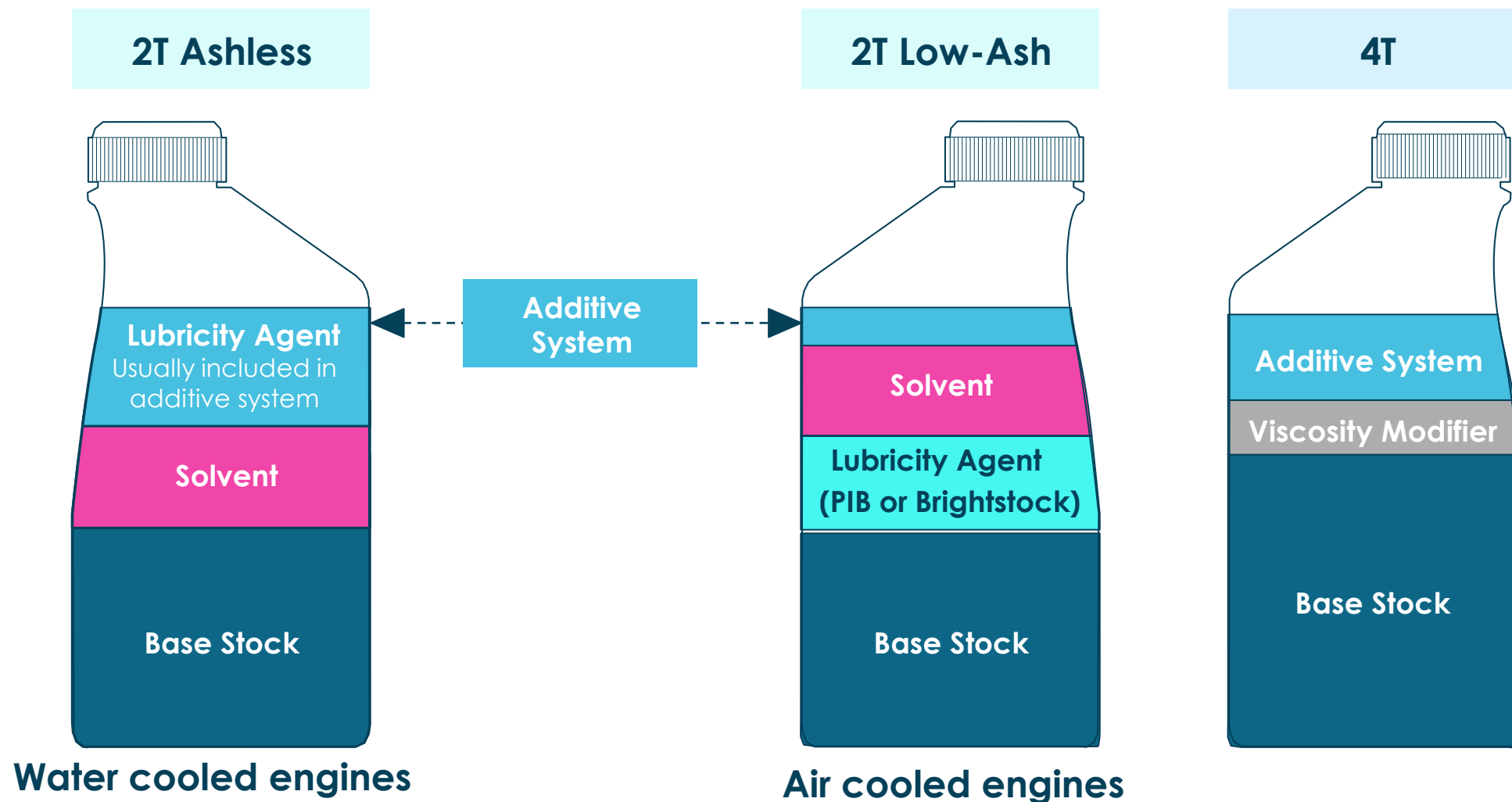
Combination of less oil and higher temperatures makes DFI engines more prone to scuffing and failure

- Deposits build up in the ring grooves behind the rings due to higher temperature, and there's less oil (cleaners) to prevent it
- Rings are pushed out by the deposits and they apply pressure to the cylinder liners, reducing film thickness and eventually causing metal-to-metal contact (scuffing) or called ring jacking, or proudness

What goes into a 4T lubricant?

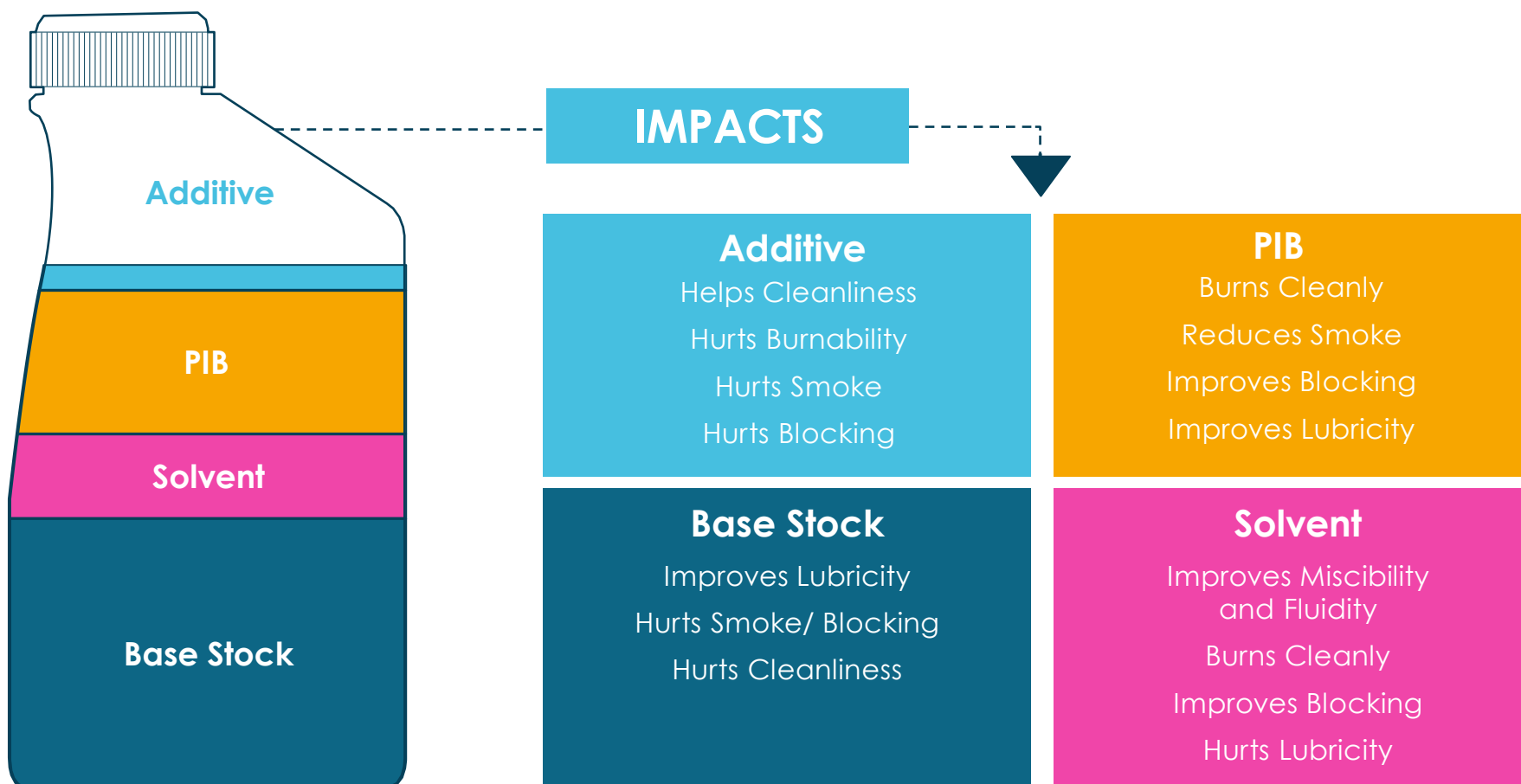


There are two types of 2T oils



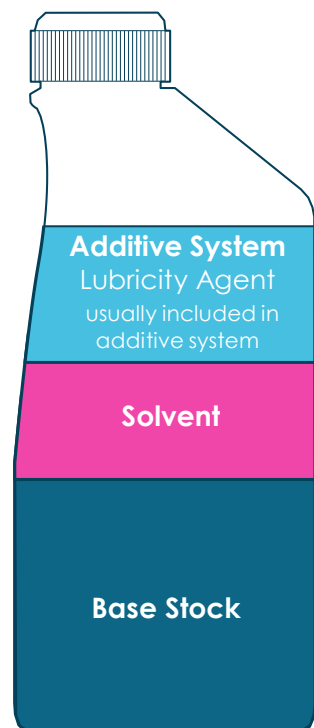
What goes into a 2T lubricant?

Desirable oil characteristics are cleanliness, low smoke, high lubricity, and low exhaust deposits (blocking)



Ashless formulations

2T Ashless



**Water cooled
engines**

Ashless additive system required to prevent pre-ignition in water cooled outboard engines

- Historically, pre-ignition was a major problem for outboards
- Engines run cooler, so ash deposits are less brittle and build up, causing pre-ignition

Ashless formulations have specialized additive packages that treat at significantly higher levels.

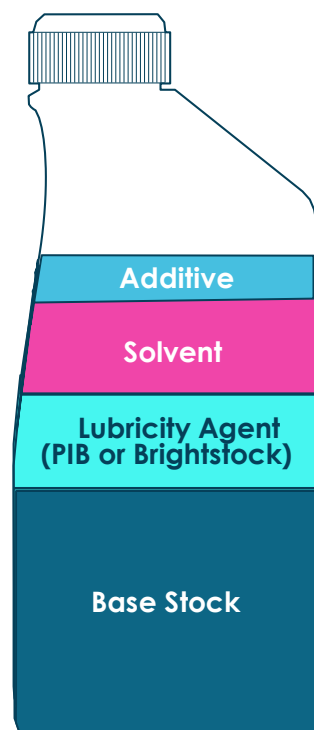
- A significant treat rate of ashless dispersants is used to compensate for not using detergent chemistry
- Lubricity agent component incorporated into the additive package.
- Polyisobutylene is used for improved lubricity and exhaust smoke performance

Solvent provides low temperature fluidity

- Important for oil-injected systems

Low ash formulations

2T Low Ash



Air cooled engines

Low ash additives and metal detergents are used for air cooled land equipment

- Lower cost and lower treat rate

Engines run hotter so can tolerate some ash without causing pre-ignition

- Ash deposits formed are thin and brittle, so blow out of the exhaust

Solvent is used to improve miscibility of the oil with the fuel

- But it does lower the oil's flash point – a safety / storage consideration

Polyisobutylene (PIB) used to improve lubricity whilst reducing exhaust smoke

- Traditionally brightstock was used for lubricity
- Brightstock has poor smoke performance

Snowmobile oils



There are no industry standards for snowmobile oils

~1.9 Million snowmobiles registered in use in North America in 2025

For Two-stroke Engines:

- Both ashless and low ash additive systems recommended by OEMs
- Requires low pour point and low-temperature fluidity
 - OEMs Recommend Pour Point $\leq -40^{\circ}\text{C}$
 - Brookfield fluidity
 - Good: $< 60,000 \text{ cP @ } -40^{\circ}\text{C}$
 - Best: $< 17,000 \text{ cP @ } -40^{\circ}\text{C}$ (J1536 grade 4)
- Exhaust odor an issue due to trail riding
- Exhaust valves (deposits) can cause poor performance at high RPM
 - Partially burned and unburned fuel and oil can create deposits on the sliding surfaces of the exhaust valves and cause them to stick

For Four-stroke Engines:

- OEMs generally recommend 0W grades.
- Most oils are at least part-synthetic, if not full synthetic

Outboard or water cooled oils



NMMA oversees leisure marine oil quality standards



Oil standards exist for leisure marine oils



National Marine Manufacturers Association



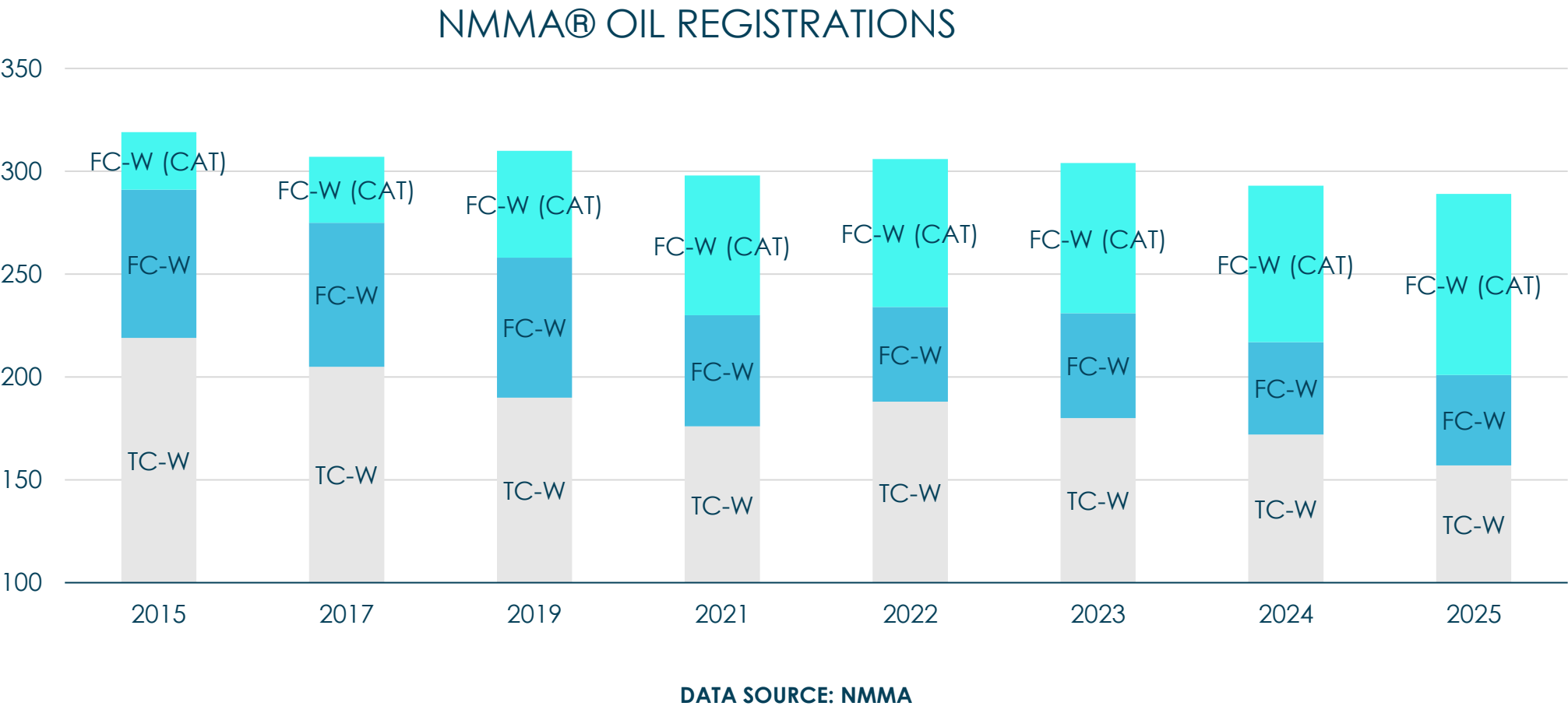
Two-Cycle - Water



Four-Cycle - Water



NMMA registrations around 300 world wide



Most outboard OEMs favor 4T technology

~14 Million recreational powered boats registered in use in North America

Most OEMs are using 4T outboard engine models to meet emission regulations

Mercury carries 4T engine designs, offering a 600hp V12 Verado (2022)

Yamaha favors 4T Technology offering a 450 Hp Outboard for offshore (2023)

Honda markets only 4T engines (2 hp to 350 hp)

Suzuki markets only 4T (portables up to V6 models)

No new investments in US in 2T outboard market

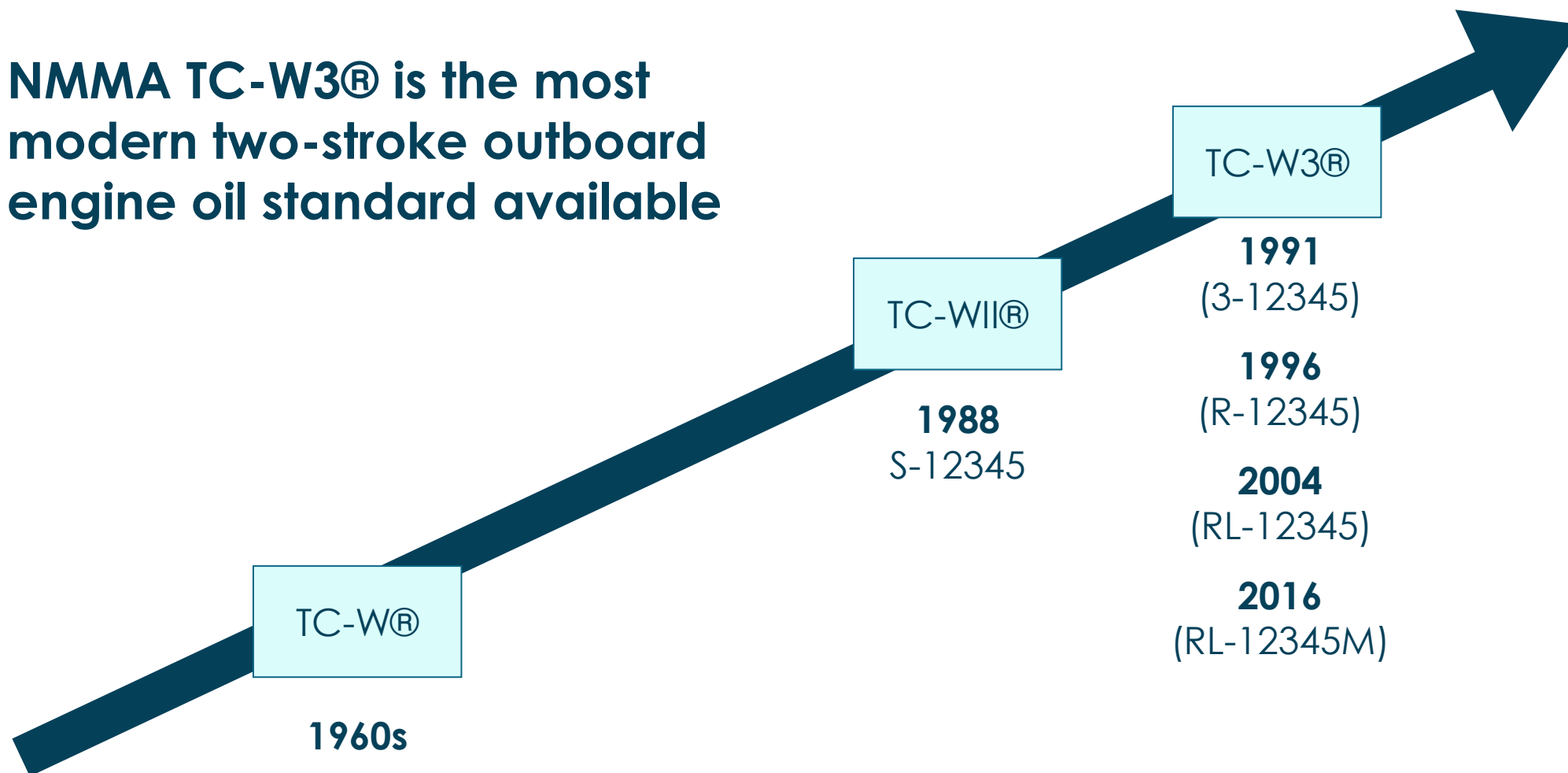
In 2020, BRP announced retirement of Evinrude brand and their exiting of the outboard market

Evinrude was very invested in 2T DFI technology, claimed improved fuel efficiency and emissions

Both **Mercury** and **Yamaha** have stopped producing 2T DFI outboards

Outboard OEMs have driven NMMA to develop higher 2T oil standards

NMMA TC-W3® is the most modern two-stroke outboard engine oil standard available



Demonstration test program ensures TC-W3® oils meet engine requirements

Analytical Testing

KV @ 40°C
 TBN
 Cloud Point
 Nitrogen
 FTIR Scan
 SASH
 Distillation

Bench Testing

Fluidity @ -25°C
 Miscibility @ -25°C
 Rust
 Filterability
 Compatibility

~\$300,000 USD for a full program

Engine Testing

CE-50 Lubricity (Yamaha 50 cc)
 Preignition (Yamaha 50cc)
 General Performance (OMC 40 HP)
 Detergency/Scuffing (Mercury 15 HP) x 2

NMMA TC-W3 certification read across

Formulation changes:

Allowed:

- Additive increases (+20% relative)
- Solvent concentration changes ($\pm 20\%$ relative) and substitutions
- PPD concentration changes ($\pm 1\%$) and substitutions (0.5%)
- PIB concentration changes ($\pm 25\%$ relative)
- Bright stock concentration changes ($\pm 10\%$)
- Base oil concentration changes ($\pm 25\%$) and supply changes
- NMMA Read across rules have been expanded to include base stock coverage to Group III

~\$1K-\$2K USD for a read-across

Not Allowed:

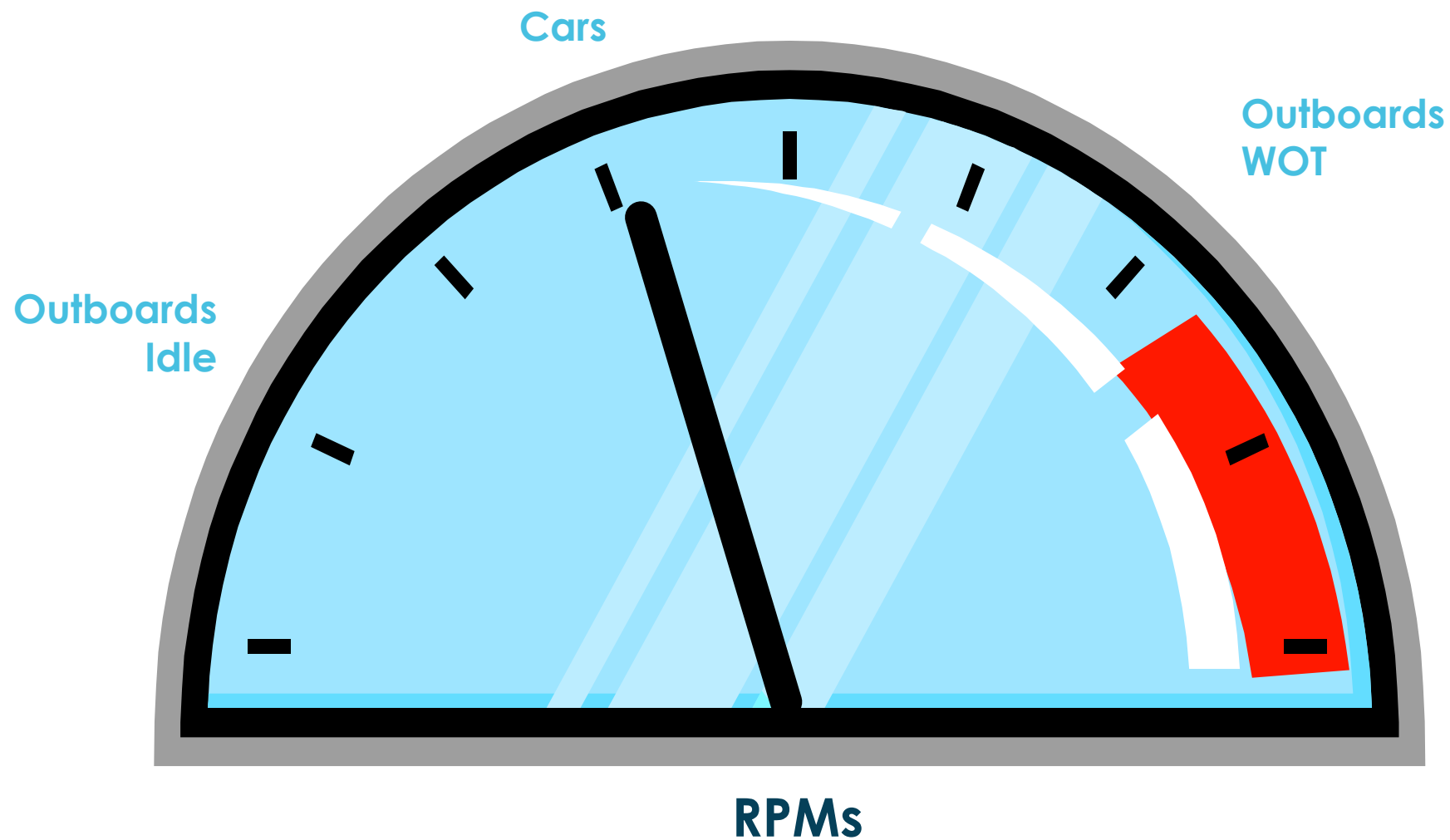
- Additive reductions and addition of new components

REQUIRED FOR ALL CERTIFICATIONS

- Marketers must obtain a trademark license from the NMMA
- License number must appear on the oil bottle
- Annual license fee per oil paid to NMMA by the oil marketer

Four stroke leisure marine oils

Marine engines operate differently from car engines



4T outboards' lubrication challenge

4T Outboard Engines operate very differently to PCMO

Vertical Engine

- Requiring exceptional bearing lubrication.

Driving regime (Idle to full throttle)

- High engine speeds, causing wear concerns
- Idle for long periods of time, causing high fuel dilution and potential for wear.

Operating Conditions

- Corrosive environments
- Cooler temperatures
- Often operate longer than recommended between oil changes, requiring improved antioxidancy.

Challenges to the Lubricant

- Bearing Durability
- Wear
- Rust
- Shear Stability

NMMA FC-W® standard establishes oil requirements

Identification

KV40°C
VI
Specific gravity
TBN
TAN
Elementals (Report all)
Sulfur
Nitrogen
IR Spectrum

Heritage

Minimum SG quality

Viscosity Grade Testing

KV100°C (Vis grade limits)
CCS (Vis grade limits)
MRV-TP1 (Vis grade limits)

Performance Bench Testing

Foam, Seq. I - III (Industry limits)
Foam, Seq. IV (200/50 max)
Shear Stability (Report)
HTHS (3.3 cP min after shear)
Mercury Rust Test (< than Ref. Oil)
Noack Volatility (Report)
EOFT (50% max)

Engine Testing

Yamaha 115 hp Gen. Perf.

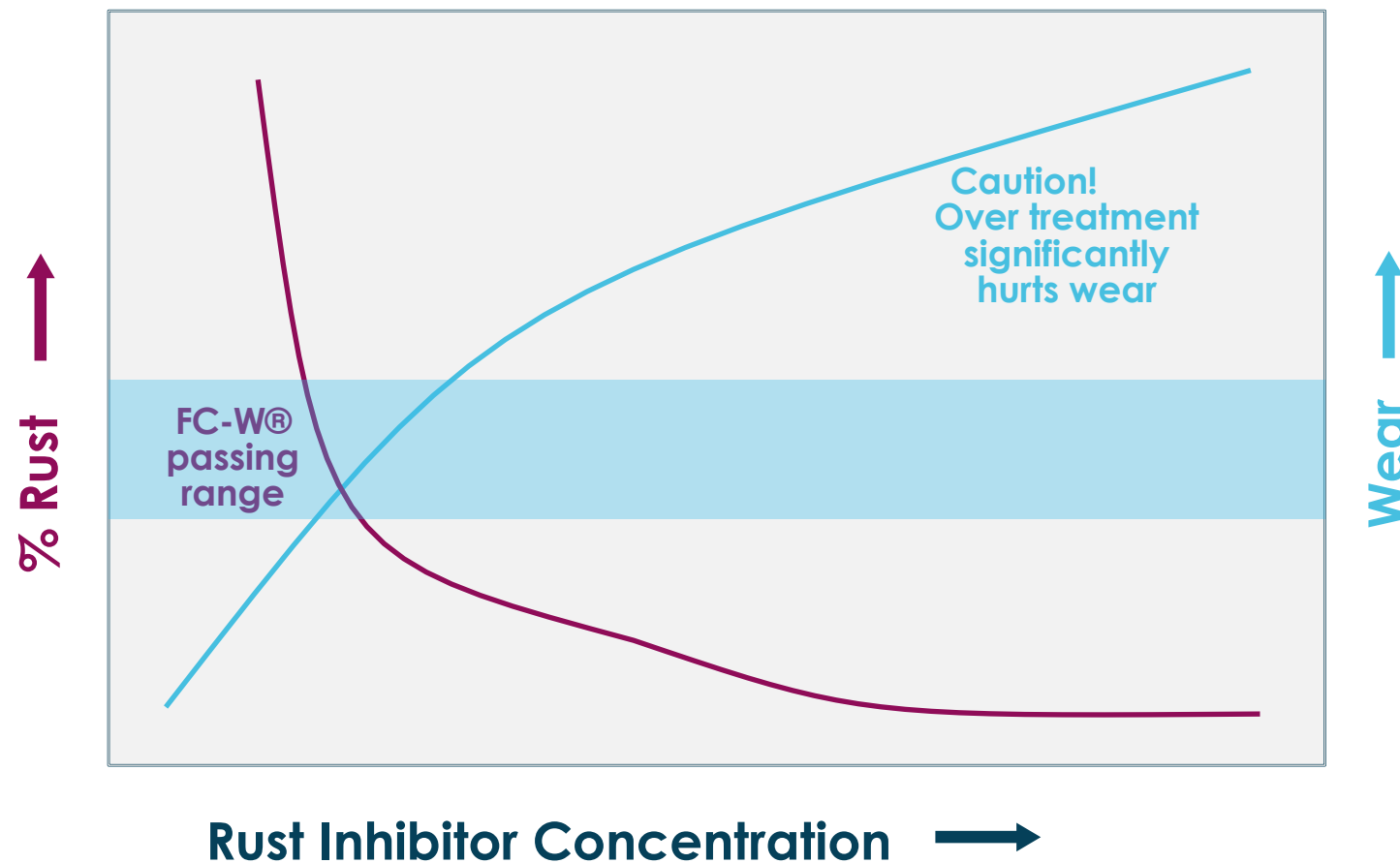
Required Additional Testing for Complete FC-W® Approval.

Expected Test Cost is
\$55K – \$65k.

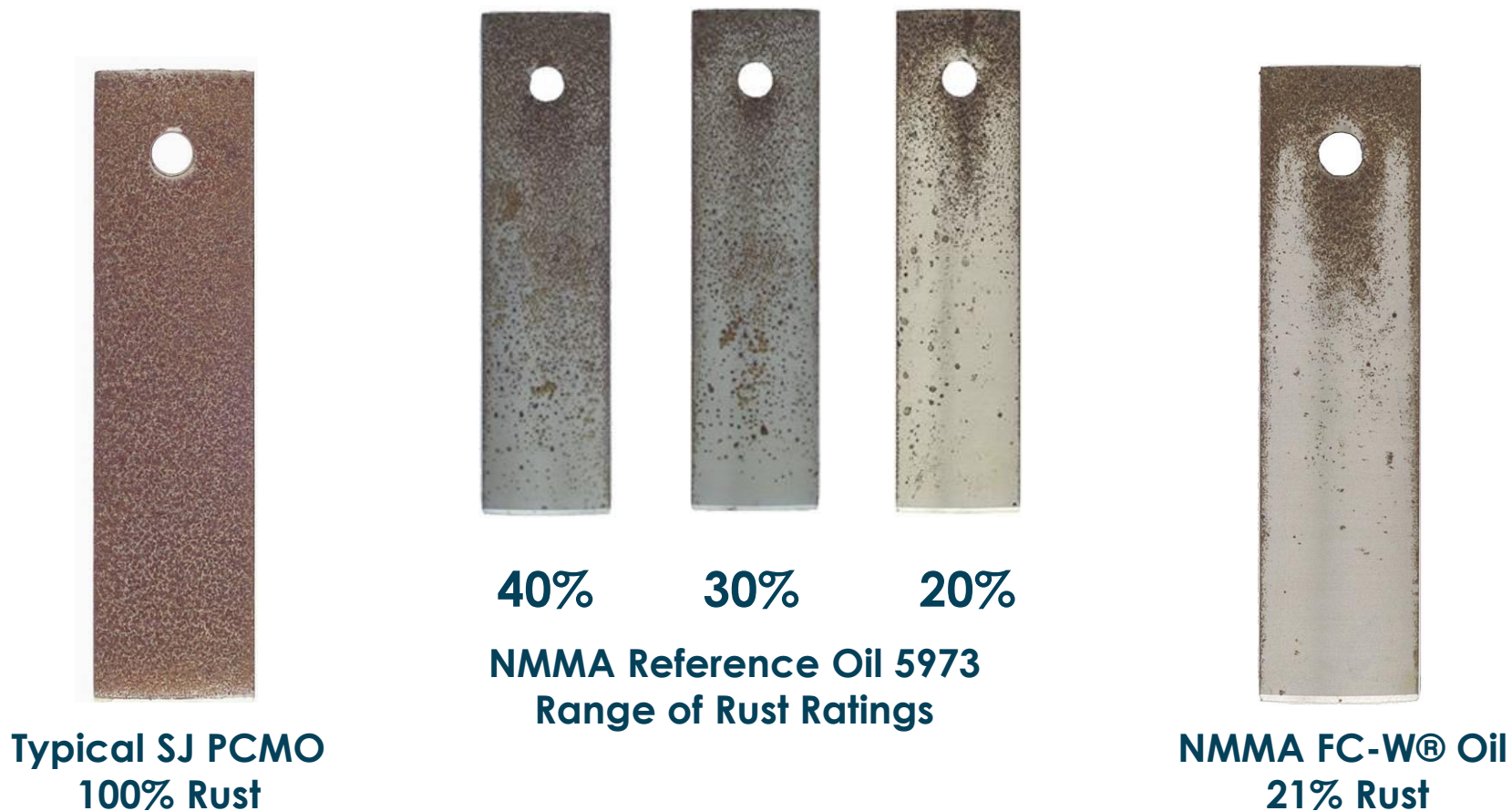
Required Testing for Basic Read Across Oil Program.

Expected Test Cost is **\$2K to 7k.**

Balance is essential as anti-wear and anti-rust additives both compete for the surface



Excellent performance in the FC-W® rust test requires component balance



FC-W catalyst compatible® standard was launched in September 2009

- **U.S. emissions limits** went into effect in 2010
- Sterndrives and inboards required **catalyst systems to meet the EPA limits.**
- **Catalytic converters** are integral to many outboard engines meeting mandates of the California Air Resource Board (CARB)
- **Engine oils** require careful formulation to avoid poisoning the catalyst in these engines
- The **NMMA** has issued a second standard for four-stroke outboard oils with catalysts to ensure availability of appropriate oils



Intended for:

- All gasoline-powered marine applications, especially those with catalytic converters
- Backwards compatible with engines calling for NMMA FC-W®

There are differences between FC-W® and FC-W catalyst compatible® standards

FC-W®

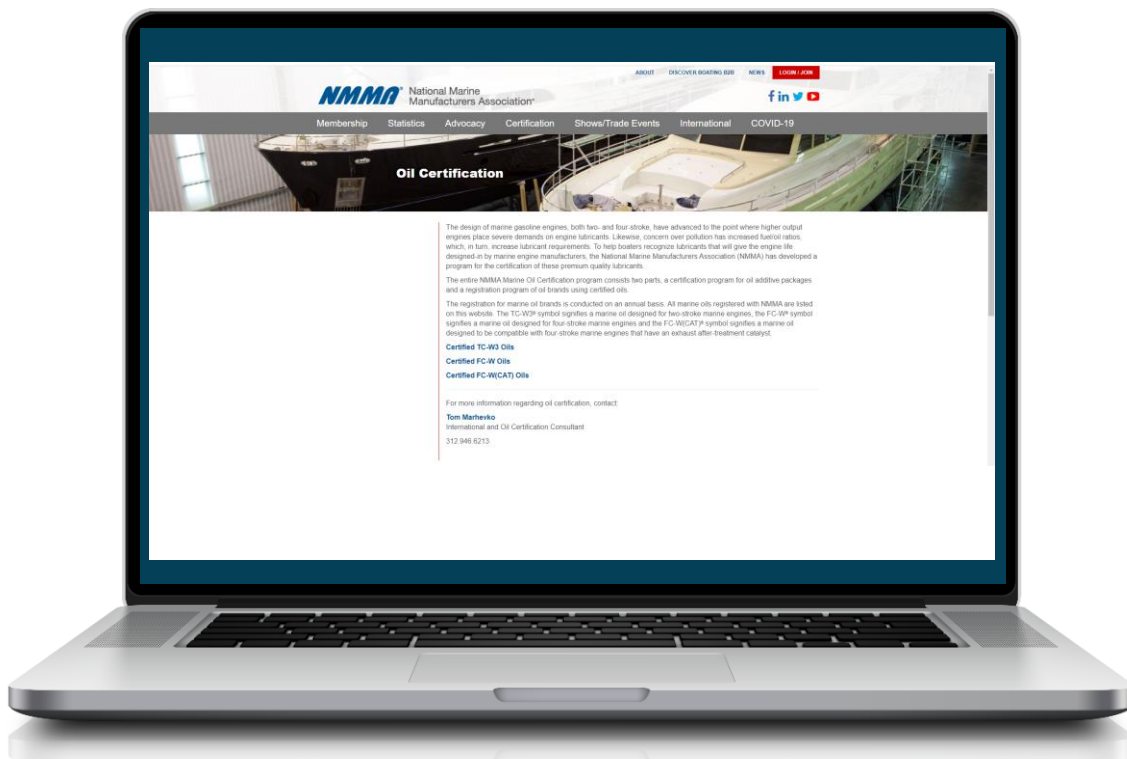
- **Performance package:**
SG quality minimum
- No limit on **P**
- No limit on **Si**
- No “**stay in grade**” limits
- No **volatility** limits

FC-W Catalyst Compatible®

- **Performance package:**
SM quality minimum
- **P range:** 0.06 - 0.08%
- **Si limit:** < 0.002%
- **Stay in grade**
- **Noack volatility:** < 22%

All other current **NMMA FC-W® requirements** and readacross rules remain the same for the catalyst-friendly oil standard.

NMMA website is a good place for information



www.NMMA.org/certification/programs/oils/

- TC-W3® Certification Procedure Manual
- TC-W3® Product Approval System (PAS)
- List of marketer-certified TC-W3® oils

www.NMMA.org/certification/programs/oils/fc-w.asp

- FC-W® Certification Procedure Manual
- FC-W® Product Approval System (PAS)
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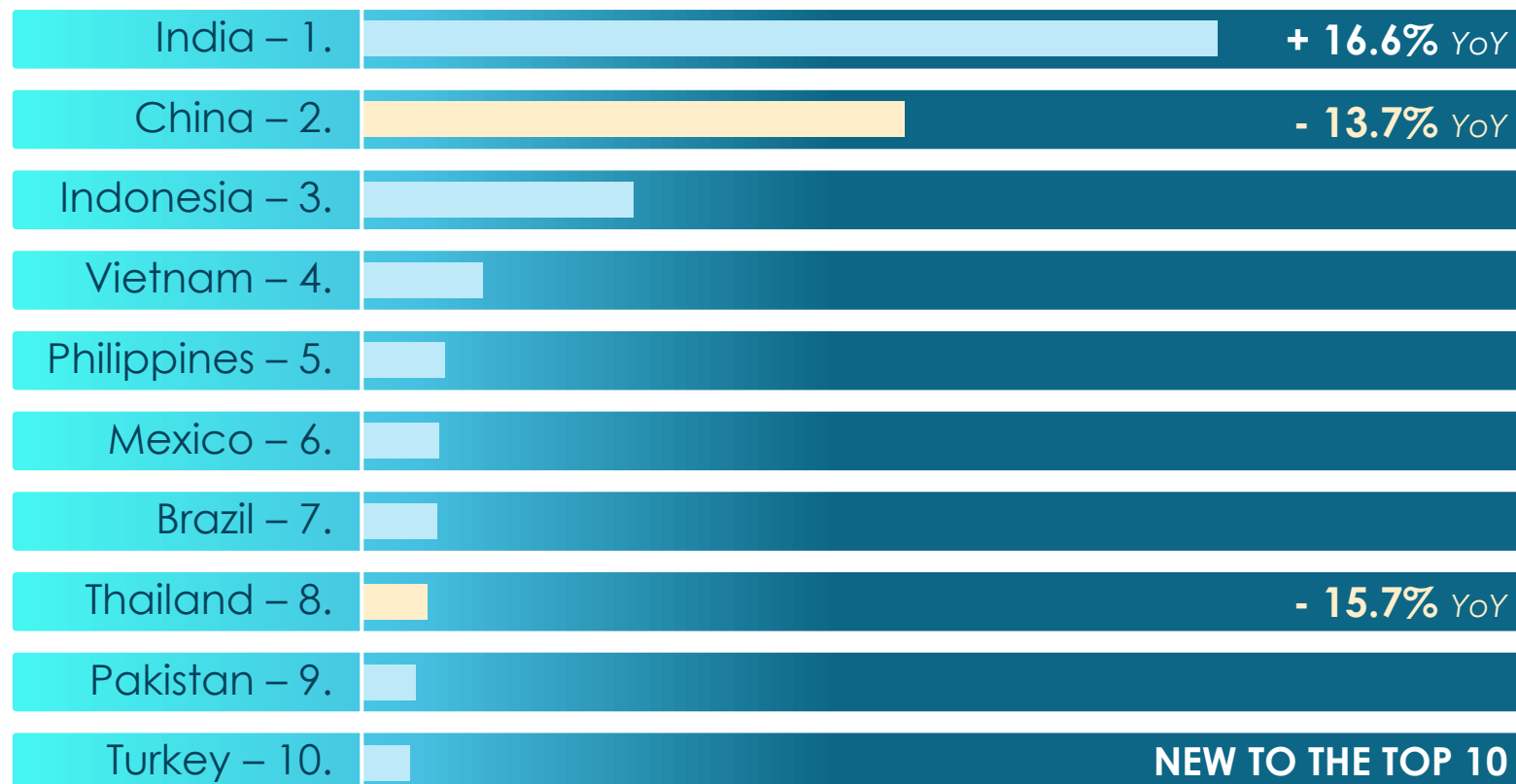
Four stroke motorcycle oils



Motorcycle markets

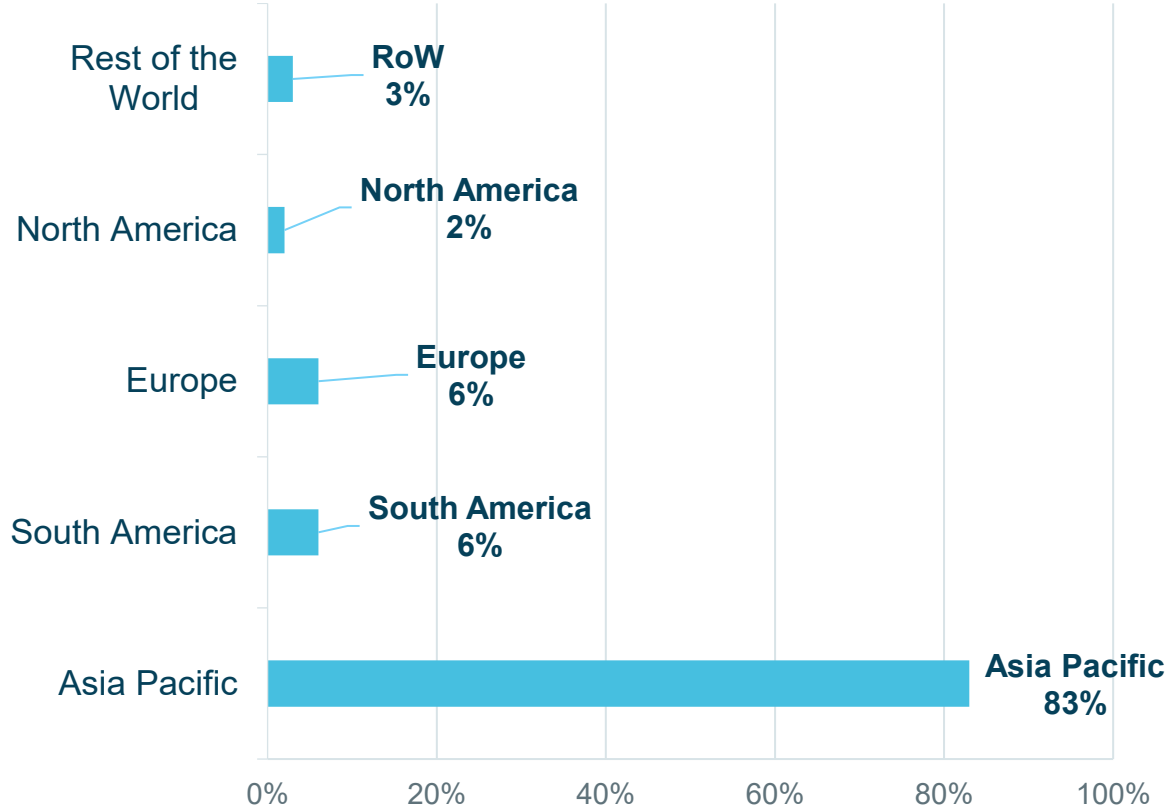
Global sales reach a record high **61.8 million**

World top 10 markets by sales



Global Population Trends

TWO-WHEELER POPULATION BY REGION



Source: Kline data

83%

of the global two-wheeler population
is in Asia Pacific

WHY GROWTH CONTINUES

Asia Pacific is also expected to deliver the strongest growth in the coming years.

- Rising incomes
- Limited public transportation
- Young populations seeking personal mobility

How are motorcycles used?

It depends on where you are in the world.



Transportation:

- Generally AP
- Used for transportation and commerce
- Smaller motorcycles
- Large rider population



Recreation:

- Generally North America and Europe
- Used for recreation and entertainment
- Larger road bikes and smaller racing bikes
- Smaller rider population

End-user preferences and requirements differ across commuting and leisure riding applications.

COMMUTER USERS



PRIMARY CONCERNS

- Deposits
- Wear
- Friction

PRODUCT NEEDS

- Engine wear protection
- Engine cleanliness
- Gear protection
- Fuel economy

LEISURE USERS



PRIMARY CONCERNS

- Power
- Acceleration
- Clutch feel

PRODUCT NEEDS

- Engine wear protection
- Drivability
- Clutch protection
- Gear protection
- Fuel economy

4T motorcycle video



4T motorcycles have different lubrication needs than automobiles

Motorcycles run under more severe conditions than cars.

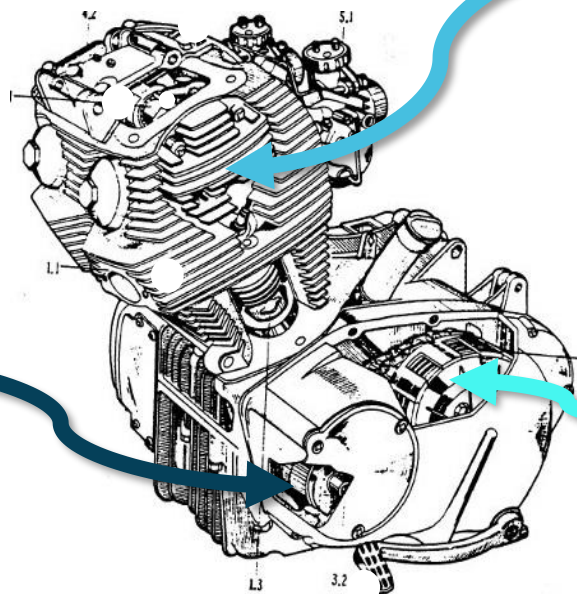
- Many are air cooled
- Run hotter and faster
- Lower oil volumes for lubrication and cooling
- **Motorcycle oils [MCO]** must lubricate clutch and gears, along with engine
- Requires a **balanced formulation approach**

PCMO requirements continue to diverge from those needed for MCOs

- **Low friction** for PCMO fuel economy impacts MCO clutch performance
- **Low Phosphorous** for PCMO for catalyst compatibility impacts MCO wear protection
- **Low viscosity** for PCMO impacts MCO gear protection and oil consumption

MCOs must meet JASO T903:2016* or T903:2023 requirements

Motorcycle oil properties are defined by three lubrication functions



ENGINE: Wear Protection

- High revving; air-cooled
- Small oil volume with short oil drain interval (ODI)
- SJ / SL / SM / SN / SN Plus / SP quality (T903:2023)

GEARS: Pitting Protection

- High oil viscosity reduces wear
- Shear stable viscosity modifier maintains viscosity
- Gear pitting is a concern with low viscosity oils

CLUTCH: Shift Durability

- High oil friction for fast clutch engagement
- Minimize Friction
Modifiers used in PCMO

JASO T903 4T motorcycle standard

JASO Has Been Registering 4T Motorcycle Oils Since 1999 to address OEM concern about PCMO inadequacies

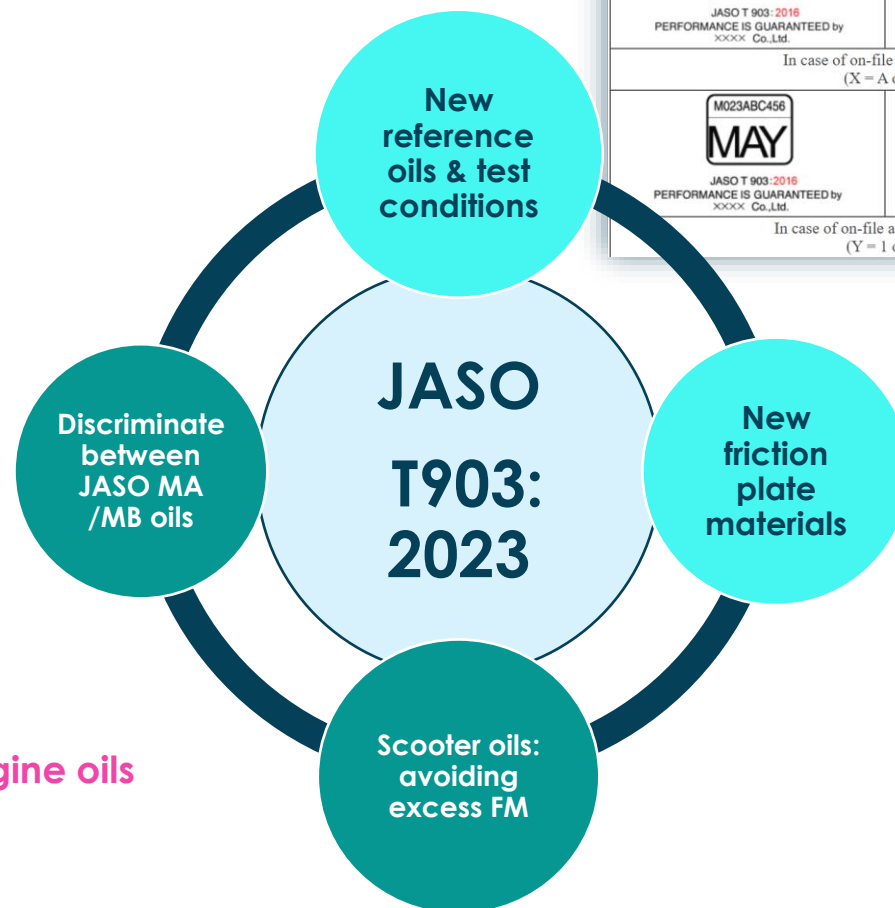
A registration logo is available for registered oils

- JASO MA friction quality for Motorcycle Oils
- JASO MB friction quality for Scooters

JASO T903:2023 is the current specification.

- Published May 2023
- Tighter Phosphorus chemical limit
- NOACK limit
- Alignment with PCMO specifications
- NO gear pitting test
- JASO T903:2016 oils remain valid until April 30, 2028

***As of 9/2023, JASO is no longer accepting a new applications for engine oils conforming to the JASO T903:2016 standard.
All new applications must meet the JASO T903:2023 standard.**



old manual	revision manual
M023ABC456 MX JASO T 903:2016 PERFORMANCE IS GUARANTEED by XXXX Co.,Ltd.	M023ABC456 MX JASO T 903:2023 PERFORMANCE IS GUARANTEED by XXXX Co.,Ltd.
In case of on-file as MA or MB (X = A or B)	
M023ABC456 MAY JASO T 903:2016 PERFORMANCE IS GUARANTEED by XXXX Co.,Ltd.	M023ABC456 MAY JASO T 903:2023 PERFORMANCE IS GUARANTEED by XXXX Co.,Ltd.
In case of on-file as MA1 or MA2 (Y = 1 or 2)	

JASO T903 specification for four stroke motorcycles has evolved

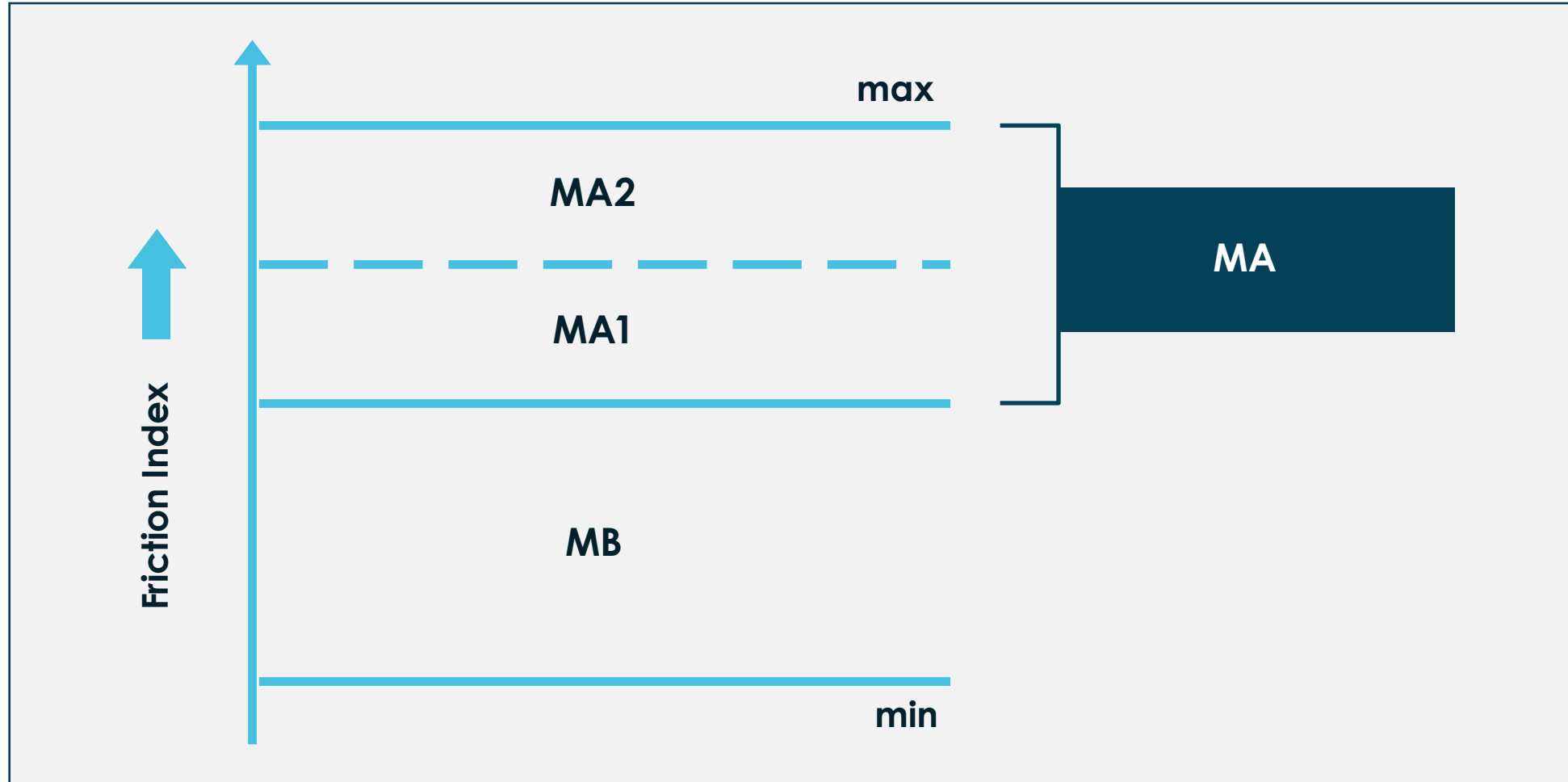
Updated Engine Requirements:

	1999 Original	2006 Revision	2011 Revision 2016 Revision	2023 Revision
API	SE to SJ	SG to SM	SG to SN	SJ to SP (including SN Plus)
ILSAC	GF-1, GF-2	GF-1, GF-2, GF-3	GF-1, GF-2, GF-3	Eliminated
ACEA	A1 to A3	A/B, C2, C3	A1/B1, A3/B3, A3/B4, A5/B5 C2, C3, C4	Eliminated
CCMC	G-4/G-5	Eliminated	--	--

Phosphorus Limits:	1999 Original	2006 Revision	2011 Revision 2016 Revision	2023 Revision
Phosphorus*	No Limits	0.08 – 0.12	0.08 – 0.12	0.08 – 0.10

*Min JASO specified phosphorus range (0.08%) is the max phos limit for API SN and later

JASO classifies friction using the SAE#2 test rig



JASO T903 four stroke motorcycle specification

Friction performance

Scooters

	Index/Classification	MA2	MA1	MA	MB
T903:2016	Dynamic friction index	$1.50 \leq x < 2.50$	$1.35 \leq x < 1.50$	$1.35 \leq x < 2.50$	$0.40 \leq x < 1.35$
	Static friction index	$1.60 \leq x < 2.50$	$1.45 \leq x < 1.60$	$1.45 \leq x < 2.50$	$0.40 \leq x < 1.45$
	Stop time index	$1.60 \leq x < 2.50$	$1.40 \leq x < 1.60$	$1.40 \leq x < 2.50$	$0.40 \leq x < 1.40$
T903:2023	Dynamic friction index	$1.45 \leq x < 2.60$	$1.30 \leq x < 1.45$	$1.30 \leq x < 2.60$	$0.20 \leq x < 1.30$
	Static friction index	$1.60 \leq x < 2.55$	$1.40 \leq x < 1.60$	$1.40 \leq x < 2.55$	$0.25 \leq x < 1.40$
	Stop time index	$1.50 \leq x < 2.65$	$1.25 \leq x < 1.50$	$1.25 \leq x < 2.65$	$0.00 \leq x < 1.25$

- All three indices must be MA2 to claim MA2.
- All three indices must be MA1 to claim MA1
- If the indices are from both MA1 and MA2, MA must be claimed
- MB must be claimed if at least one index is in the MB range

JASO website is a good place for information



<http://www.jalos.or.jp/onfile/jaso.htm>

- JASO T903:2023 (Current) Application Manual
- JASO T903:2016 (Old) Application Manual
- JASO T903:2011 (Old) Application Manual
- List of filed oils

Two-stroke low ash oils (air cooled or land equipment oils)



API TC was the only api specification for 2T oil air-cooled applications



American Petroleum Institute Two-stroke Standards			
Category	Application examples	Test procedures	Critical lubrication requirements
TA	Mopeds Lawn mowers Small generators/pumps	OBSOLETE	
TB	Motorscooters Small (<250cc) motorcycles Higher oil/fuel ratio chainsaws	OBSOLETE	
TC	Lean oil/fuel Ratio chainsaws Hi-performance motorcycles Snowmobiles	Yamaha Y350M-2 Piston deposits Ring sticking Yamaha CE50S Tightening Preignition	Piston scuffing Deposit-induced preignition Ring sticking
TD	Outboard motors	OBSOLETE	

API TC evaluates a two-stroke oil's performance in **ring sticking, lubricity, and preignition**, all in small air-cooled two-stroke engine tests.

All other API categories are obsolete.

API TC does not have a certifying body

- **No process exists** for certifying or registering oils that have passed the API TC requirements.
- Marketers may claim API TC performance **without having actually tested their oil.**
 - But there must be sufficient data and/or logic for making an API TC claim.
- API TC program cost: **>\$44k**

OEMs in Japan created a 2T standard because they felt that API TC was inadequate



JASO M345 2T standard revision driven by test engine availability

Standard	Lubricant Performance Requirement	Current engine
JASO M340	Lubricity test	Husqvarna – ZENOAH (65.6 cc)
JASO M341	Detergency test	Husqvarna – ZENOAH (65.6 cc)
JASO M342	Smoke test	YAMAHA (63 cc)
JASO M343	Exhaust system blocking test	YAMAHA (63 cc)

JASO has been registering 2T oils since 1994

- Marketer must register the oil with JASO in order to use the JASO logo.
- Logo and registration number must appear on the bottle for registered oils.
- One-time registration fee of 40,000 Yen (\$250) per oil must be paid to JASO by the oil marketer.
- JASO quality claims can be made without JASO registration
- **Old approvals remain valid and do not need to be re-approved**
 - **M345:2003** registered oils does not need to upgrade to 2018
 - **M345:2018** registered oils does not need to upgrade to 2023



PRODUCT MEETING JASO M 345:2024
COMPANY GUARANTEEING THIS FX PERFORMANCE:
XXXX Co.,Ltd.

**New JASO M345:2024 standard available
in English**

https://jalos.or.jp/onfile/pdf/2T_2025_EV250_5.pdf

Small engine summary

1

Small engine 2T & 4T oils

require
dedicated
and
balanced
formulations

2

2T for outboards (water-cooled)

Require ashless technology

- Quality set by NMMA TC-W3® standard

2T for land equipment (air-cooled) Require low-ash technology

- Quality set by JASO M345 and API TC

3

4T for outboard applications

Require rust prevention technology

- Marine quality set by NMMA FC-W® and FC-W Catalyst Compatible® standards

4T Motorcycle applications

Require suitable friction and wear performance

- JASO T 903 MA and MB standards for motorcycles and scooters

Small engines – special applications requiring special lubricants



Thank you



Formulating tomorrow together

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