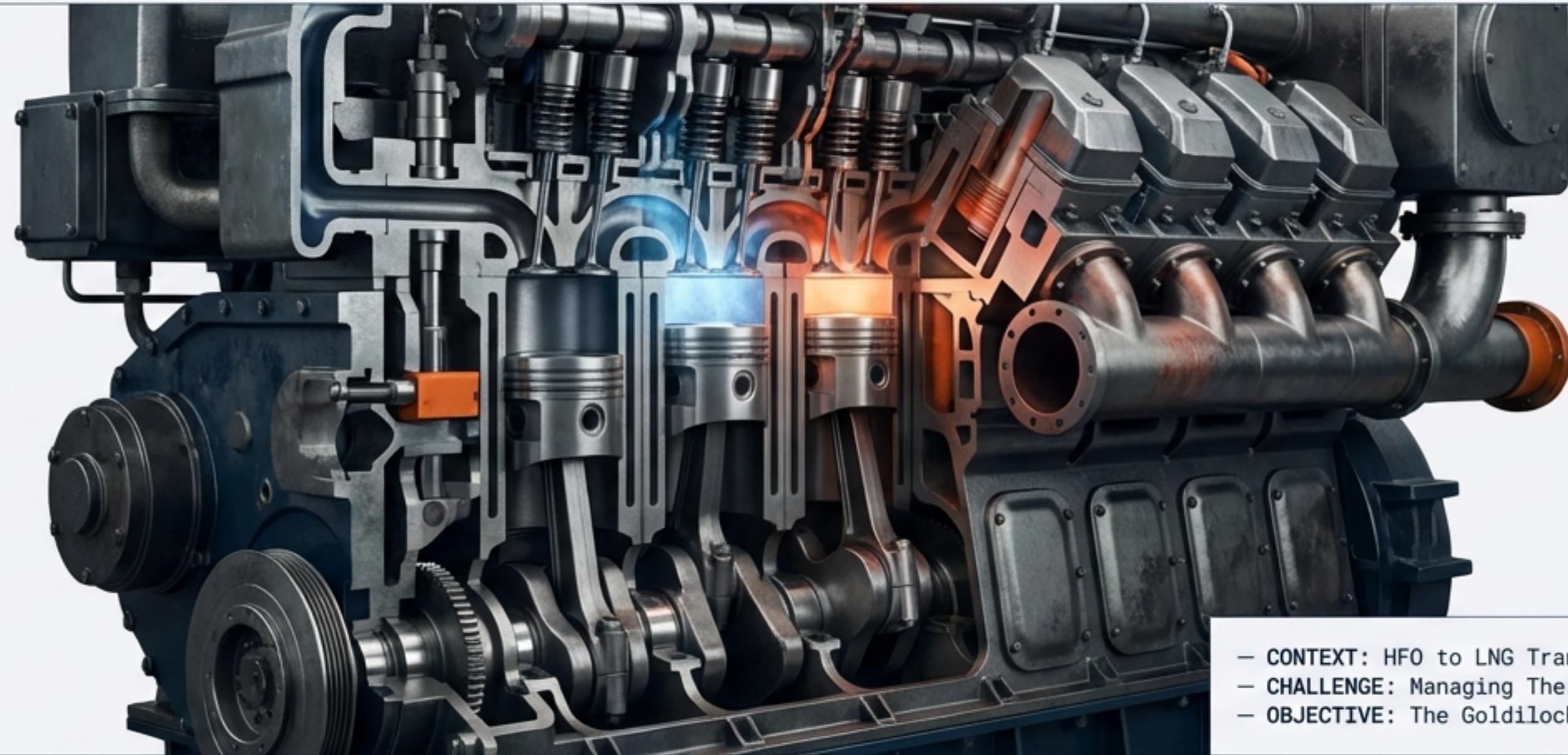


ASH CONTROL IN DUAL-FUEL GENERATORS

GENERATORS

The Fine Line Between Efficiency and Failure



- CONTEXT: HFO to LNG Transition
- CHALLENGE: Managing Thermal Stress & Deposits
- OBJECTIVE: The Goldilocks Balance

A TALE OF TWO CHEMISTRIES

Why LNG Demands a New Lubrication Paradigm

OLD WORLD: HFO



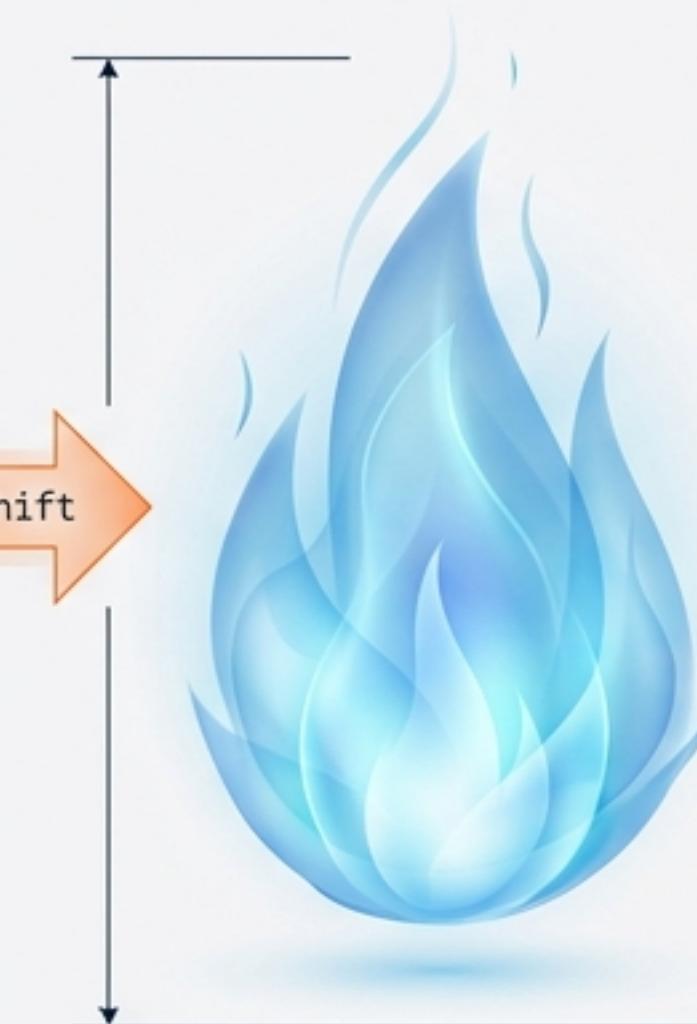
Sulfur Content:
→ > 2.0%

Byproduct:
Sulfuric Acid (H_2SO_4)

Requirement:
High Base Number
(BN 30-70)

Ash Profile:
High (> 1.0%) for
Neutralization

NEW WORLD: LNG



Sulfur Content:
~ 0%

Byproduct:
Nitration (NO_x) & Heat !

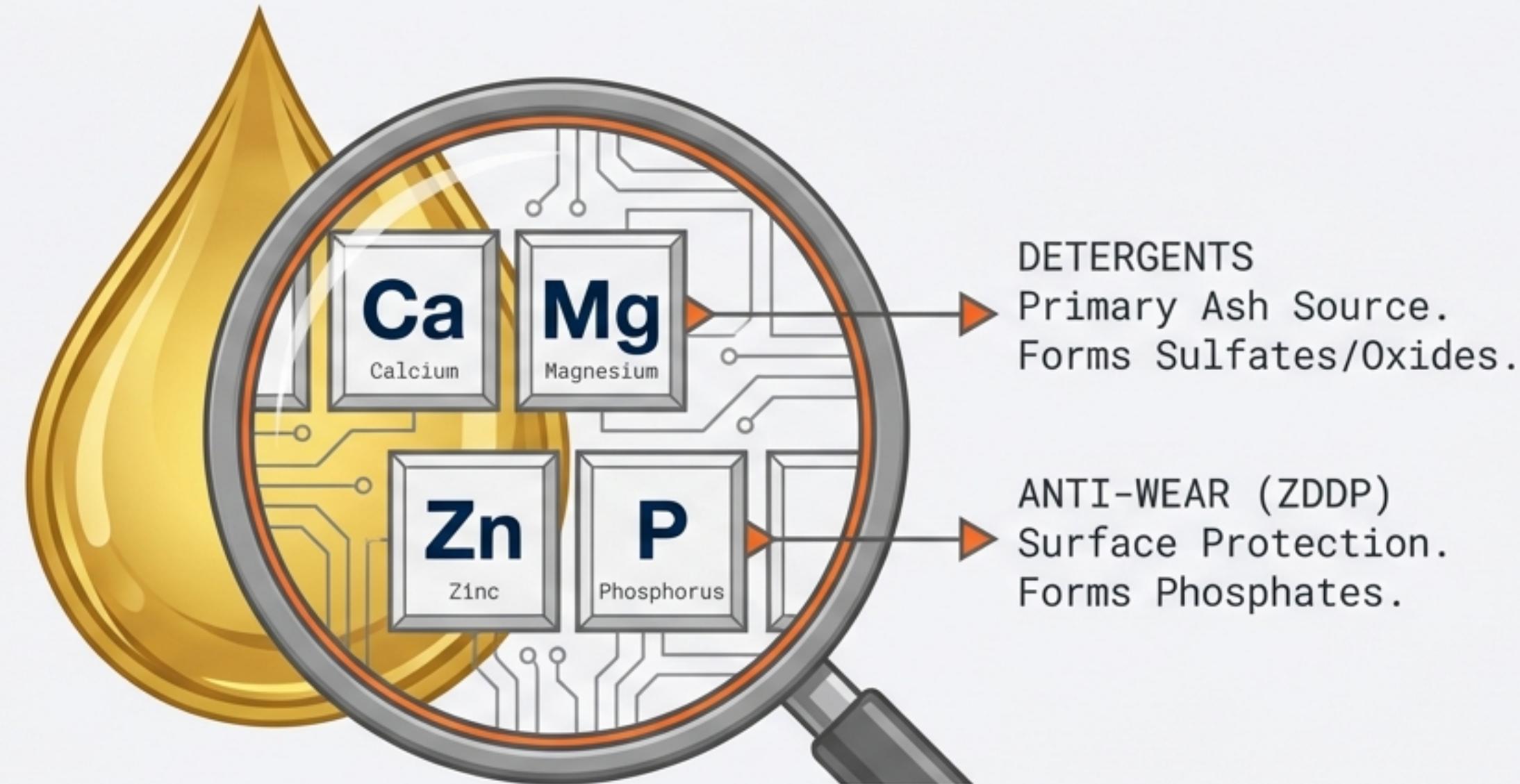
Requirement:
Low Base Number
(4-15)

Ash Profile: ✓
Low (< 0.5%) to
Prevent Deposits

Paradigm Shift

DECONSTRUCTING ASH

The Hidden Residue of Performance Additives



DETERGENTS

Primary Ash Source.
Forms Sulfates/Oxides.

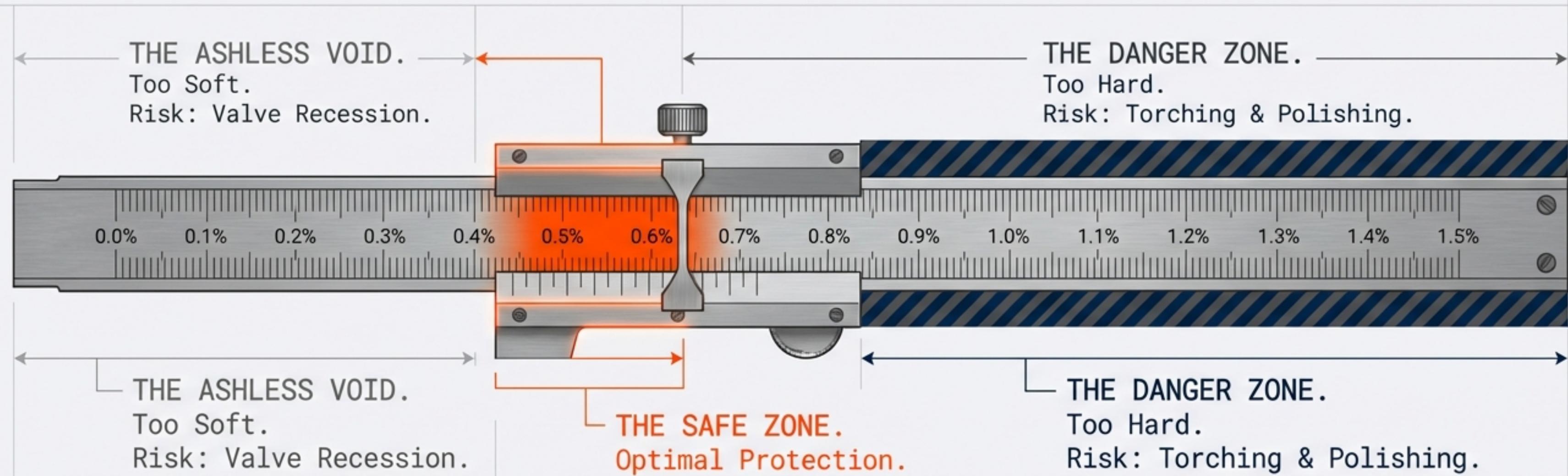
ANTI-WEAR (ZDDP)

Surface Protection.
Forms Phosphates.

Sulphated ash is not an impurity. It is the solid ghost of the additives meant to protect the engine.

THE GOLDILOCKS PRINCIPLE

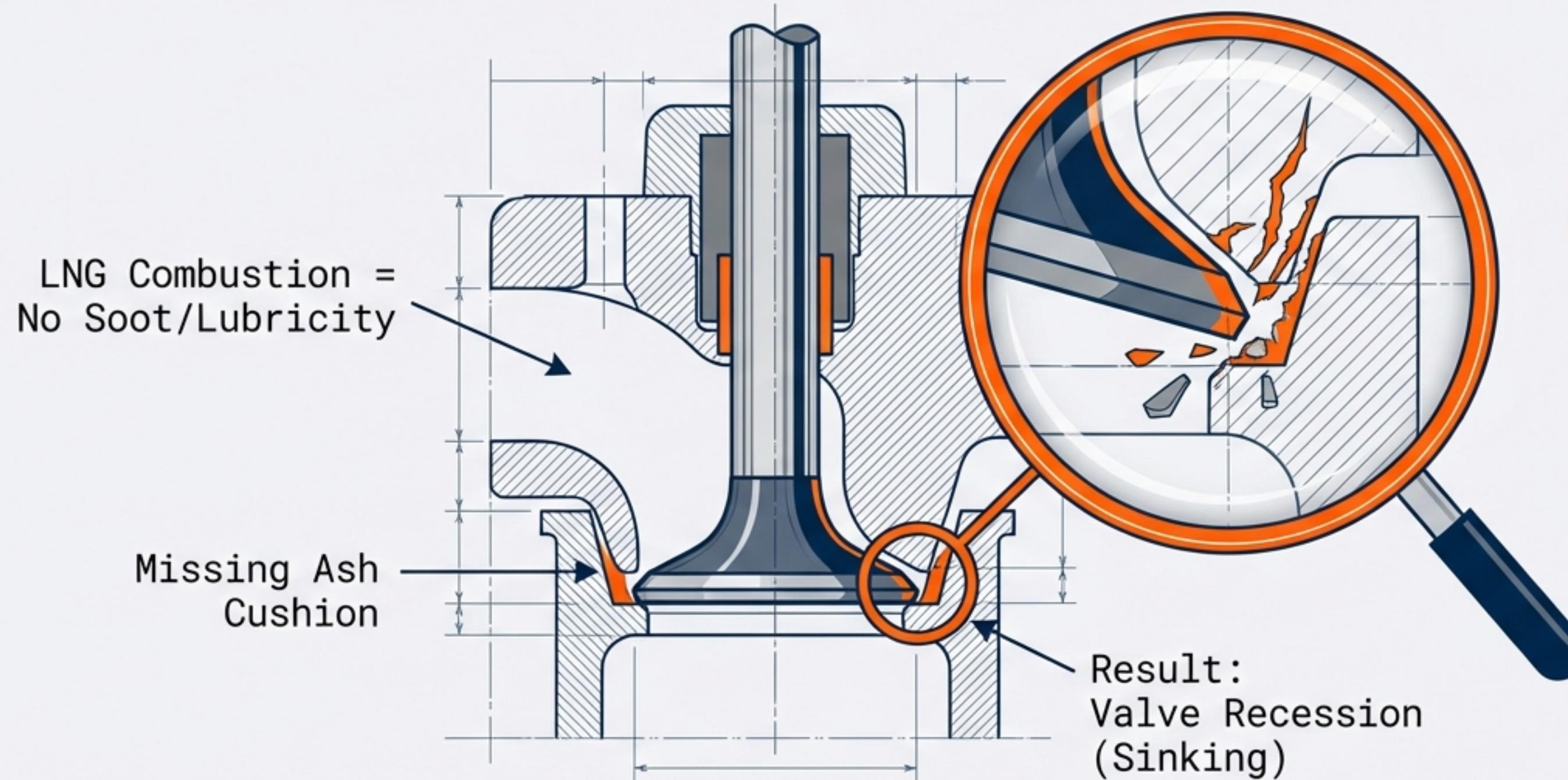
The Unforgiving Window of Operation



“In gas engines, protection is not linear.
More additive ≠ Better protection.”

THE 'DRY' FUEL DANGER

Valve Recession & Microwelding



Consequence:
Loss of valve lash,
cylinder head
scrapping.

THE BLOWTORCH EFFECT

Valve Guttering & Torching

1. DEPOSITION:

Ash builds up $> 0.6\%$

2. FLAKING:

Deposits crack,
creating a gap

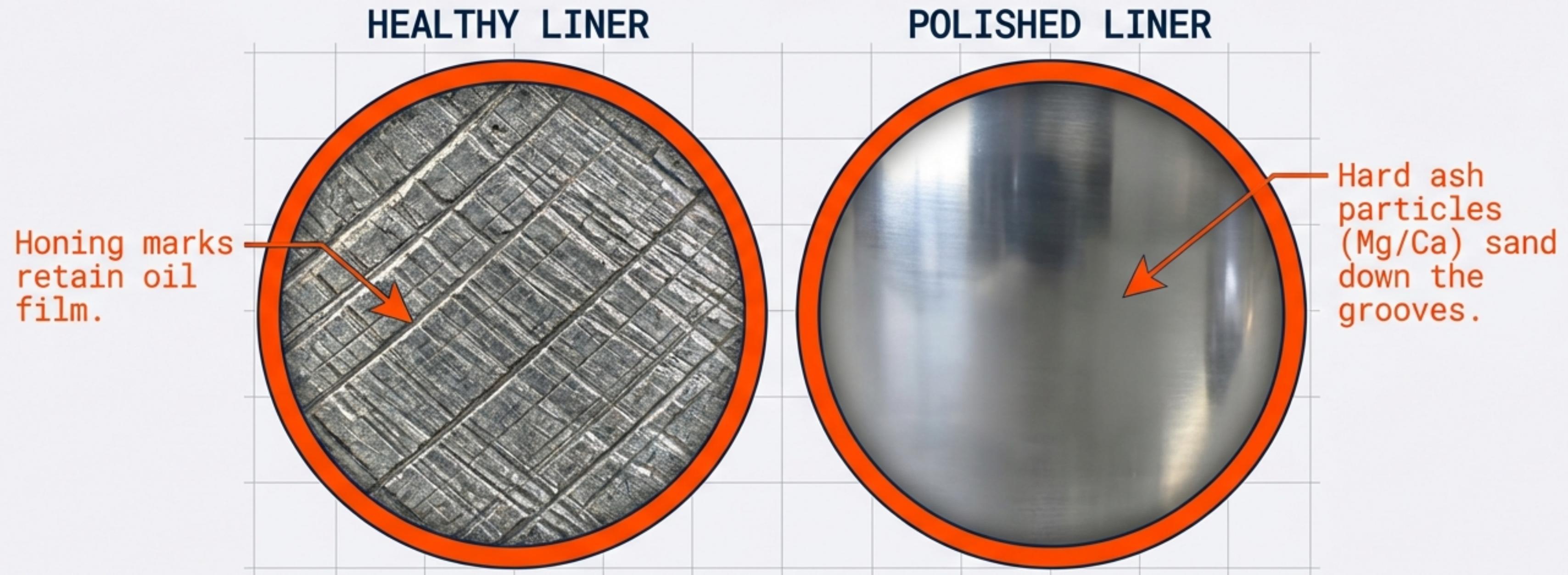
3. TORCHING:

Leak acts like
oxy-acetylene cutter



THE SILENT KILLER: BORE POLISHING

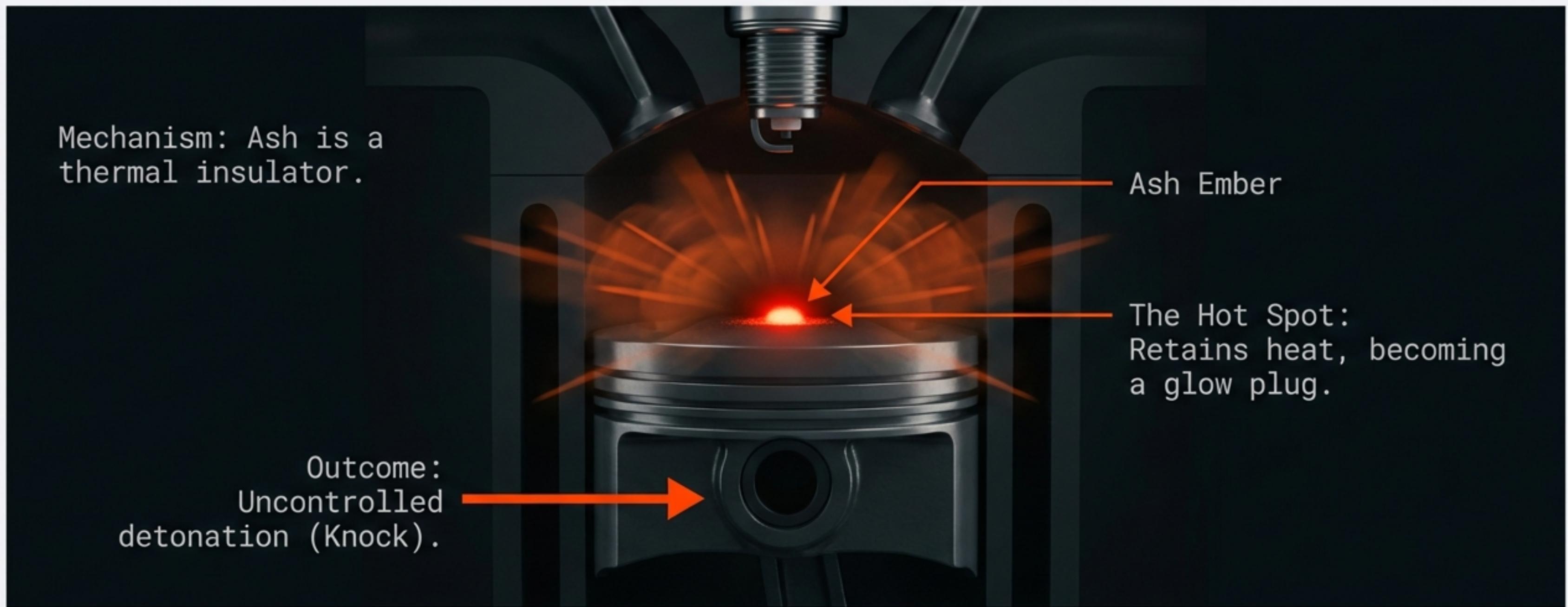
When Ash Becomes Abrasive



RESULT: Oil Film Failure -> Scuffing -> Excessive Blow-by.

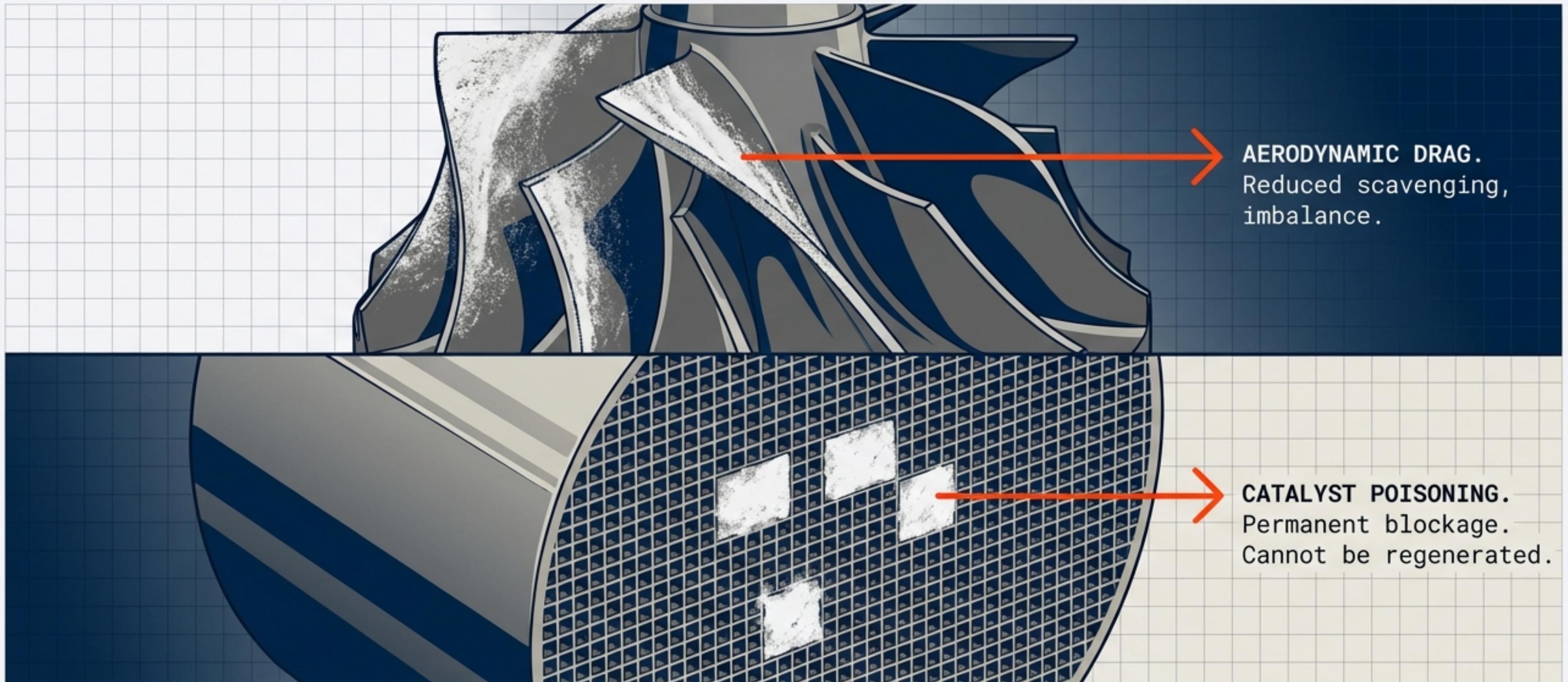
THE GLOW PLUG EFFECT

Pre-Ignition & Knock



BEYOND THE CYLINDER

Turbos & After-Treatment



CHEMICAL EVOLUTION

Sulfonates vs. Salicylates

OLD TECH: SULFONATES

Forms Hard,
Abrasive Ash.



Ash Quality

Salicylates provide
High Alkalinity (BN)
with lower ash mass,
preventing bore
polishing.

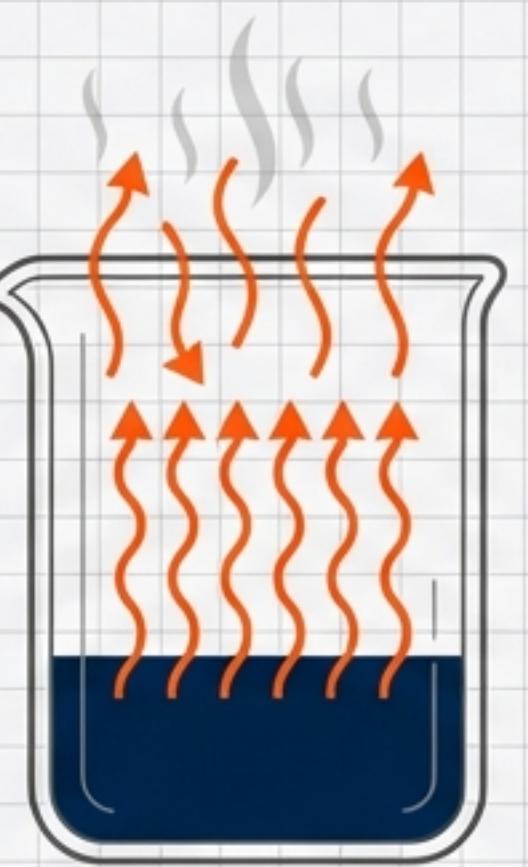
NEW TECH: SALICYLATES

Forms Soft,
Manageable Ash.

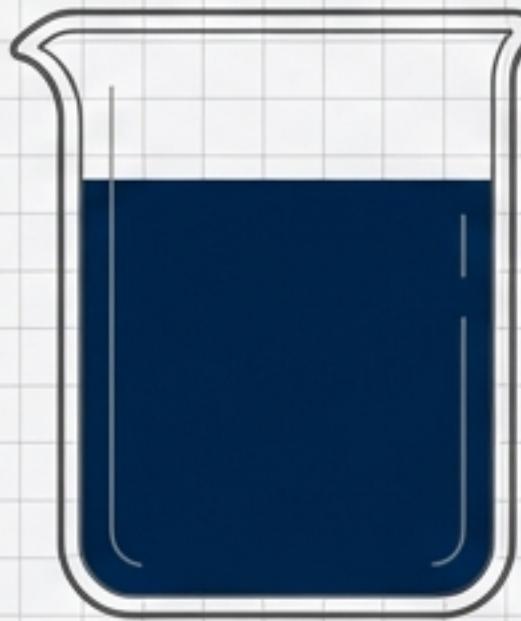


THE FOUNDATION

Why Base Oil Quality Matters



Standard Base Oil
(Group I)



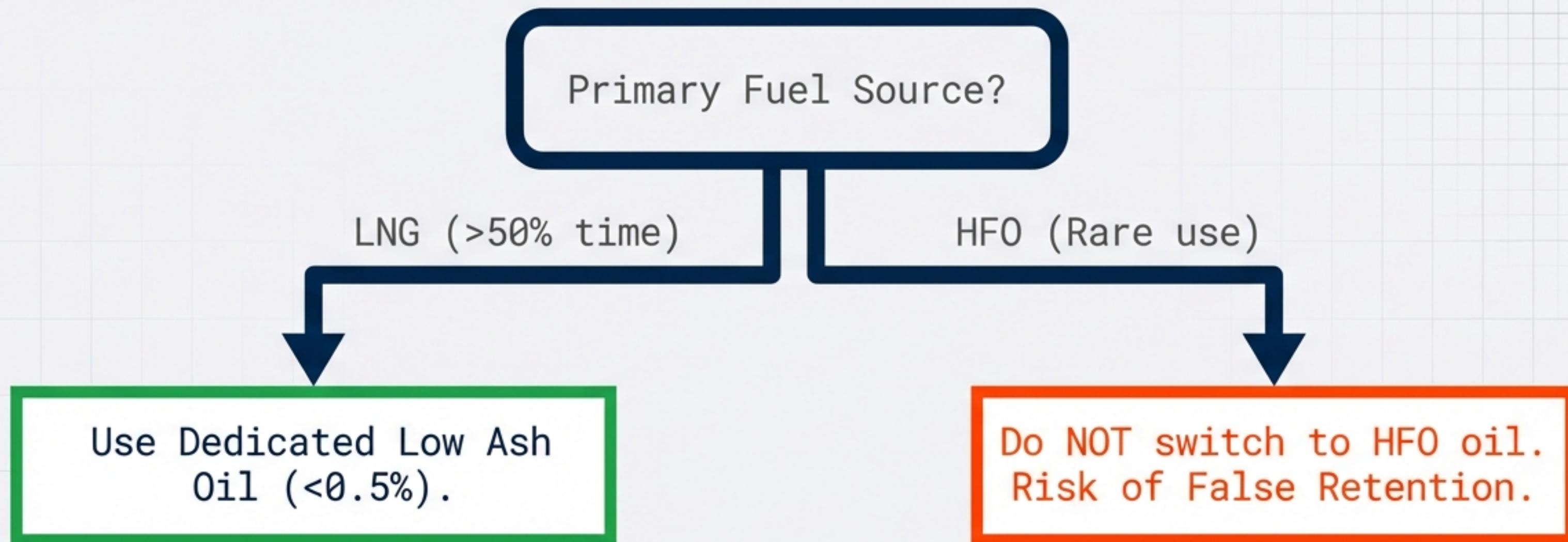
Hydrocracked Base Oil
(Group II/III)

Logic: Less oil evaporation = Less oil burned = Less total ash accumulation.

Spec: Group II or III Base Stocks required.

THE DUAL-FUEL DILEMMA

Managing the Switch

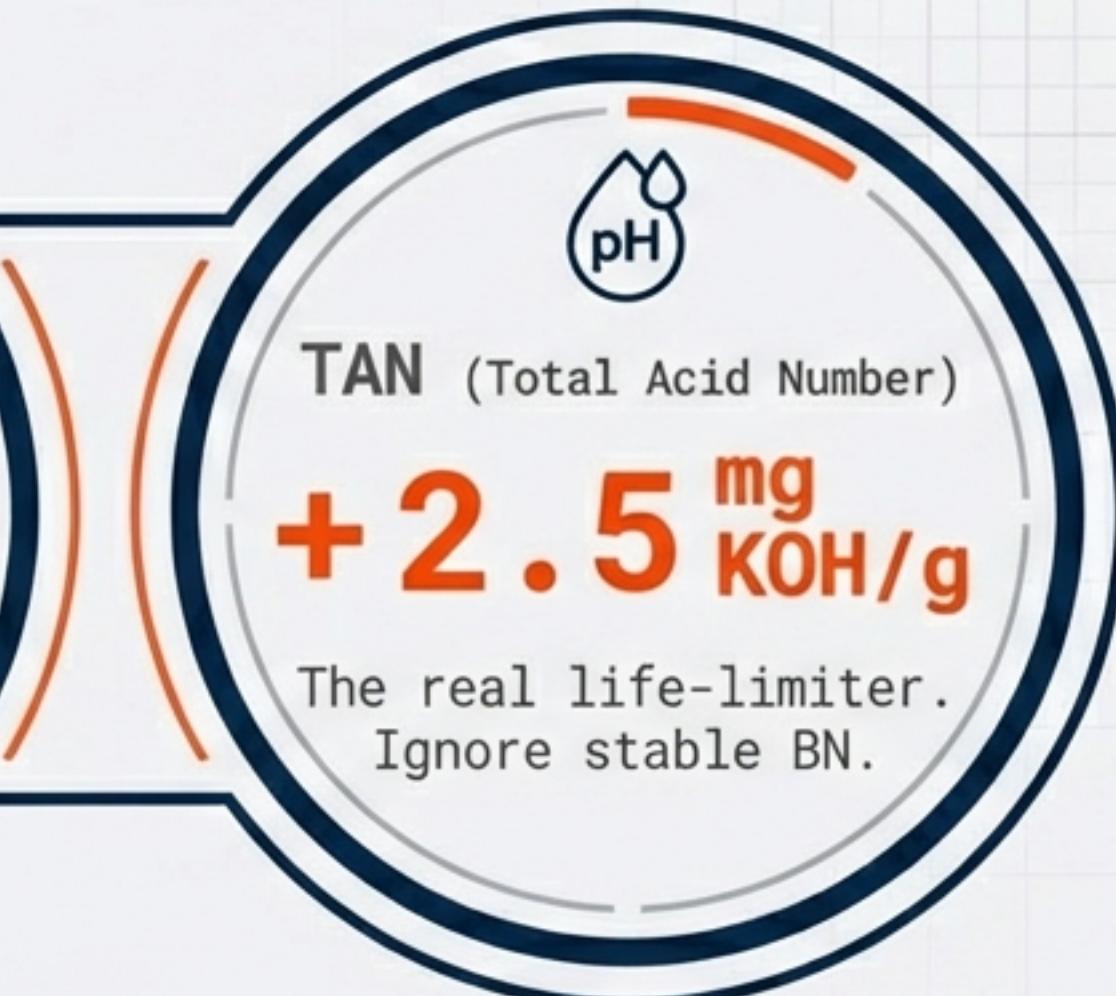
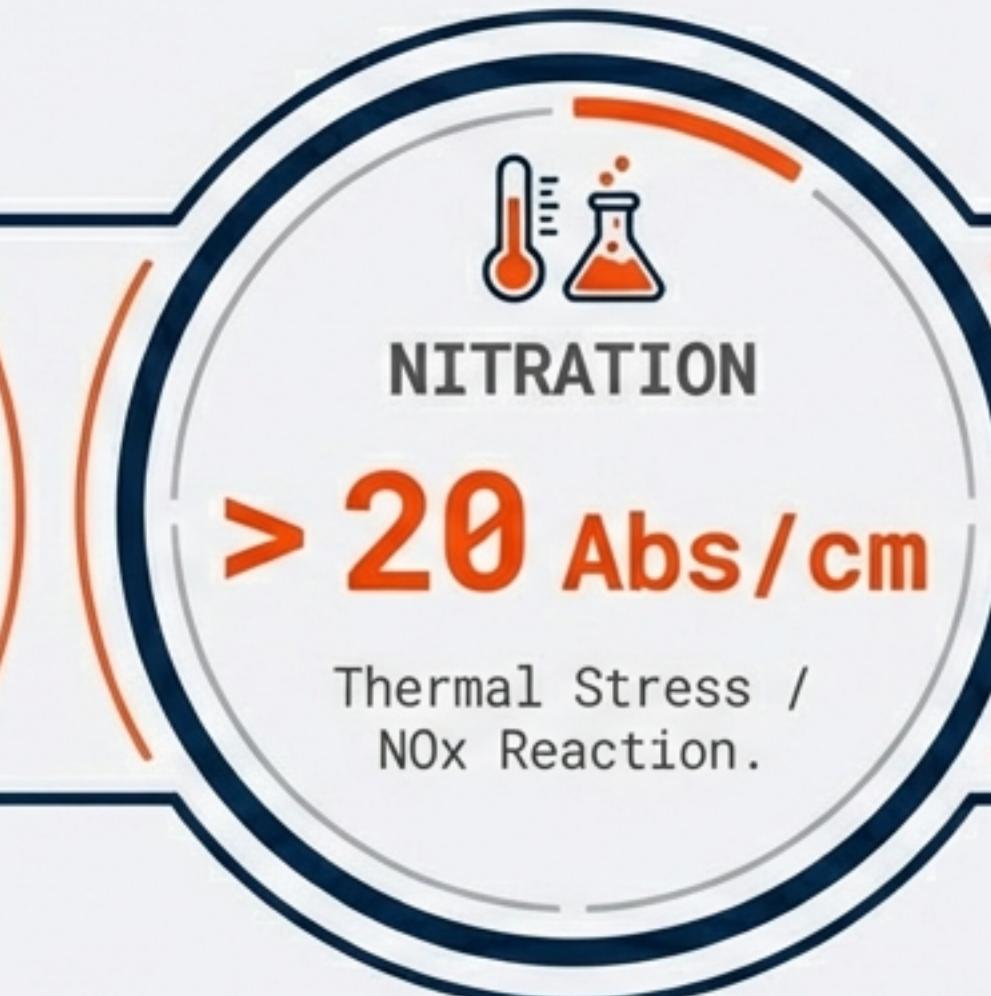


THE HFO TRAP:

High BN oil in a gas engine retains BN (False Positive) while ash deposits build up silently.

CONDITION MONITORING

Reading the Signals



THE 3 PILLARS OF ASH CONTROL

Strategy for Reliability



SELECTION

Low Ash (0.5%).
Salicylate
Chemistry. Group
II/III Base Oil.



OPERATION

Manage thermal
stress. Minimize
Nitration.



VIGILANCE

Monitor Valve Lash.
Trend TAN &
Nitration.

RELIABILITY IN THE LNG ERA

A Choice of Chemistry



Reliability is no longer about heavy-duty protection.
It is about **CHEMICALLY CORRECT** protection.

CALL TO ACTION: Review fleet specs against OEM Gas-Mode Guidelines.

References: MAN Energy Solutions, Wärtsilä, Caterpillar