

H2S Acid Corrosion in Biogas Engines

Why CJC Offline Filtration & Tan Delta Monitoring Beat Premature Oil Dumps

EXECUTIVE SUMMARY & ENGINEERING SCOPE

Executive Overview: Biogas-fueled Combined Heat and Power (CHP) engines face severe operational stresses due to **Hydrogen Sulfide (H₂S) acid corrosion**, rapid **TBN depletion**, and early **TAN/TBN crossover**. Conventional inline full-flow filters are chemically inert and incapable of arresting acid buildup or fine particle contamination. This engineering brief details how integrating **CJC® offline fine filtration** with continuous **Tan Delta online oil condition monitoring** neutralizes acidity, absorbs moisture, and enables true condition-based maintenance—extending oil service lifespan by **+66% to >4.1x** across major engine platforms.

Up to 4.1x

Oil Extension (MAN 2842)
547h to 2,275h

80% Drop

Catastrophic Failures
(35-Engine Fleet Trial)

£125,000/yr

Direct Savings Realized
in Jenbacher 320 Fleet

1. CHEMISTRY OF H2S ACID CORROSION & TBN DEPLETION

In anaerobic digester and landfill gas applications, raw biogas contains significant concentrations of **Hydrogen Sulfide (H₂S)** alongside moisture and volatile organic compounds. During cylinder combustion, unremoved H₂S oxidizes into sulfur dioxide (SO₂) and aggressive acidic vapor by-products. These sulfurous acids blow past piston rings into the engine crankcase, directly attacking internal components such as copper/lead bearings, cylinder liners, and valve train mechanisms.

To counter acid attack, **biogas engine oil** is heavily formulated with alkaline detergent additives, quantified by its **Total Base Number (TBN)**. TBN serves as a sacrificial alkaline buffer, neutralizing incoming blow-by acids. However, ongoing acid ingress drives rapid **TBN depletion**, degrading the lubricant's protective capacity over time.

CRANKCASE ACIDIFICATION MECHANISM

Chemical Pathway in Crankcase Lube Oil:

- Combustion Phase:** Raw Biogas (H₂S + O₂) → Acidic Combustion By-Products (SO_x / Acid Vapor)
- Blow-by Phase:** Acid Vapors + Condensed Water → Sulfurous / Sulfuric Acid Ingress into Crankcase Sump
- Neutralization Phase:** Acid Ingress + Alkaline Reserve (TBN) → Neutralized Salts + Depleted TBN Reserve (Rising TAN)

2. THE TAN/TBN CROSSOVER & PREMATURE OIL DUMPS

As sacrificial alkaline additives are consumed, the **Total Acid Number (TAN)** steadily increases while TBN declines. When TAN exceeds TBN—known as the critical **TAN/TBN crossover point**—or when initial pH (i-pH) falls below OEM limits (typically < 4.5), the oil enters an aggressive corrosive state.

Why Conventional Main-Loop Inline Filters Fail: Standard full-flow inline engine filters are designed strictly to capture coarse wear particles (>10–15 µm) to protect bearings. However, inline filters present severe operational limitations in biogas service:

- **Chemically Inert:** Inline filter media cannot remove dissolved acids, lower TAN, or restore i-pH levels.
- **Incapable of Absorbing Water:** Moisture passing through combustion blow-by remains trapped in the sump, accelerating acid hydrolysis.
- **Coarse Filtration Mesh:** Microscopic soot, oxidation sludge, and fine debris (<5 µm) pass freely, accelerating wear.
- **Engine-Dependent Operation:** Filtration ceases completely whenever the CHP engine is shut down or idling.

Consequently, plant engineers are forced to execute premature, schedule-based oil dumps every 300 to 600 hours solely to prevent acid accumulation—wasting hundreds of liters of usable lubricant base stock and creating unnecessary plant downtime.

3. CJC® OFFLINE FILTRATION: CHEMICAL & FINE CLEANLINESS

To break the cycle of frequent oil drains, installing a dedicated **CJC® offline filtration system** creates a continuous, 24/7 kidney-loop purification process independent of main engine operation. Operating at optimized low flow rates, CJC systems combine physical micro-filtration with active chemical neutralization.

Key Technological Subsystems of CJC Offline Filtration:

- **Chemical Acid Neutralization:** Specialized CJC Filter Inserts (e.g., **Insert AOJ** featuring aluminum oxide/cellulose or **EL Amberlyst ion-exchange inserts**) actively bind organic and inorganic acids, reducing TAN, elevating i-pH, and preserving the engine's TBN reserve.
- **Ultra-Fine Micro-Filtration:** Depth filter cellulose media captures solid contaminants down to **0.8 µm nominal (3 µm absolute)**, removing fine carbon, soot, and wear particles that cause abrasive wear.
- **Moisture & Varnish Absorption:** Organic cellulose fibers absorb dissolved and free water from blow-by condensation, eliminating the precursor required for sulfuric acid formation.
- **Continuous 24/7 Processing:** Equipped with an independent motor-pump unit, CJC offline filters circulate and polish oil continuously, even during engine maintenance or standstill periods.

4. TAN DELTA ONLINE OIL CONDITION MONITORING

While offline filtration maintains oil purity, plant managers require immediate, reliable verification of fluid degradation to safely extend drain intervals without risk. Integrating a **Tan Delta sensor** for continuous **online oil condition monitoring** provides real-time intelligence directly to the plant SCADA/PLC.

Full Spectrum Holistic (FSH™) Sensing: Unlike basic dielectric sensors, Tan Delta OQSx sensors measure total molecular distortion across a 1200 to 0 scale (Tan Delta Number / TDN) with a **0.01% sensitivity**, tracking chemical wear, additive depletion, TAN increase, soot, water, and fuel dilution simultaneously.

Condition-Based Oil Drains & Early Warning: Instead of relying on delayed off-site lab reports, maintenance engineers receive real-time alerts when fluid health reaches true condemning limits. Rapid TDN drops provide immediate early warning of abnormalities (e.g., coolant leaks), allowing shutdown before catastrophic failure.

5. PROVEN FIELD PERFORMANCE & LIFESPAN EXTENSION

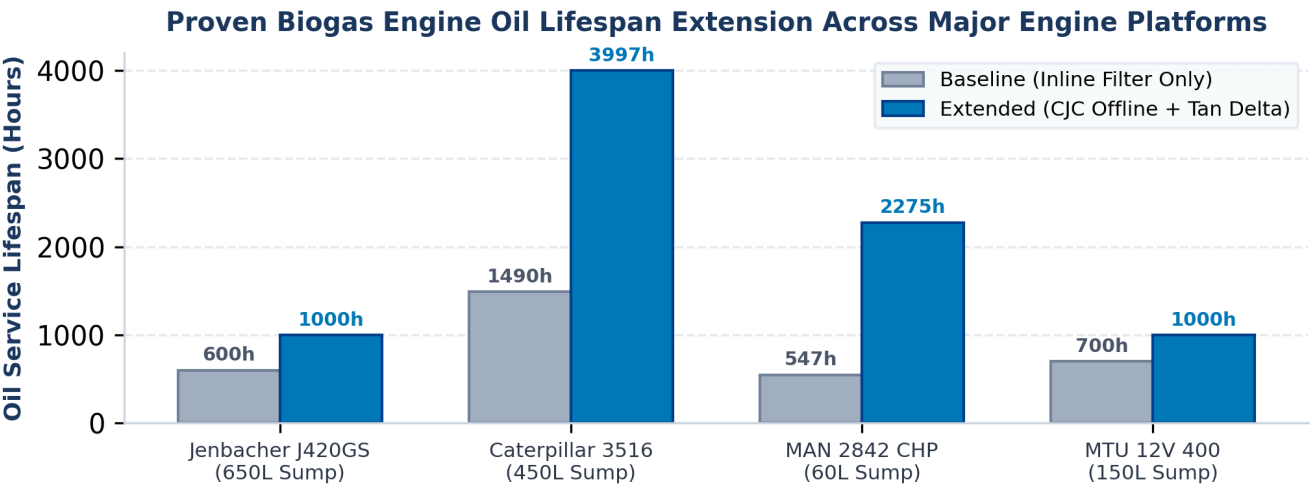


Figure 1: Comparison of Biogas Engine Oil Service Life (Hours) across Major OEM Platforms before and after CJC Offline Filtration Implementation.

5. PROVEN FIELD PERFORMANCE (DETAILED CASE DATA)

Industrial Field Study Performance Summary across Engine Platforms:

Engine Model & Application	Baseline Oil Life	CJC Filter / Sensor Setup	Extended Oil Life	Key Operational Impact
Jenbacher J420GS (1,450 kW / 650L Oil)	500 – 600 hours	CJC Fine Filter 27/108 (Insert AOJ Alumina)	1,000 hours (+66.7% gain)	Neutralized TAN/acid buildup; doubled oil life; minimized downtime.
Jenbacher 320 Fleet (35 Engines Trial)	Calendar hours / Periodic Lab	Tan Delta Real-Time OQSx Sensors	Condition-Based Monitoring	Saved £125,000/year; reduced catastrophic engine failures by 80%.
Caterpillar 3516 (1,036 kWe / 450L Oil)	1,490 hours	CJC HDU 27/27 (EL Ion-Exchange Insert)	3,997 hours (>2.6x extension)	Maintained stable viscosity (<150 cSt); drastically reduced oil cost.
MAN 2842 CHP (300 kWe / 60L Oil)	547 hours	CJC Off-line Filter (EL + A Inserts)	2,275 hours (>4.1x extension)	Controlled TAN & i-pH within OEM bounds; cut oil waste by 75%.
MTU 12V 400 (370 kW / 150L Oil)	700 hours	CJC Fine Filter HDU 27/54	>1,000 hours (+42.9% gain)	Synchronized oil drain stops with 1,000h spark plug service interval.

6. STRATEGIC RECOMMENDATIONS FOR MAINTENANCE TEAMS

ACTIONABLE IMPLEMENTATION ROADMAP

- Address Acid Chemically:** Do not rely on inline mechanical filters to protect against H₂S corrosion. Install an offline CJC system with ion-exchange / alumina inserts to control TAN and preserve TBN.
- Deploy Real-Time Sensing:** Replace conservative calendar-based oil changes with Tan Delta online sensors to capture true fluid degradation and catch mechanical faults early.
- Synchronize Maintenance Windows:** Align extended oil lifespan with major mechanical service intervals (e.g., 1,000-hour spark plug replacement), eliminating isolated oil-change shutdowns.