

## Used Oil Interpretation Guidelines for Heavy Duty Engine Oils

The following limits are intended to provide general interpretation guidance when reviewing a single used oil analysis result. When multiple samples are evaluated a statistical approach is recommended. It is assumed that the used oil sample was taken at the engine manufacturer's recommended oil drain interval. A new oil sample analysis is recommended for comparison. The limits may be applied to all Heavy Duty Diesel Engines regardless of manufacture (**Caution: The guidelines do not cover extended oil drains nor do they apply to 2002 or newer EGR equipped diesel engines**).

| Analysis Parameter      | Viscosity Kv100.cSt | TBN D4739 | TBN D2896 | TAN D664 | Oxidation/Nitration, abs/cm |
|-------------------------|---------------------|-----------|-----------|----------|-----------------------------|
| <b>Normal Range</b>     | 11-18               | >4        | >6        | <1       | <10                         |
| <b>Borderline Range</b> | 18-20               | 2-4       | 4-6       | 1-3      | 10-25                       |
| <b>Warning Range</b>    | <10 or >20          | <2        | <4        | >3       | >25                         |

(1) For 15W-40 grade oils

(2) If new oil TBN is known, the Warning Range is a reduction greater than 50%. Normal Range TBN ≥ TAN

### Recommended Used Oil Analysis Wear Limits for Heavy Duty Diesel Engines

| Wear Metal, ppm         | Aluminum | Chromium | Copper | Iron | Lead | Molybdenum | Nickel | Tin |
|-------------------------|----------|----------|--------|------|------|------------|--------|-----|
| <b>Normal up to...</b>  | 10       | 5        | 10     | 100  | 20   | 10         | 5      | 10  |
| <b>Warning above...</b> | 20       | 15       | 25     | 200  | 50   | 20         | 10     | 25  |

### Recommended Used Oil Contamination Limit for Heavy Duty Diesel Engines

| Analysis Parameter        | Dirt (Silicon) | Soot % Weight | Coolant, ppm |        | Water, % Volume | Fuel Dil. % Volume |
|---------------------------|----------------|---------------|--------------|--------|-----------------|--------------------|
|                           |                |               | Potassium    | Sodium |                 |                    |
| <b>Warning, above...</b>  | 25             | 3             | 20           | 40     | 0.25            | 2                  |
| <b>Critical, above...</b> | 50             | 6             | 50           | 100    | 0.50            | 5                  |

(3) For engines with sliding follower valve train Warning above 2%, Critical above 3%

### Recommended Actions

1. Within Normal Ranges – no action required
2. Above the Warning Limits – change oil and filters, resample at next oil change
3. Single result above Critical Limits, or second sample above Warning Limits – change oil and filters, and effect corrective action

Never recommend engine disassembly based on oil analysis alone. Confirm condition with a mechanical evaluation of the equipment.

Note that some parameters are interactive and their presence in combination may be more significant than if seen individually. For example:

- Iron + Chromium in the presence of Silicon indicate dirt ingestion and ring/liner wear
- Lead + Tin indicate possible bearing babbitt wear
- Soot + Iron indicate soot-induced wear

**Note: The used oil analysis limits provided above are intended to be used as general interpretation guidelines and should not be the sole criteria used to render a decision.**

### Typical Metals Found in Diesel Engines\*

| Manufacturer          | Bearings                 | Crankshafts | Cylinder | Piston         | Rings                      |
|-----------------------|--------------------------|-------------|----------|----------------|----------------------------|
| <b>AGCO</b>           | Tin, Copper              | Iron        | Iron     | Iron           | Chromium, Iron             |
| <b>Caterpillar</b>    | Lead-Tin, Copper, Nickel | Iron        | Iron     | Iron, Aluminum | Chromium, Iron             |
| <b>Cummins</b>        | Lead-Tin, Copper, Nickel | Iron        | Iron     | Iron, Aluminum | Chromium, Iron             |
| <b>Detroit Diesel</b> | Lead-Tin, Copper         | Iron        | Iron     | Iron, Aluminum | Chromium, Iron             |
| <b>International</b>  | Tin, Aluminum, Copper    | Iron        | Iron     | Tin, Aluminum  | Chromium, Iron, Molybdenum |
| <b>Mack</b>           | Tin, Copper              | Iron        | Iron     | Iron, Aluminum | Chromium, Iron             |

\* Most diesel engines have a Lead-Tin overlay topcoat on engine bearings.

### Element Source of Element

| Element              | Engine  |   |  |                                       | Torque Converter             |
|----------------------|---|---|--|---------------------------------------|------------------------------|
|                      | Engine  | Transmission  | Differential                                     | Differential                          |                              |
| <b>Iron (Fe)</b>     | Cylinder, Block, Gears, Crankshaft, Wrist Pins, Rings (cast), Camshaft, Valve Train, Oil Pump, Liners               | Gears, Discs, Housing, Bearings, Brake Bands, Shift Spools, Pumps | Gears, Shafts, Bearings, Housings                | Housings, Bearings, Shafts            |                              |
| <b>Copper (Cu)</b>   | Wrist Pins - Bushings, Bearings, Cam Bushing, Valve Train, Oil Cooler, Thrust Washer, Oil Pump                      | Clutches, Steering Discs, Bushing/Thrust Washers, Oil Cooler      | Bushings, Thrust Washers, Oil Pumps (where used) | Bushings, Thrust Washers (where used) |                              |
| <b>Aluminum (Al)</b> | Pistons, Bearings (near failure), Bushings (some) Blocks (some), Housing, Oil Pump Bushing, Blowers, Thrust Bearing | Pumps, Clutches (some) Thrust Washers, Bushings                   | Thrust Washers, Pump Bushings (some)             | Impeller Turbine, Pump (some)         |                              |
| <b>Chromium (Cr)</b> | Rings, Roller/Taper Bearings (some), Liners, Exhaust Valves, Water Treatment  | Roller/Taper Bearings, Water Treatment (oil cooler)               | Roller/Taper Bearings (some)                     | Roller/Taper Bearings (some)          |                              |
| <b>Tin (Sn)</b>      | Pistons (overlay), Bearings (overlay), Bushings   | N/A   | N/A  | N/A                                   |                              |
| <b>Lead (Pb)</b>     | Bearings, Gasoline Octane Improver  | Oil Additives (some)  | Oil Additives (some)                             |                                       |                              |
| <b>Silicon (Si)</b>  | Anti-foam, Ingested Dirt  | Disc Lining   | Ingested Dirt                                    | Ingested Dirt                         |                              |
| <b>Sodium (Na)</b>   | Oil Additives (some) Anti-freeze, Road Salt Ingested Dirt   | Oil Additives, Ingested Dirt Road Salt, Anti-freeze               | Ingested Dirt                                    | Ingested Dirt                         | Oil Additives, Ingested Dirt |

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