Diesel Soap – Formation and Related Problems

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Background – Why the Concern About Diesel Cleanliness?

- HPCR (High Pressure Common Rail) diesel injection systems are cleaner burning, less polluting engines, but need cleaner fuel;

- BP began surveying state of diesel fuel cleanliness in the marketplace and how to make it cleaner;

- BP’s fuel cleanliness studies led to diesel soap problem;
  - Possible link to fuel corrosion?
  - Many blocked filters contain diesel soap and rust;

- Theory possibly explaining this soap-corrosion phenomenon;
What is Diesel “soap” and why is it a problem?

• Diesel soaps – what are they?
  – Metal carboxylates form from corrosion inhibitors, lubricity improvers, etc. and tank water bottom cations (e.g. sodium, calcium, etc.);

• Soaps tend to plug filters (both dispenser and vehicle);
  – May cause fuel dispensing equipment to malfunction;
  – May possibly lead to fuel injection system deposits;
  – Soaps also contribute to lingering haze problems even though dissolved water is only 100 ppm or so;
  – Similar problems with gasoline also found;

• If available corrosion inhibitor in fuel reacts to form metal soaps and/or is less fuel soluble, it may leave fuel more corrosive and lead to rust and corrosion problems. BP has found that the two typically go hand in hand;
Making Diesel Soap – Filter Rig & Bench Top

- Two methods of making diesel soap have been used;
  - BP Dispenser Filter Rig – 10 gallons fuel w extra corrosion inhibitor and salt;
  - BP Bench Top Blender – 1 liter fuel in Waring blender as above;
  - Many corrosion inhibitors from multiple manufacturers studied;
- Filter rig hard to clean, switched to blender exclusively;
- Hazy samples form soaps in the sample container bottom within minutes; “Synthetic” CI’s seem to make more soap.
- Removing excess water doesn’t stop fuel from continuing to generate soap;
- Samples can remain hazy for months;
Diesel Soap Test -- BP Dispenser Filter Rig
Diesel Soap Test – Soap Formation

10X Magnification

10X Magnification
• Ordinary ULSD was treated with 25 ppm of a common acid type corrosion inhibitor and also with 25 ppm of a partial “synthetic” inhibitor (from same manufacturer);
  – Both samples made similar amounts of soap – CI with synthetic component made slightly more;
  – Resulting particulate identified by analytical methods as sodium carboxylates (metal soap);
Base ULS2 tested at a “D” NACE;
  – “Soaped” sample #1 (25 ppm common Cl) = “B”;
  – “Soaped” sample #2 (25 ppm common Cl + synthetic) =“B”;

Samples sat undisturbed for 2 weeks and retested for NACE corrosion:
  – Both samples tested at “E” NACE (worst rating)
Samples tested for NACE at refinery, at pipeline breakout terminals and at destination (product) terminals. Examples of the test results were:

- Refinery = “A/B++” (B\(^+\) or better is passing)
- Pipeline Breakout Terminal = “D/E”
- Destination Terminal = “D/E”

Lubricity improver added at terminal improved product to “B” or “C” (B\(^+\) is normal) -- means customers are generally protected, but distribution system assets (tanks/pipelines) may be affected.

Similar trends observed with gasoline on occasion;

Instances are believed to be rare -- however the fact that they have been observed means that it can happen.
Metal soaps are easily formed in minutes mixing ordinary ULSD with common corrosion inhibitors and salt-laden water;

Corrosion inhibitors both with and without a synthetic component make soap, though synthetics typically make more;

Resultant fuel can become corrosive due to corrosion inhibitor being “used up” by soap formation;

Corrosive fuel can lead to tank and piping corrosion piping in as little as 3 weeks (probably less);

Metal soaps have been shown to pass through ordinary dispenser filters – some is removed, but not all of it;

Even if fuel is filtered, soaps can keep forming in storage tanks.
Diesel Soap Study – Conclusions/Recommendations

• New information suggests that common corrosion inhibitors make nearly as much soap as common inhibitors with synthetic component – full “synthetic” CI’s previously shown to make the most soap;

• Study suggests corrosion inhibitor can be used up quickly and possibly lead to fuel with less corrosion protection soon after entering distribution systems;
  – Could this be one of the reasons for increased corrosion complaints?

• New corrosion inhibitor chemistries may be needed? Chemistries in use for many years may no longer be adequate –
  – Higher treat rates don’t seem to consistently provide the corrosion protection needed with new ultra low sulfur fuels;

• More study is needed to evaluate the efficacy of corrosion inhibitor through the distribution system;

• Time to think about a retail NACE corrosion specification (both diesel and gasoline)?
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