PAG gets good reviews from two top generating companies

It's the rare user group meeting that doesn't have a discussion about sticking servos or other problems caused by varnish formation in lube- and/or control-oil systems. Typically, participants mention the use of a particle-agglomeration or an electrostatic device as the preferred cleanup solutions. An alternative is to chemically clean the affected system and fill with new oil.

Most plants opting for new oil, refill with the hydrocarbon formulation used previously. With everything else the same, varnish reappears in time. At the 2009 7F meeting there was significant discussion on the merits of, and experience with, changing the type of oil from a hydrocarbon fluid to a synthetic polyalkylene glycol (PAG, see table).

One presentation this year was an update by a senior engineer from one of the largest US utilities on experience with a PAG at a repowered 2 × 1 combined-cycle plant in the Southwest. In mid 2001, the company coupled two 7FAs and companion heat-recovery steam generators to a 170-MW steam turbine which had been commissioned 40 years earlier. The plant operates in base-load service.

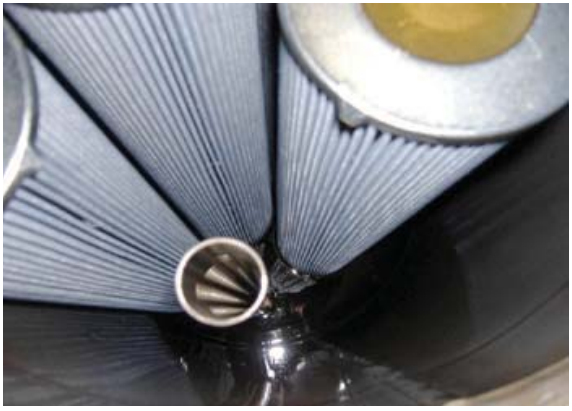
The switch to a PAG (specifically EcoSafe TF-25, see box) was made during a hot-gas-path inspection for one gas turbine (GT) in November 2007; the second was converted in March 2008. To make the switch, all the plant did was drain the existing oil and refill with TF-25; there was no flush step.

First slide in the presentation had the title and the presenter's name—no surprise there. The second slide in the update said "Everything went Okay. Questions?" Of course there was more, but it got everyone's attention. The utility had conducted regular analyses (November 2007; May, July, September, and November 2008; and April 2009) of the fluid and key parameters were presented in a chart. Here's a summary:

- Color, clear with bronze to brown tint.
- Viscosity (SUS), preferred range of 100 to 150. Results virtually constant—129 or 130.
- Total acid number (TAN), preferred range of 0.1 to 5.0. Test results showed 0.10 to 0.24.
- Particle counts (ISO 4406) revealed only one minor deviation from the preferred maximum of 7/5/2 until the April 2009 test was conducted and that blemish was corrected before the next sample was taken. The April results were 7/6/4. Investigation revealed that the lab had "recalibrated" its instruments just before the analysis was done and the quality of its work was still under review at the time of the meeting.
- Sodium readings ranged from 1 to 2.5 ppm, potassium from 7.4 to 8.8, calcium from 1.0 to 1.8, barium from 290 to 320.
- The additive package did not degrade over time (100% of the initial formulation for all samples).
- Water. The fluid is slightly hydroscopic, so water content spikes during summer. Limit is 7500 ppm. In summer 2008 water peaked at

Comparing EcoSafe TF-25 to a premium hydrocarbon turbine oil

Parameter	TF-25	Hydrocarbon
ISO viscosity grade	25	32
Viscosity at 212F	5.19 cSt, 5.11 cP	5.56 cSt, 4.78 cP
Viscosity at 104F	26.23 cSt, 25.84 cP	32.44 cSt, 27.90 cP
Viscosity index	132	109
Specific gravity	0.985	0.86
Pour point, F	-55	-22
Flash point, F	468	420



No gel, varnish, or particulates have been found on lube-oil filters when using EcoSafe TF-25, one plant reports

Explaining PAG

In electric generating plants, polyalkylene glycols, aka PAGs, are synthetic substitutes for hydrocarbon or mineral oils as turbine lubricants and control fluids.

They often are specified where varnish and/or sludge adversely impact plant availability. Gas turbines, in particular, are challenging duty for lubricants and control fluids because of their high operating temperatures.

Dr Martin Greaves, technology leader for Dow Chemical Co's UCON™ products, which are the base stocks for fluids such as EcoSafe TF-25, said in a signed article that appeared in the April 2009 issue of *Compoundings,* "when hydrocarbon oils degrade they form high-molecular-weight polar byproducts that become insoluble in the hydrocarbon base oil. Consequently, sludge develops over time, and in some cases, varnish formation occurs."

He also noted that "the more paraffinic nature of the newer base oils has resulted in the oxidative degradation products being even less soluble in the base oil, accelerating sludge and varnish formation." This is not a comforting message for powerplant owner/operators.

"In contrast to hydrocarbon oils," Greaves continued, "PAGs are extremely polar in nature. When they degrade by oxidation, smaller polar byproducts are formed, which are soluble in the PAG base oil. The net result is that sludge is almost eliminated and equipment reliability enhanced."

EcoSafe T-25, as noted, is based on Dow's synthetic lubricant technology. It is marketed by American Chemical Technologies Inc, Fowlerville, Mich.

3070 ppm, but settled back to 520 by November.

An increase in generator hydrogen consumption occurred after both conversions to PAG. This was not caused by the loss of hydrogen, but rather by purity degradation requiring increased scavenging. With the PAG fluid density at 0.985 compared to oil at 0.86 (table), oil supply pressure went up by 15 psi, and seal-oil differential pressure from 6 to 8 in. H_20.

Higher seal-oil flow meant increased air infiltration. However, the utility's test philosophy was to maintain a direct conversion from mineral oil to PAG to see what impacts, if any, there would be on equipment—no tweaking allowed until engineers were able to evaluate how the fluid performed on GTs. The speaker said the plant intended to decrease seal-oil delta P to 6 in. H_2O at the next outage to see if hydrogen consumption would return to normal.

Visual results: No gel, varnish, or particulate matter has been found in filter canisters. Filter elements in photo are cleaner than might be expected.

More 7F experience

Calpine Corp's Oneta Energy Center, Broken Arrow, Okla, is another convert to EcoSafe TF-25. This snippet of information came from the Dow Chemical Co booth at the vendor fair. Although at least one plant representative attended the 7F meeting, there was no formal presentation. So the editors followed up by phone.

Oneta consists of two 2 × 1 7FA-powered combined cycles. The plant experienced varnish and carbon build-up (in servo valves, pencil filters, reservoir interiors, and piping), which were attributed to turbine-oil degradation caused by high heat and friction.

After unsuccessfully testing several methods and systems designed to remove and/or reduce varnish, the plant decided to replace the lubricant with a product that would better resist its formation. EcoSafe TF-25 was the fluid selected.

Preparations to switch lubricants included a complete varnish flush using a cleaning formulation in the original oil. Varnish and sludge were removed from system components. Next, 3500 gal of TF-25 was circulated through the GT and drained. Then the system was refilled with fresh TF-25.

The problems with varnish and sludge have disappeared. Plant personnel also noted a slight drop in bearing metal temperatures (2 to 3 deg F) under comparable operating conditions. The latter benefit is attributed to less friction loss in the bearings. Results of follow-up analytical tests over a year's operation met expectations.