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The value proposition offered by HEPA filtration

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Walk by all the booths in the exhibit hall at the 24th annual meeting of the Western Turbine Users Inc and you'll see about 10 manufacturers or their representatives offering air inlet filters for gas turbines. If shopping, you'll hear a lot of good reasons to buy a particular brand and/or grade of filter. Listen carefully to the attributes of each product and carefully evaluate them against your engines' specific needs before making a buying decision.

To some owner/operators, a filter is a filter, and the less you pay for it the better. A low-cost "garden variety" filter may be a good fit for a peaking unit that runs a few hundred hours a year, or less, in a location with "normal" ambient conditions. But that same filter might not be a wise choice at a seacoast location or in an area that gets an extreme amount of rainfall. Do your homework.*Caveat emptor* is something to keep in mind at all times.

High-efficiency particulate air (HEPA) filters are at the opposite end of the spectrum from the most basic of air inlet filters. They are designed to capture the very small particulates entrained in gas-turbine inlet air that are most responsible for compressor fouling. But at a price: The cost of an E12 HEPA filter may be as much as four or five times the asking price for a "conventional" F8 filter. When hydrophobicity is combined with HEPA performance, the filter can prevent ingestion of both submicron particles and water-soluble contaminants—such as salt—which can damage the engine over time.

Initially there were not many takers when W L Gore & Associates Inc introduced HEPA filtration to US gas-turbine owner/operators six or seven years ago. Until then, Gore's industrial filtration business had focused on high-efficiency filtration for pollution control and had not been involved in the supply of air-inlet filters for gas turbines.

Soon after Gore's product launch, one gas-turbine OEM strongly recommended against water washing its largest compressors because of blade cracking issues (an advisory since rescinded) and several of the

industry’s traditional filter suppliers added HEPA products to their offerings. The popularity of HEPA filters continues to increase as more plants report positive experiences.

But many users still question whether the much higher cost of these filters can be justified. Early economic analyses conducted by owners typically focused on compressor performance and assumed a one- to two-year lifetime for HEPAs serving high-hours engines. Based on those parameters alone the HEPA was, and continues to be, a tough sell. But where the cost of replacement power is expensive or unavailable, water washing is not feasible, or a corrosive ambient environment is causing premature engine failure, HEPA filtration may be readily justified.

McMahon

Economics 101. An evaluation of Gore HEPA filters by Alliance Pipeline—an integrated Canadian/US high-pressure natural-gas transmission system which began operation in December 2000—over the last four years indicates that an analysis based solely on the value of compressor cleanliness does not fully reflect HEPA’s advantages.

A recent presentation by Alliance Pipeline’s Rob, a regular participant in Western Turbine meetings, revealed that HEPAs also eliminate the significant cost of compressor washing and the risks associated with starting and stopping the engine to do offline cleaning. These benefits also should be included in your evaluation.

Plus, fouling of hot parts is reduced because cleaner compressor bleed air is used for cooling. Hot parts that run cooler last longer. McMahon believes HEPA filters may allow Alliance to extend the interval between overhauls of its aero engines from 25,000 to as many as 50,000 hours (from three to six years). That could translate into an annual saving for the fleet well into seven digits. Finally, the engine expert says HEPA filters may have a service life twice as long as originally thought, reducing the investment cost.

CCJ ONsite began chronicling Alliance Pipeline’s experience with HEPA filters on its Kerrobert and Windfall gas turbines back in 2012, when McMahon started sharing this information with his Western Turbine

colleagues. An update was published during the 2013 WTUI meeting. A couple of weeks ago, the editors interviewed McMahon about how well the filters performed since the last meeting. Here's a summary of that conversation:

1. Airborne contaminants and wash water residue plug cooling holes in a first-stage HPT blade. Engine was not equipped with HEPA filters

Fourth anniversary. Shortly after the 24th annual WTUI conference ends, the Kerrobert compressor drive will celebrate its fourth year of service with the original Gore HEPA filters (April 2014). Delta p is still acceptable at about 1.7-1.8 in. H2O. The Windfall 1 unit hits the same milestone a few weeks later. However, while Windfall 1 will have operated on HEPAs for all that time, its original filters were replaced in November 2013—as a precaution.

Reason: The unit had experienced some delta-p spiking last fall and not having first-hand experience on how HEPA filters fail, Alliance erred on the side of caution going into winter—peak season for a gas pipeline. Note that Windfall 1 was the only engine in the company's fleet using HEPA filters *without* coalescer wraps. The replacement filters installed in November 2013 have those wraps.

In the last two years (April 2012 to April 2014), Alliance has avoided nearly 150 water washes. More importantly, it has eliminated nearly 150 shutdowns that might have caused other issues to arise.

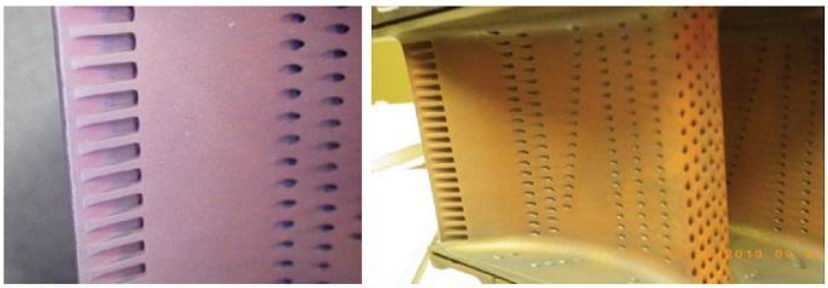
During the telephone interview, about two months after the Kerrobert HP section was overhauled at a depot, McMahon reflected on the secondary effects of allowing airborne contaminants into the engine, other than the obvious fouling of compressor airfoils. He explained that LM2500 hot-section components are cooled by air extracted from HPC stages nine and 13 and that any contaminants in that air would be piped to nozzles, blades, etc, where they would foul small air passages not

conducive to cleaning by water washing. In fact, water washing can exacerbate fouling, he said.

2. Fouling at the trailing edge of a first-stage nozzle. Engine was not equipped with HEPA filters

Most airborne dirt entering the compressor is deposited in the bell mouth, front frame, IGVs and first seven stages of compression. The soap solution used to loosen up the accumulated dirt during a soak period is rinsed through the HPC and drained from the combustor. However, some of that dirty soap solution finds its way into the cooling manifolds at stages nine and 13, clogging cooling passages and reducing the life expectancy of hot parts.

McMahon offered several photographs as evidence. Fig 1 shows airborne contaminants and wash water residue plugging the cooling holes in a first-stage HPT blade; Fig 2 is of fouling at the trailing edge of a first-stage nozzle. Figs 3 and 4 are from the Kerrobert overhaul in December 2013. First-stage nozzle is clean as a whistle after three years of service on an engine protected by HEPA filters.

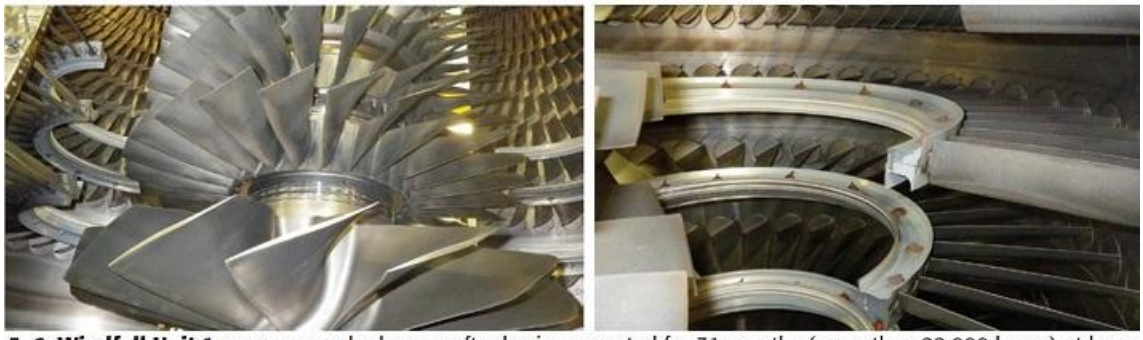


3, 4. Kerrobert first-stage nozzle is clean as a whistle after three years of service on an engine protected by HEPA filters

Critical to hot-section component endurance, McMahon said, are the following:

- Maintain exhaust-gas temperature (so-called T48) at or below the OEM's stated maximum.
- Ensure good quality fuel gas.
- Use HEPA technology to keep blade and nozzle cooling passages pristine.

Windfall 1, outfitted with Gore HEPA filters in May 2010 was last water washed in May 2011 with no sign of dirt in the rinse water and no efficiency increase. It was removed for a scheduled 50,000-hr overhaul early in January 2014 after operating for 31 months at base load with no water washes (more than 22,000 hours). Obvious from Figs 5 and 6 is that no dirt has entered the compressor since the May 2011 water wash.



5, 6. Windfall Unit 1 compressor looks new after having operated for 31 months (more than 22,000 hours) at base load with no water washes

McMahon had the original filters weighed after they were replaced in November 2013. Each of the 272 filters had gained about one pound since installation 43 months ago.