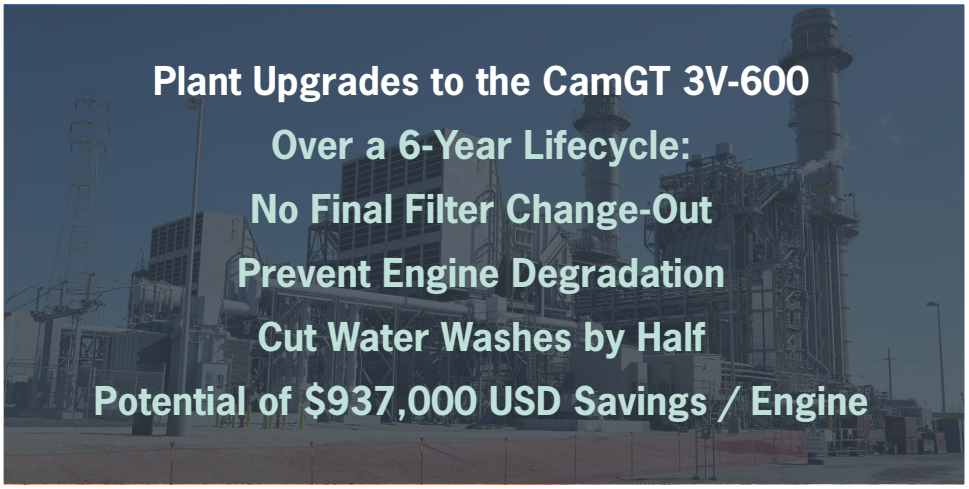
CASE **STUDY**

Power Systems



CamGT 3V-600

Optimum water drainage capabilities

PLANT UPGRADES TO THE CAMGT 3V-600 FOR A 6-YEAR LIFECYCLE & TO PREVENT ENGINE DEGRADATION

COMPARISON TEST INDICATES A POTENTIAL OF $937,000 USD SAVINGS OVER A SIX-YEAR TIMEFRAME BY UPGRADING TO EPA

A new combined cycle plant on Louisiana's Gulf Coast has been operating commercially since 2014. The plant has two GE 7F.04 gas turbines, producing 171 MW each, and a steam turbine that produces 218 MW, totaling 560 MW of power.

In early 2016, a small team of fleet turbine managers took proactive measures to prevent compressor corrosion and fouling that had impacted other 7FA turbines' power output across their fleet. Corrosion, if unchecked, could potentially cost the organization millions of US dollars due to engine refurbishment and loss of revenue. Further, the team understood how fouling could lead to power and engine degradation. Although degradation caused by fouling can be mitigated somewhat by offline washes, some non-recoverable degradation will remain.

Another initiative of the plant is to change their major outage schedule from three to six years, therefore requiring final filters with a six year lifecycle. In order to select the appropriate filters that will prevent corrosion and fouling at this new plant, they decided to test various filter configurations with Camfil's on-site testing trailer. The CamLab, a 28-foot mobile test lab, consists of four separate ducts that can be fitted with pre-filters and final filters in order to monitor and analyze the performance of each configuration's capability of handling a site's contaminants before purchasing filters.

The trailer is a tool that provides critical insight into what filtration configuration will withstand the harsh conditions of the surrounding environment, prevent the need for water washing, and eliminate corrosion-related maintenance.

THE SITE

The plant is located less than 20 miles from the Gulf Coast, along the Mississippi River in South Louisiana. This particular site has annual temperatures averaging 70°F, with temperatures between May and September often exceeding 90°F, with relative humidity over 90%[1]. During summer, afternoon thunderstorms produce heavy rainfall over short periods of time.

Situated in an industrial area, the turbines are exposed to heavy dust concentrations of various particulate matter such as gypsum and airborne grain from neighboring production plants.

The combination of humidity and heavy dust load makes this site a challenging environment.

CURRENT FILTER CONFIGURATION

The filter configuration in 2016 was a two-stage, 12" bag pre-filter, rated at an M5 efficiency and a 17" compact final filter, rated at an F9[2] efficiency. Heat rate increases, caused by fouling, required water washes for recovery. The team performed daily online washes and two offline washes per year; this resulted in a 2% improvement in the heat rate each time they water washed offline.

THE TEST

The CamLab was commissioned at the site for 2200 hours (3 months) with three different, 2-stage configurations outlined in Table 1.

The table shows that the CamGT 3V-600 24" E10[3] filter, while offering a better efficiency, clearly outperformed the competitor's 17", F9 filter in terms of pressure drop. The Camfil CamGT 4V-300 12" E10 filter had a similar pressure drop performance to the competitor initially, even with its higher efficiency. This highlights that filter depth is only one part of the design - aerodynamics, media performance, media surface area, as well as construction, are equally important in designing a well-performing filter.

The 3V-600 configuration performed well in terms of pressure drop and efficiency due to its 24" deep frame (twice the depth of the 4V-300), aerodynamic configuration, and optimized media area. This deep frame allows for unparalleled media area and low velocity, providing the lowest pressure drop and longest available life. In similar environments, the 3V-600 has lasted over 5 years without change-out, resulting in high engine availability.

[1]Philip Grigsby, Forecaster for the National Oceanic and Atmospheric Administration, U.S. Department of Commerce
[2]F9 per EN779:2012 : European filter rating system : Average Efficiency ≥ 95% on 0.4µm
[3]E10 per EN1822 : European filter rating system : E10: Initial Efficiency ≥ 85 on MPPS (most penetrating particle size), typically between 0.1-0.2µm

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Chart 1: Pressure Drop Over 3 Months

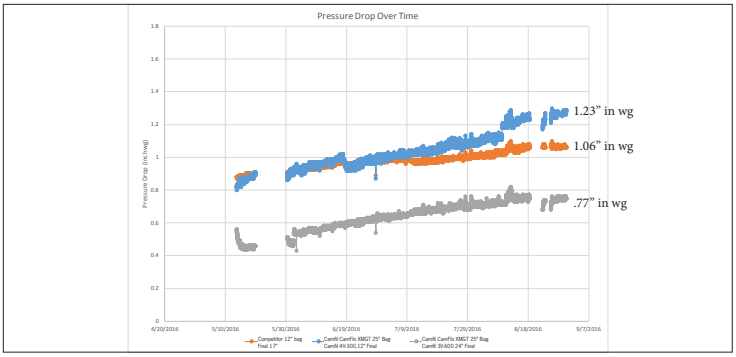


Table 1: Filter Class and Pressure Drop

Filter	Filter Class	Average Efficiency 0.4µm	dP "w.g.
Competitor 12" bag + 17" final	M5 / F9	78.30%	1.06"
Camfil CamFlo 25" bag + CamGT 4V-300, 12"	F7 / E10	97.86%	1.23"
Camfil CamFlo 25" bag + CamGT 3V-600, 24"	F7 / E10	99.48%	0.77"

LIFE CYCLE COST (LCC) ANALYSIS

An LCC, total cost of ownership analysis, was performed to determine the most cost efficient set-up.

Figure 1 indicates that the lowest total cost of ownership over a six-year timeframe is predicted for the 3V-600 configuration. Due to the higher E10 efficiency class, the plant would encounter minimal fouling effects. The majority of savings, therefore, are a result of lesser fouling leading to higher power output, with savings up to 88% percent. By minimizing the fouling effect in this case, Table 2 shows that the plant could reduce maintenance needs by requiring half as many offline washes.

Table 2 further shows that the 3V-600 configuration requires final filter change-out after 48,000 hours. This would allow the plant to meet their initiative of operating continuously for six years without shutdown for final filter replacement.

The plant is expected to potentially save a total of approximately 29% as compared to the competitor configuration, or an estimated $937,000 USD over a six-year period[4].

UPGRADE

As a result of the CamLab results and LCC analysis, Camfil was awarded with the project of installing the CamFlo prefilters as a first stage and CamGT filters as a final stage.

ADVANTAGES OF THE CAMGTs[5]

A common phenomenon in ordinary inlet air filters is bypass and leakage, which allows salt, water, as well as coarse and submicron particles to pass through filters. Controlling bypass and leakage will prevent fouling and corrosion, wearing down of turbine components, as well as unnecessary and expensive downtime.

Gasket

The CamGT has a one-piece, poured in place endless gasket as compared to four-pieces. Since there are no openings with a one-piece gasket, it prevents any water penetration.

Glue

The CamGTs solid, airtight frame is designed to prevent any bypass due to Camfil's patented new glue technique, the double sealing design. Media is typically glued to the filter header with 2-4 glue steps, however, the double sealing design is a 6-step glue technique that fixes the media to the frame, which ensures leakage prevention.

Resistant to Humidity

The CamGT not only offers large media surface area, it also features vertical pleating and patented interrupted hot melt separators for optimum water handling.

Its construction allows trapped water to drain freely from the filter during operation, thus avoiding re-entrainment of dissolved impurities (i.e. salt) and maintaining low pressure drop under high humidity conditions.

CamGT Key Features:

- High filtration efficiency
- Low pressure drop also in wet conditions
- Long filter life
- Resistance to turbulence

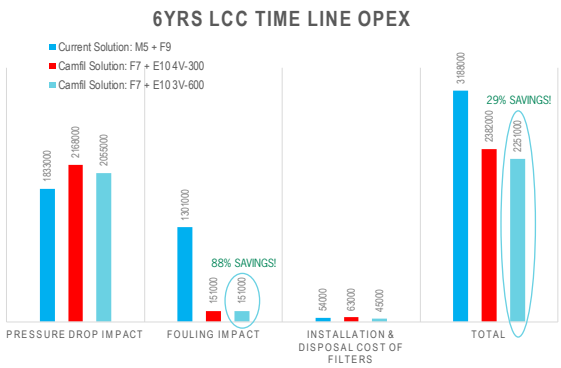
CamGT User Benefits:

- Increased turbine availability
- Lower fuel consumption
- Higher power output
- Extended turbine life
- Reduced life cycle costs (LCC)

Table 2: 6 Year Life Cycle Cost Analysis

Filter	Offline Water Wash	Expected Final Filter Life
Competitor 12" bag + 17" final	Twice / Year	24,000 hrs
Camfil CamFlo F7 bag + CamGT 4V-300, 12"	Once / Year	16,000 hrs
Camfil CamFlo F7 bag + CamGT 3V-600, 24"	Once / Year	48,000 hrs

Figure 1: 6 Year Life Cycle Cost Analysis



[4]The LCC was calculated using site-specific data and cannot be used as a prediction for every site. Request a personalized LCC for your site: http://www.camfil.com/ps/Contact

[5]The CamGT 3V-600 and 4V-300 have the same media and filter frame. Due to the redesigned shape and increased amount of media in the 3V-600 versus the 4V-300, a much lower and stable pressure drop can be achieved.

camfil POWER SYSTEMS

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