BY STEPHEN D. HINER

A Breath Of Fresh Air For Gas Turbine Inlet Systems

Selecting the right technologies amid a number of new challenges for optimizing gas turbine air inlet filtration system

The days of the one-size-fits-all technology for gas turbine inlet air filtration systems are over. Today, as turbines get used in an ever-increasing range of applications and environments, air filtration systems face a number of new challenges. With a wider breadth of fuel quality burned and mounting expectations that turbines will have longer life, higher efficiency and reduced maintenance requirements, the quality of air entering the gas turbine has never been more crucial.

So how do you select the best filtration system for a gas turbine inlet system? Especially with parameters that can be so different, or even opposing?

The answer calls for unique solutions for each type of environmental challenge, gas turbine platform technology and fuel quality. These guidelines can help determine what optimized technologies might work best for air inlet filtration systems.

Advanced Turbines Mean More Complexity, Smaller Margin For Error

Gas turbines are high-precision, highly optimized machines that consume a massive quantity of air. In some cases, the air passing through a turbine in just two hours is equivalent to consuming all the air within a professional sports stadium in the same amount of time.

Turbines are used in a range of environments, including offshore oil and gas installations, mechanical drives, mobile power, power generation and marine propulsion. They're sensitive, though, to contaminants in the air or fuel that may pass through them. Using the wrong filtration system can lead to reduced performance, expensive repairs and, eventually, the gas turbine components may catastrophically fail. This can stem from four main problem types: erosion, plugging, hot corrosion and compressor fouling.

With advances in engine design, the need for superior filtration is essential. Turbines have become much more powerful, reliable and efficient; with those improvements, however, they have also become more complex. They have multiple stages and can have multiple shafts, higher pressure ratios, higher firing temperatures, reduced component clearances and intricate cooling passageways. This complexity means reduced allowance for failure in the components.

When it comes to contamination and abuse, there's a very small margin for error. However, there's a logical process that can be defined for selecting the optimum gas turbine inlet filtration system for most applications.

There are three major categories to consider in selecting the gas turbine filter system: environmental considerations, the gas turbine type and plant operational considerations.

Environmental Considerations

Gas turbines are used in diverse environments that can be split into nine broad categories. A closer look at those environmental categories also provides detail about potential contaminant types and levels:

Environment type	Salt levels	Dust levels	Other challenges
Marine	High	Low	Bulk water
Offshore	High	Medium	Vapors
Coastal	Medium	Medium	Vapors
Dusty	None	High	Vapors
Dusty Coastal	Medium	High	Vapors
Desert	None	Very High	-
Urban	None	Medium	Vapors
Sub... Arctic	-	-	Snow and Ice
Sub... Tropical	-	-	Bulk water

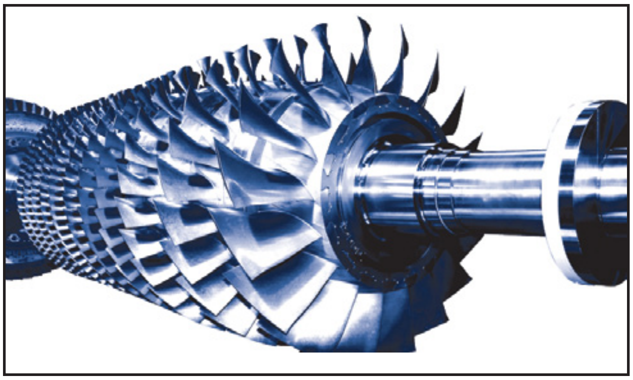
To further evaluate these contaminants, consider the following additional characteristics:

Characteristic	Evaluation Criteria
Coastal / Corrosive	Distance from a source of salt
Water Levels	Max rainfall Instances of fog
Dust Levels	Extremely high High Seasonally high Low
Particulate Type	Dry / Sticky
Mean Particulate Size by Number	<2 microns / > 2 microns
Min Temperature	< 40F
Snowfall	Inches per year

Stephen D. Hiner is a consulting engineer for GE Energy, based in Alton, Hampshire, U.K.

Conditions Specific To The Gas Turbine

Besides the environmental factors, there are also considerations that relate specifically to the gas turbine. Determination is needed, for example, for the sensitivity to fuel quality, specifically sulfur, as well as the expected component life and its effect on the time between planned outages. Both of these are directly related to the specific type of gas turbine used.



From a filtration point of view, turbines can typically be classified into four categories:

Low-tech — Most of these turbines were introduced in the 1960s and 1970s. The component life is relatively short, so extended filter life may not be required. These systems are also tolerant of fouling, so lower efficiency filters may be acceptable, and they're generally tolerant of high sulfur fuels with lower firing temperatures.

Medium-tech — Developed in the 1980s, component life is longer, so considerations must be given to avoid outages just to change filters. They're also less tolerant of fouling, so higher efficiency filters may be required, but are still generally tolerant of high sulfur fuels.

High-tech — These turbines were developed in the 1990s. Their longer component life means there is again a likely need to find ways to avoid outages just to change filters. They're also less tolerant of fouling, so higher efficiency filters — even HEPA grade — may be required. These turbines generally have a lower tolerance of high sulfur fuels, requiring higher salt efficiency filter systems when salt is present as a contaminant.

Next generation — Introduced after 2000, next generation turbines can be considered similar to high-tech GTs with respect to filtration needs. Outage avoidance to change filters, lower fouling tolerance and lower tolerance of high sulfur fuels means higher efficiency inlet filtration may be required.

Plant Operation Considerations

There are three main plant operation considerations: availability for a maintenance shutdown, the cost of downtime and the availability of a skilled workforce.

With the availability for a maintenance shutdown, for instance, there is a need to know if the GT load profile is base-load or peaker. Also, it must be determined if there's redundant GT capacity available to cover downtime. Particular attention should be paid to other maintenance downtime opportunities that can be utilized to change filters, such as scheduled offline water wash frequency. Consider:

- With downtime, what would be the consequences of a shutdown?
- Would there be a reduction in production of high value process plant products, such as LNG?
- What would be the market value of the MW lost?
- Would there be large delays and an expensive restart if there's a complete shutdown of a production process plant?
- And, even worse, could off-grid power to a region lead to blackouts?

In addition, with more GT installations occurring in developing countries and remote locations, availability of a skilled workforce may be a consideration. These areas also typically have less reliable transportation infrastructure.

Availability for a maintenance shutdown, the cost of downtime and the availability of a skilled workforce are all factors that highlight the need for plant autonomy, making it even more important to have extended periods between maintenance and greater time between outages.

Filtration Solutions

The challenge for optimizing a gas turbine air inlet filtration system is compounded by the fact that many gas turbines last several decades. Potential pollutants in a local environment can change over time because of factors such as weather, pollution, construction, agriculture work or other activities that create dust or other pollutants.

In general, there are five forms of contaminants. Each of these contaminants is present at most locations and controlling or removing them requires a different filtration approach for each.

Salt — Depending upon the humidity, salt may be present in the form of a droplet, a dry particulate or a partially solid/wet sticky dust. That's an important point to consider because, even after capture, the salt can change state and this could overcome the effectiveness of the capture mechanism. With salt, use a Vane/Coalescer/Vane (VCV) System or a Hydrophobic Filter System. Here are some advantages and disadvantages:

Benefit	VCV	Hydrophobic
Wet salt removal	+	-
Dry salt / dust removal	-	+
Compactness	+	-
Simplicity	-	+
Cost	-	+

+ = Most favorable
- = Least favorable

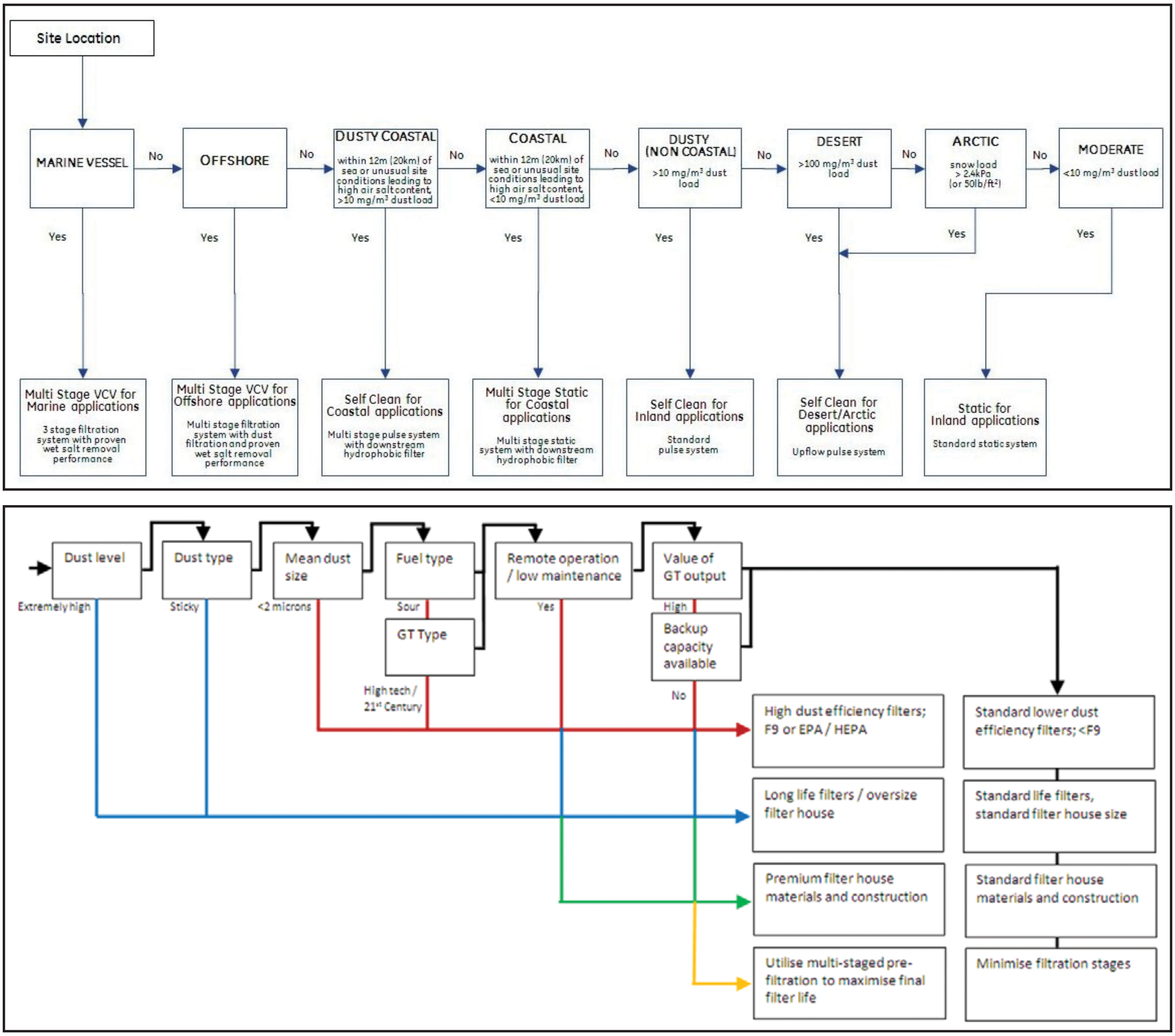
Bulk water — This can stem from driving rains or breaking waves, depending upon the location (e.g., coastal or tropical). Potential solutions include either Vane Separators or Rain Hoods and Louvers. Here's a closer look at each:

Benefit	Vane	Hood / Louver
Capacity for water quantity	+	-
Droplet size efficiency	+	-
Compactness	+	-
Cost	-	+

+ = Most favorable
- = Least favorable

Dust — Present in all locations, dust can have a unique type and composition ranging from dry and inert to oily and sticky. Dust characteristics can also change over time and with the seasons of the year. Static filters are typically used for low or average dust concentrations, and for high dust concentrations, self-cleaning systems such as "Pulse" filters are more common. There are also "Upflow" Pulse fil-

GE Air Filtration has developed these flowcharts (below) to act as a guide when evaluating gas turbine inlet filtration solution.



ters for locations of even higher dust concentrations. Here's how the filter systems compare:

Benefit	Static	Standard Pulse	Upflow Pulse
Initial dust efficiency	+	-	-
Filter life	-	0	+
Sensitivity to fog / mist	+	-	-
Compactness	+	0	-
Cost	+	0	-

+ = Most favorable
0 = Unbiased
- = Least favorable

Snow/ice — These contaminants can block filters and damage gas turbines. Icing comes in several forms. With snow, it's difficult to predict how it will form or settle. For light snow, Snow Hoods have been effective, and for heavy or extended snow conditions, Pulse Filters have been used. In cold climates, Inlet Heating can help prevent icing. Here's how they stack up against each other:

Benefit	Snow Hood	Upflow Pulse	Inlet Heating
Effectiveness vs. Ice	-	0	+
Effectiveness vs. Snow	-	0	+
Cost	+	-	-

+ = Most favorable
0 = Unbiased
- = Least favorable

Vapor — Turbines face many sources of vapor, including pollution such as un-burnt hydrocarbons that result from combustion, hydrogen sulfide from oil and gas operations, or oil vapor from lube oil vents. These vapors can clog filters or pose risks such as accelerated GT corrosion as they cannot be easily removed.

Mist or fog can also be a challenge to the filter system. Most often a coalescing filter is installed upstream of the main filter stages to reduce the pressure loss during periods of fog and mist when captured contaminant can swell. This type of filter can also combine a portion of the mist/fog droplets to drain them away.

Evaluating Solutions

Using the decision trees above will help determine the most successful "major filtration system type" and define some of the requirements of the inlet air filtration system, such as sizing to help optimize the technologies for your needs. These are general guidelines; equipment, facility and environment may introduce unique factors that must also be taken into account toward selecting the right technologies to optimize any gas turbine inlet air filtration system.