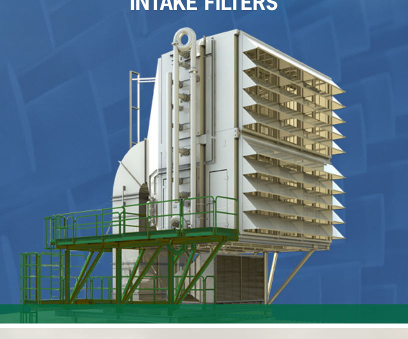
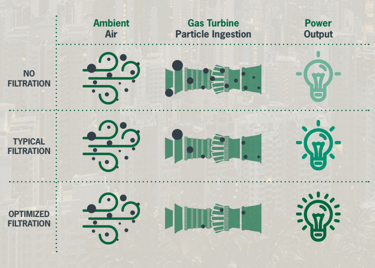
AN OPERATOR'S GUIDE TO SELECTING TURBOMACHINERY AIR INTAKE FILTERS



Gas turbines ingest approximately 98% air and 2% fuel. Although fuel is the power source for the gas turbine, most of what it ingests is air! Even a seemingly clean area of 20µg/m³, a 500 MW gas turbine can ingest up to 419 kg/yr (924 lb/yr). The consequence of poor air quality is a reduction in GT performance, leading to lower availability and reliability. This explains why air filters are so important, especially for critical applications such as power generation or oil & gas.

GAS TURBINE INPUT	GAS TURBINE OUTPUT
700 MW CCGT AIR 2000 lbs/s or 900 kg/s FUEL 50 lbs/s or 25 kg/s	Can power a city of over 500 000 people

IMPACT OF FILTRATION



FIVE ISSUES THAT AIRBORNE PARTICLES CAN CAUSE

Gas turbines are exposed to a variety of contaminants that can be detrimental to its performance. Larger particles are easier to remove from the airstream with most air filters, but submicron particles require higher efficiency filters to accomplish this. The consequences of sub-micron particle ingestion include fouling, plugging of cooling passages and corrosion of the gas turbine.

1 FOREIGN OBJECT DAMAGE (FOD)
Large objects are ingested by a turbine that damages the turbine's compressor blades; often resulting in catastrophic damage.

2 EROSION
Ingestion of particles > 5 microns in size that over time will erode compressor blades. This erosion will result in a change of the blade's aerodynamic profile, as well as the tip clearance. These changes will decrease the performance of the compressor section and thus overall turbine performance.

3 PLUGGING OF COOLING PASSAGES
Ingestion of small particles that eventually plug cooling passages of the combustion blades. The result of blocking of these passages could be a thermal failure/fracture of a blade and catastrophic turbine damage.

4 FOULING
Fouling of the turbine's compressor blades is the case where small particles attach to surfaces the blades. Over time particles will build up on the blades which will alter the aerodynamic profile of the blade and increase the aerodynamic drag of the blade due to increased surface roughness.

5 CORROSION / HOT CORROSION
Ingestion of corrosive/reactive particulate that over time will result in corrosion of turbine components. Hot end corrosion often occurs when salt present in the combustion air chemically reacts with any residual sulfur in the fuel. The result of this reaction is highly corrosive gas that will attack the blades and components of the turbine's power section.

MITIGATION WITH AIR INLET FILTERS

There are a wide variety of air inlet filtration systems to address degradation risks. Tailoring your inlet system to the environmental and operational conditions in which it will operate results in the following:

- HIGHER COMPRESSOR EFFICIENCY
- REDUCED MAINTENANCE
- LOWER LIFE CYCLE COST
- LOWER CARBON INTENSITY

There are many factors to consider when selecting filters. To help narrow down your filter selection process, once you know the efficiency needed according to standard ISO 29461-1:2021, you can use The Value Rating calculator to see its impact on your gas turbine. Take it a step further and request a full Camfil Life Cycle Cost Analysis personalized to your site conditions and operations.

1. Efficiency per ISO 29461-1 2021
2. The Value Rating Calculator
3. Life Cycle Cost Analysis

WHAT IS ISO 29461-1:2021

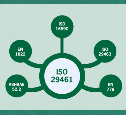
ISO 29461-1 is the first international test standard for reporting the performance of air intake filters for gas turbines, compressors, and other turbomachinery applications. It has been developed to help operators select air filters more efficiently.

WHY? UNIFORM STANDARD FOR TURBOMACHINERY

WHICH HAS THE HIGHEST EFFICIENCY?

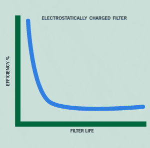
FILTER A	FILTER B	FILTER C
MERV 15	F9	ISO $ePM_{2,5}$ 80%
per	per	per
ASHRAE 52.2	EN779	ISO 16890

1 ELIMINATES CONFUSION
The gas turbine industry has been using multiple HVAC filter efficiency standards to help select filters. This makes it difficult to compare filters to one another, ISO 29461-1 consolidates and replaces these standards, and is the most relevant for gas turbines.

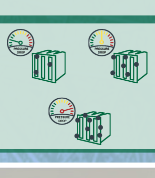


2 MEASURES MECHANICAL EFFICIENCY
ISO 29461-1 closely models the efficiency of filters operating in the field by measuring their mechanical efficiency/ discharged efficiency, which is not influenced by an electrostatic charge.

An electrostatic charge can exaggerate filter performance, resulting in a high classification. This has little relevance for gas turbines since the charge dissipates in a short period of time relative to the filter service life, causing efficiency to plummet. This puts your gas turbine at risk of ingesting finer particulate that could cause fouling and corrosion / hot corrosion.



3 REPORTS DUST HOLDING CAPACITY
In addition to efficiency, ISO 29461-1 reports the dust holding capacity (DHC) for all filters, not just pre-filters. DHC is a measurement of the quantity of test dust captured and held by the filter until the final pressure drop of the test is reached. The result gives a good indication on service life expectation.



CLASSIFICATION TABLE ISO 29461-1:2021

ISO 29461-1 has 13 classifications, ranging from T1 to T13. It shows the efficiency of a turbomachinery air intake filter for a specific size range: coarse, ePM_{10}, $ePM_{2,5,min}$, $ePM_{1,min}$ or MPPS (most penetrating particle size).

Class	Group	MPPS efficiency	ePM_1, min	$ePM_{2,5}$, min	ePM_{10}	Initial gravimetric arrestance A_{100}
ISO T1	Coarse					20% < A_{100} < 50%
ISO T2						≥ 50 %
ISO T3						≥ 70 %
ISO T4						≥ 85 %
ISO T5	ePM10				≥ 50 %	
ISO T6	ePM2,5			≥ 50 %		
ISO T7	ePM1		≥ 50 %			
ISO T8			≥ 70 %			
ISO T9			≥ 85 %			
ISO T10	EPA	≥ 85 %				
ISO T11		≥ 95 %				
ISO T12		≥ 99,5 %				
ISO T13	HEPA	≥ 99,95 %				

*min refers to minimum discharged efficiency. T1 - T5 are measured for average efficiency, including a charge since the charge has a negligible impact on coarse grade filters. Finer particulate would still get through!

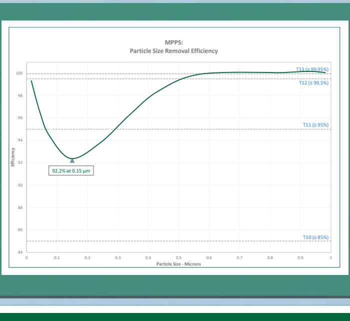
WHAT IS BEING MEASURED?

Coarse	ePM_{10}
Percentage (by mass) of dust captured by the filter for 100g dust fed	Percentage (by mass) of particulate ≤ 10 µm captured by the filter

$ePM_{2,5}$, min	ePM_1, min
Percentage (by mass) of particulate ≤ 2,5 µm captured by the discharged filter	Percentage (by mass) of particulate ≤ 1 µm captured by the discharged filter

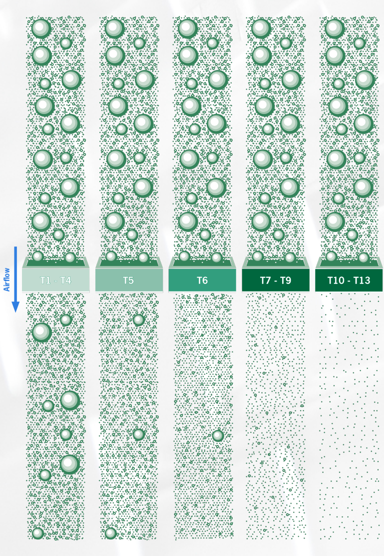
MPPS

The minimum efficiency (or lowest point) for a discharged filter, for all particle sizes. The image below shows an example of a filter tested for MPPS.



WHAT DOES THIS MEAN FOR YOUR GAS TURBINE?

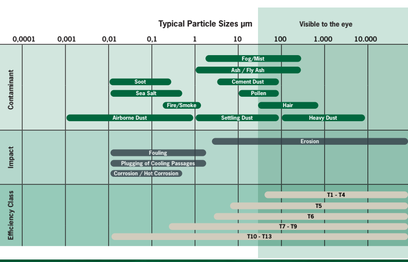
The graphic below shows the percentage of particulate captured by a filter according to its efficiency rating, T1 - T13.



TYPICAL PARTICLES, THEIR IMPACT ON GT, & FILTER CLASS SELECTION GUIDE

The illustration below shows how different sized contaminants can impact gas turbine performance, including erosion, fouling, plugging of cooling passages and corrosion / hot corrosion. Efficiency Class shows the range of filter efficiencies needed to protect your turbomachinery from these contaminants.

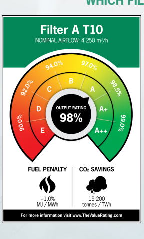
Keep in mind that air quality varies considerably depending on seasons, nearby activities, wind directions, and other factors. If you would like to measure the air quality at your site, **contact Camfil** for more details.

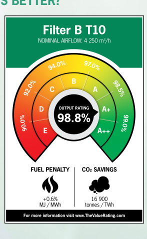


THE VALUE RATING CALCULATE A FILTER'S IMPACT ON YOUR GT

The Value Rating of a filter shows the impact of pressure drop, dust holding capacity and efficiency on your turbine's output. If you are undecided between filters with the same ISO 29461 efficiency rating, use The Value Rating calculator to help make your selection.

WHICH FILTER IS BETTER?





WHY DOES FILTER B HAVE A BETTER VALUE RATING IF IT HAS THE SAME EFFICIENCY AS FILTER A?

- It has a higher efficiency rating at MPPS
- Its initial pressure drop is lower
- Its pressure drop after loading 250g of ISO fine is lower

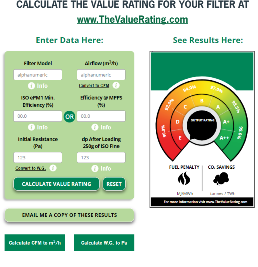
WHAT DOES THIS MEAN FOR YOUR OPERATIONS?

	SAVINGS (USD)
ADDITIONAL OUTPUT REVENUE* A 0.8% output rating means that you would produce an additional 8 000 MWh, or generate approximately $280 000 additional revenue.	$280 000
FUEL SAVINGS A 0.4% lower fuel penalty means that you would save approximately $96 000 on fuel when producing 1 TWh.	$96 000
CARBON SAVINGS 1 700 tonnes less CO_2 emissions means that you would save $34 000 on carbon taxes when producing 1 TWh.	$34 000
TOTAL SAVINGS Total savings per year, per gas turbine	$410 000

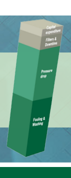
[1]**Assumptions:** Baseline = 125 MW; Baseload; Heat rate = 8000 kJ/kWh; 8000 hrs / yr; Fuel: $3 USD/GJ; $35 USD per MWh sold; $20 tax rate per tonne of CO_2

CALCULATE THE VALUE RATING FOR YOUR FILTER AT www.TheValueRating.com

Enter Data Here: See Results Here:



Once you calculate The Value Rating of your filter, take it a step further and request a full Life Cycle Cost Analysis personalized to your site conditions and operations. Contact us for more information.



Visit www.camfil.com/ISO29461 for more information.

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