camfil

STANDARD
ISO 29461-1:2021 & 29461-2:2022

ISO 29461

The First International Test Standard for Turbomachinery Air Intake Filters

Clean air solutions for turbomachinery

ISO 29461

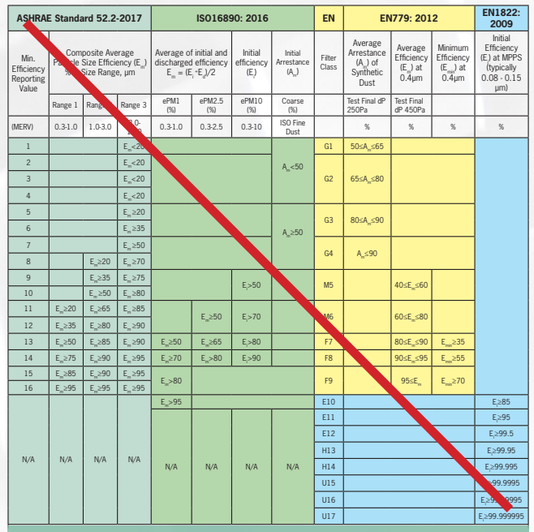
Gas turbines and other turbomachinery are sensitive equipment that require protection against harmful particulates that could diminish life and performance. Air inlet filters are the most cost-effective way to protect your assets since they prevent contaminants from reaching your turbomachinery. Operators can now select filters by referring to the ISO 29461, the first international test standard for reporting the performance of intake filters specifically for gas turbines, compressors, and other turbomachinery assets. It presents a uniform method for testing filters that enables operators to more easily compare and select filters.

ISO 29461-1:2021

The first international test standard that reports efficiency and dust holding capacity for all turbomachinery filters

WHY ISO 29461-1:2021

1 Operators use filters with a wide range of particle capture efficiencies, from coarse pre-filters to ultra-fine final filters designed to keep engines clean and running at peak performance. There are multiple standards used in the industry to help select filters; most prevalent are the EN779, ASHRAE 52.2, and ISO 16890 for lower efficiency filters and ISO 29463 (previously EN1822) for higher efficiency filters. All of the existing standards have been developed for other industries leading to compromises when applied to turbomachinery applications. Navigating the standards were also confusing since there was no clear correlation between them. The new ISO 29461-1 eliminates this confusion with a single standard specially designed for gas turbine and other turbomachinery applications. It replaces these four standards, and as such ***is the first filter classification that can be applied to the entire range of filters in a single uniform standard that is more relevant to real-world performance.***



ASHRAE Standard 52.2-2017				ISO16890: 2016				EN	EN779: 2012			EN1822: 2009
Min. Efficiency Reporting Value	Composite Average Particle Size Efficiency (E_2) Size Range, µm			Average of initial and discharged efficiency $E_{ave} = (E_1+E_2)/2$			Initial Arrestance (A_1)	Filter Class	Average Arrestance (A_1) of Synthetic Dust	Average Efficiency (E_1) at 0.4µm	Minimum Efficiency (E_{min}) at 0.4µm	Initial Efficiency (E) at MPPS (typically 0.08 - 0.15 µm)
	Range 1	Range 2	Range 3	ePM1 (%)	ePM2.5 (%)	ePM10 (%)	Coarse (%)		Test Final dP 250Pa	Test Final dP 450Pa		
(MERV)	0.3-1.0	1.0-3.0	3.0-10.0	0.3-1.0	0.3-2.5	0.3-10	ISO Fine Dust		%	%	%	%
1			E_3<20				A_1<50	G1	50≤A_1≤65			
2			E_3<20					G2	65≤A_1≤80			
3			E_3<20									
4			E_3<20									
5			E_3≥20				A_1≥50	G3	80≤A_1≤90			
6			E_3≥35									
7			E_3≥50					G4	A_1≤90			
8		E_2≥20	E_3≥70									
9		E_2≥35	E_3≥75			E_1>50		M5		40≤E_1≤60		
10		E_2≥50	E_3≥80									
11	E_1≥20	E_2≥65	E_3≥85		E_2≥50	E_1>70		M6		60≤E_1≤80		
12	E_1≥35	E_2≥80	E_3≥90									
13	E_1≥50	E_2≥85	E_3≥90	E_1≥50	E_2≥65	E_1>80		F7		80≤E_1<90	E_{min}≥35	
14	E_1≥75	E_2≥90	E_3≥95	E_1≥70	E_2≥80	E_1≥90		F8		90≤E_1<95	E_{min}≥55	
15	E_1≥85	E_2≥90	E_3≥95	E_1>80				F9		95≤E_1	E_{min}≥70	
16	E_1≥95	E_2≥95	E_3≥95									
N/A	N/A	N/A	N/A	E_1≥95				E10				E_1≥85
				N/A	N/A	N/A	N/A	E11				E_1≥95
								E12				E_1≥99.5
								H13				E_1≥99.95
								H14				E_1≥99.995
								U15				E_1≥99.9995
								U16				E_1≥99.9995
								U17				E_1≥99.999995

There are multiple filtration standards used to rate filters. Say goodbye to them! The ISO 29461-1:2021 has been specially developed for turbomachinery filters and replaces all other standards.

2 It closely models the efficiency of filters operating in the field by measuring their mechanical efficiency which is not influenced by an electrostatic charge. Electrostatic charged efficiency has little relevance for gas turbine and other turbomachinery applications since the charge dissipates in a short period of time relative to the filter service life.

3 In order to better compare filter life, ISO 29461-1 requires a standardized dust loading procedure for all filters. This is the first standard that dust loads (H)EPA filters for filter life comparison.

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ISO 29461-1 CLASSIFICATION SYSTEM

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 %				

The classification system shown in the table categorizes filters in groups and classes based on their minimum efficiency.

- Classes T1 - T4 are tested per ISO 16890 with arrestance measured on first 100g of dust loading.
- Class T5 is tested per ISO 16890.
- Classes T6 - T9 are tested per ISO 16890 where only minimum efficiency is considered.
- Classes T10 – T13 are tested per ISO 29463.

CAMFIL FILTERS	
Filter Categories	**ISO 29461-1:2021**
Bag	T4 - T9
Panel	T2 - T6
Compact	T7 - T13
Cartridge	T5 - T10, T12

ISO 29461-2:2022

The first international test standard that rates a filter's endurance in fog and mist environments and determines a filter's resistance to water penetration

WHY ISO 29461-2:2022

1. A turbine that is protected by an EPA filter lacking hydrophobicity features will still suffer from degradation due to fouling, erosion, and corrosion. When water is present on the filters, some contaminants captured in the filter will dissolve in the water (such as salts). Other contaminants may be pushed through by the water. If the final filter is not hydrophobic and lets this water through to the clean air side, these contaminants will make their way to the turbine. Measuring a filter's hydrophobicity is therefore critical for turbomachinery applications.

2. Poor filter drainage will allow water to build up on the filter's media. This can lead to spikes in filter pressure drop, which in turn, can cause the turbine to trip, in worst cases. High pressure drop can also increase the risk of contaminant migration through the filter media. ISO 29461-2 measures the endurance of the entire filter, against its resistance to pressure.

3. ISO 29461-2:2022 is the first official standard that evaluate a filter's endurance in fog and mist environments, including both pressure drop and hydrophobicity. Previously, filter manufacturers applied in-house testing methods with different test parameters to measure hydrophobicity since a common standard did not exist; some measured only the filter media hydrophobicity according to the EN20811/ISO811 and AATC 127 standards; and some filter manufacturers did not test for hydrophobicity at all - making it difficult to compare filters. ***ISO 29461-2:2022 is the first universal standard that measures the hydrophobicity and pressure drop of the entire filter element, and can be applied to all turbomachinery air intake filters.***

When selecting filters, it is important to consider both the ISO 29461-1 efficiency standard and the ISO 29461-1:2 hydrophobicity standard. ***For most applications exposed to heavy water concentrations, Camfil recommends final filters that are high efficiency T10+ according to ISO 29461-1:2021 and hydrophobic with a low and stable pressure drop according to ISO 29461-2:2022.***

The graph on the right shows the importance of considering both standards. All filters are equivalent in efficiency, however, Filters A, B, and C failed either by water bypass, pressure drop or both. Filter D passed the fog endurance test, however, the water dye test showed water droplets downstream of the filter, whereas Filter E showed no bypass. The results show that Filter E would perform the best in high humidity, fog conditions.

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ISO 29461-2 TEST METHOD

Does the filter *pass or fail* the Fog & Mist Endurance Test, and is it Hydrophobic?

ISO 29461-2 requires filters to be measured and rated according to the following test parameters:

1. The test procedure is 3 hours
2. The filter must have a pressure drop less than 1000 Pa (4" w.g.)
3. There cannot be any measurable water downstream of the filter
4. Optional test method if a filter is to be labeled "Hydrophobic": use a water dye to confirm that there is no water downstream of the filter.

A filter passes the fog & mist endurance test if it meets criteria 1-3. A filter is considered as "hydrophobic" If meets all 4 criteria.

Graph: Fog & Mist Endurance Test Filter Comparison

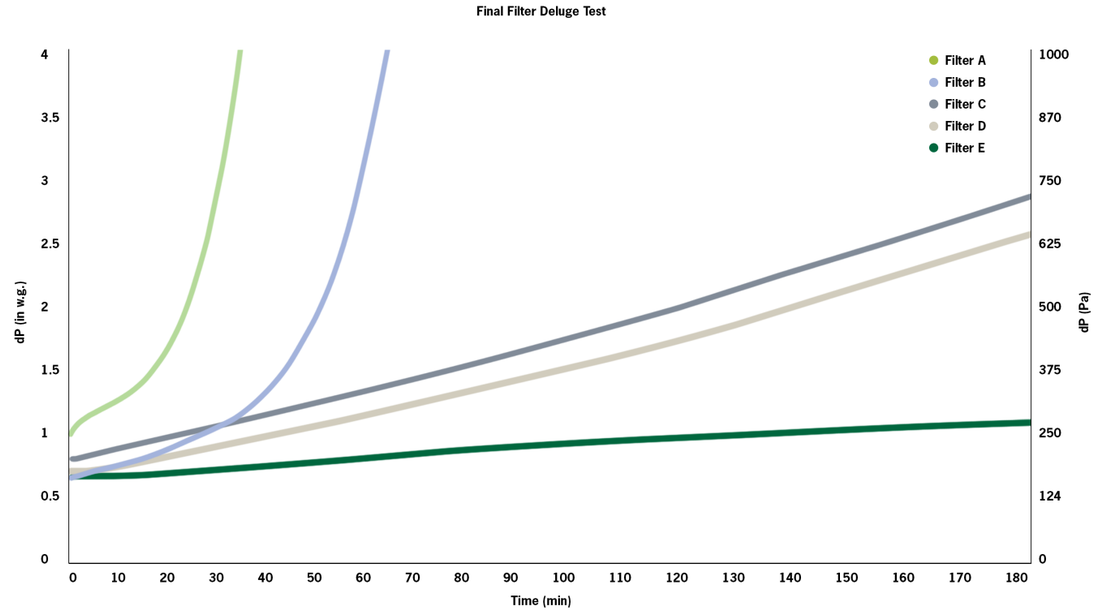
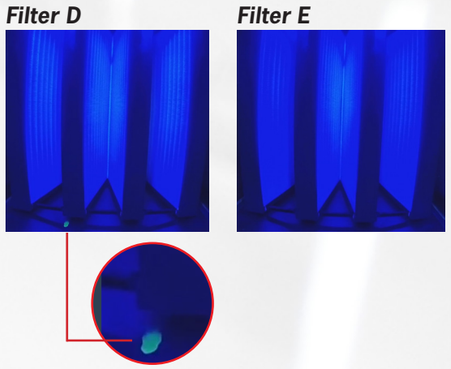


Table: Fog & Mist Endurance Test Final Filter Comparison

Final Filter	Test Duration (min)	Water Sprayed (liters)	Water Bypass (liters)	Max. dP During Test (inch wg / pascal)	Pass or Fail	Optional dye test for water droplets: *Is the filter hydrophobic?*
Filter A T10	35	15	0	4.0 / 1000	Fail	-
Filter B T10	65	18	14	4.0 / 1000	Fail	-
Filter C T10	180	74	20	2.9 / 720	Fail	-
Filter D T10	180	76.5	0	2.6 / 645	Pass	No
Filter E T10	180	76.5	0	1.2 / 300	Pass	Yes

Image: Water Dye Test

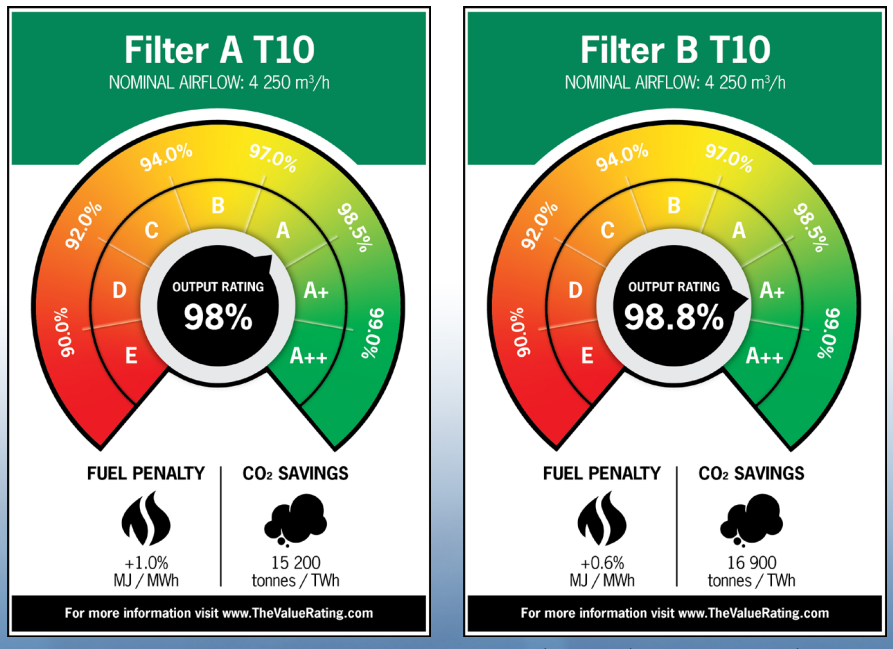


THE VALUE RATING

All filters are not created equal!

When determining the true performance of your filters, you need to look deeper than just the efficiency rating. The Value Rating was developed to help GT operators easily compare various filters and gain a quick understanding of the impact each filter will have on turbine performance. In this example below, both are T10 filters. However Filter B has a slight advantage in Output Rating, Fuel Impact and CO_2 Savings. But even a small advantage can lead to huge payoffs every year. The additional .8% Output Rating means that your turbine can produce an additional 8 000 MWh per year*, or $280 000 in revenue. With the 0.4% savings on Fuel Penalty, you'll save $96 000 on fuel when producing 1 TWh. And with the increased CO_2 savings of 1 700 tonnes, you could save up to $34 000 on carbon taxes per year when producing 1 TWh.

Once you narrow down your filter selection based on the ISO 29461-1: 2021 standard, use The Value Rating Calculator to evaluate your filters before you buy! Simply input the filter data to get a complete value rating. Visit www.TheValueRating.com.



[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

The Camfil Group is headquartered in Stockholm, Sweden, and has 33 manufacturing sites, six R&D centres, local sales offices in 30 countries, and about 4,800 employees and growing. We proudly serve and support customers in a wide variety of industries and in communities across the world. To discover how Camfil can help you to protect people, processes and the environment, visit us at www.camfil.com.

CAMFIL - Clean Air Made for Improving Life