



Extended Availability and Reliable Operation Through Gas Turbine Inlet Filtration

Gas Turbine Air Filtration
for the Oil & Gas Industry



The World's Most Diversified Filtration Company

CLARCOR is the world's most diversified filter company, and we know how to develop and produce high quality gas turbine air inlet filters. Whether you are in need of a cartridge, vCell, pocket or panel filter, our portfolio is comprehensive. With extensive knowledge built up with nearly 50 years of making inlet filters and gas turbine inlet filtration solutions, and a variety of media options to meet a multitude of challenges, we deliver filters that perform in the most demanding environmental conditions.

When it comes to selecting the right filter for your need, our **altair**® filter portfolio offers extremely high levels of turbine protection for a wide range of environments. Our filter elements are designed to fit a range of new and retrofit systems and are available in various sizes and materials of construction.

Founded in 1966, **altair** became known as a specialist in offshore filtration while skillfully branching into other areas of filtration. Acquired by General Electric in 2006 and renamed GE Air Filtration, we continued the **altair** brand while utilizing the GE expertise in gas turbine design to further refine the right criteria for proper inlet filtration. The **altair** name and history is now a key product and brand for CLARCOR Industrial Air.

Through our **altair** brand, we have real world knowledge that will help you get more output and more reliability from your machine.



1966



1998



current

Solving Complex Problems for LNG, Refinery, Pipeline, and Offshore

Harsh weather conditions, high levels of airborne particulate, and salt ingress are just some of the challenges you face as a gas turbine operator in the oil and gas industry.

Often situated in remote locations such as jungles, deserts, offshore platforms and FPSOs, gas turbines used in this industry encounter extremely challenging operating environments. High levels of small particulate in the form of sand, dust and shot-debris from drilling, salt aerosols in offshore and coastal locations, and harsh weather conditions all threaten the performance and health of a gas turbine.

Today, operators require high availability and low downtime rates from their turbines. Due to the very large quantities of air that turbines require for operation, airborne contaminants can pose a significant challenge to the ongoing health of these precision pieces of rotating equipment. Failure to address contaminants can lead to reduced performance, expensive repairs, and eventually could cause a catastrophic failure of the turbine components.

Our **altair** name symbolizes delivering solutions that bring air quality to the turbine, improve gas turbine availability and provide extended operational capability.



Extended Availability. Reliable Operation. Discover the altair story.

Fighting the Combination of Water and Dust

The offshore environment is brutal for any piece of equipment, let alone one that needs to continuously run in the face of harsh storms, sea spray, mist, fog and almost any other type of water challenge.

CLARCOR Industrial Air knows how to handle your marine challenges. It's where our history began. For nearly 50 years, we've designed filter systems for offshore oil and gas platforms, Navy ships, cruise liners and more, with ongoing technological developments to ensure your water issues become secondary concerns.



The combination of water and dust poses the biggest challenge to filter manufacturers. Offshore, we use a number of different upstream salt concentration standards such as NGTE or NAVSEA. We have also written our own standard that defines salt concentration and droplet distribution. It is called MMBL. It states that the typical concentration of salt in air by weight is 0.1067 ppm. This standard provides a realistic figure for salt in the Marine Boundary Layer (MBL), and allows us to project average salt levels in any region of the world. In turn, that enables us to design and develop customized solutions for any salt challenges you have, no matter what part of the globe you're located at.

An Extensive Filter Range, From Pre-filters to (H)EPA

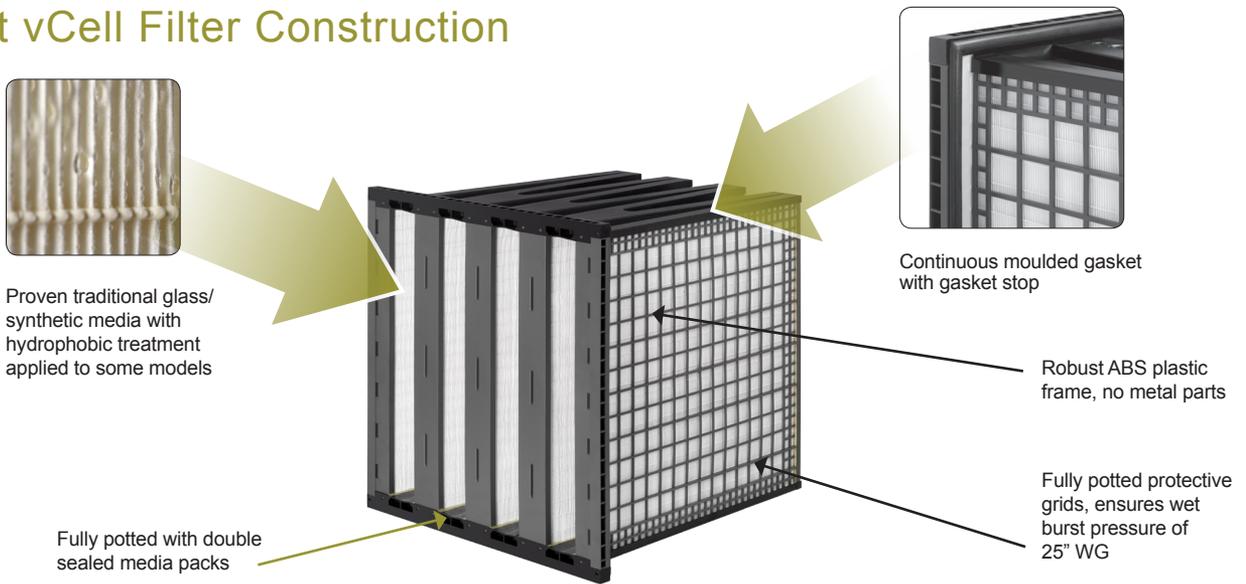
Our breadth and depth of filtration products is wide-ranging, offering you choices from G1-H13. Selecting the right filter starts with the pocket or panel pre-filter (such as the PB1 or PBR), which is designed to extend the life of your higher grade, higher cost filters downstream. We also offer high-efficiency coalescers including the legacy HVL and HVX filters from our **altair** System2 and Aquila products.

Our most recent developments have come with pleated media filters. Traditionally offered in the form of a 12"

deep vCell, we've taken the concept much further, and now offer both 17" deep and 24" deep families of vCell filters. By focusing on media selection, accurate sealing and a robust ABS plastic frame, our vCell final filters can reliably outperform competitor products.

If your inlet system requires pulse cartridge filters, we have a broad selection of geometries that will continue to provide predictable and reliable performance.

Robust vCell Filter Construction



altair PRO Cartridge Characteristics



Our Filtration Solutions for Your Environmental Challenges

Environment	Filter Type	Intermediate Filter										
		Prefilter				Final Filter						
		G3	G4	M5	M6	F7	F8	F9	E10	E11	E12	H13
Offshore, Land-based	Pockets, Panels	✓	✓	✓	✓	✓						
Land-based	Cartridges						✓	✓				
Offshore, Land-based	12" vCell				✓			✓				
Land-based	17" vCell						✓	✓	✓		✓	
Offshore	17" vCell							✓	✓			
Offshore	24" vCell							✓	✓	✓	✓	
Land-based	24" vCell							✓	✓	✓	✓	✓

Why choose?

- Higher efficiency pre-filter protects final filter investment
- Can change online with final filter in place
- Less sensitive to water events
- Higher velocity operation
- High efficiency means reduced water washing
- Less sensitive to fog and mist

The (H)EPA Choice of Major OEMs for Harsh Environments

Reliability and availability. It's what you want when you operate your gas turbine in harsh conditions. **altair** is known for making filters that deliver these operating characteristics, and now you can benefit from the same (H)EPA filters that major turbine OEMs are choosing to put in front of their machines.

A recent independent, third party test conducted by a manufacturer proved that **altair's** vCells were equal to or better in performance than those of a competing manufacturer. That means less pressure loss events, better efficiency and a more stable and predictable life than a competitor's (H)EPA filtration offering.

See how the results compare:

altair		Competing manufacturer
✓	Efficiency	
✓	Pressure Loss	
✓	Salt efficiency	
✓	Salt penetration	
✓	Burst pressure	✓
✓	Dust-holding capacity	✓

Comprehensive System Solutions for Your Most Challenging Oil & Gas Applications

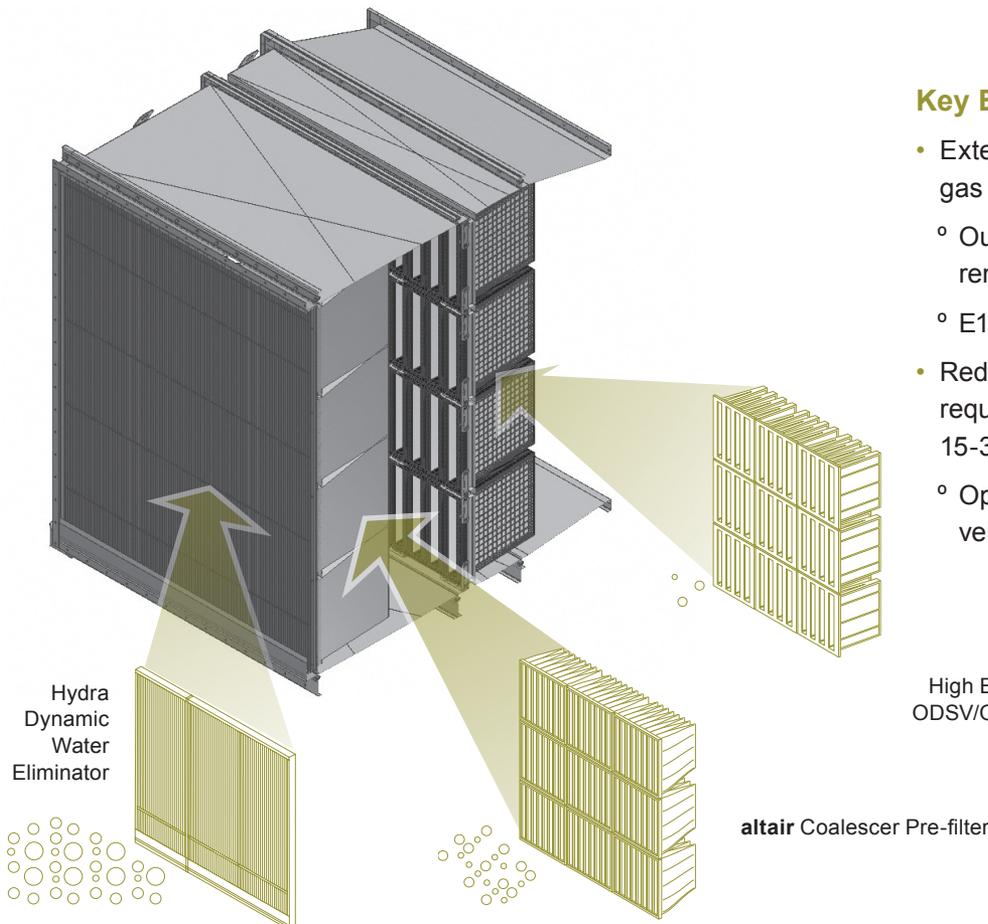
If you are an operator or specifier of gas turbines in the oil and gas industry, CLARCOR Industrial Air can help you with filter systems for new projects, retrofits and upgrades. We can recommend a solution based on your specific environment and your performance objectives. From compact, high-velocity Air Inlet Filter Houses (AIFH) through to multi-stage EPA for extended operation in the LNG sector, CLARCOR Industrial Air has the filter expertise and proven track record to deliver.



altair Static Offshore E10-E12 Systems

Key Benefits

- Extended availability of your key gas turbine assets
 - Outstanding wet and dry salt removal efficiency
 - E10-E12 v EN1822:2009
- Reduced space envelope requirement typically saving 15-30% weight
 - Operates at medium to high velocity 4-6 m/s



High Efficiency **altair** ODSV/ODSY vCell Filter

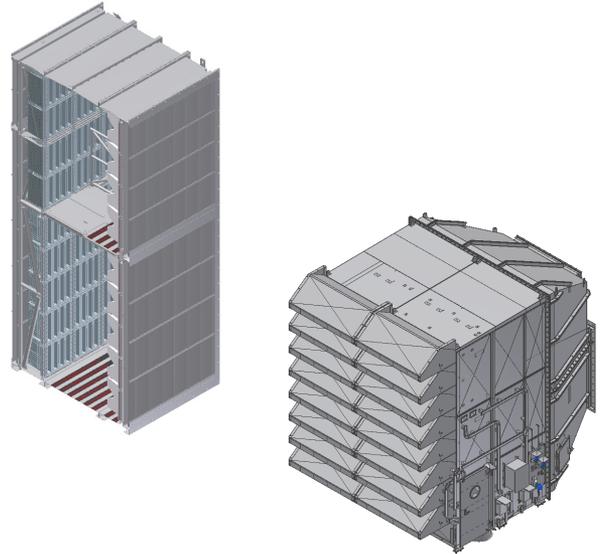
altair Coalescer Pre-filter

Hydra Dynamic Water Eliminator

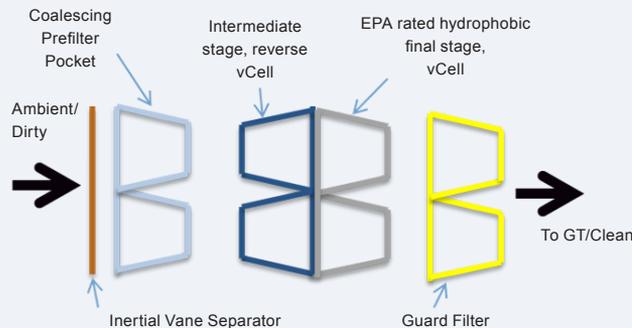
Compact Systems for Offshore & Coastal Applications

The **altair** legacy continues in CLARCOR Industrial Air's effectiveness at designing the most comprehensive offshore systems and consistently re-inventing the technology that to this day continues to deliver superior salt and water removal performance.

- Compact
- Medium or high-velocity
- M5-E12 filter classification
- Very high salt efficiency
- Excellent wet salt removal
- Reduced sensitivity to mist & fog events
- Designed for FPSO and fixed platforms
- For gas turbines up to 35MW (single lift module)
- Combustion only or split path combined outlets
- OSHA compliance with internal access
- 316L stainless steel construction
- Weatherhoods and anti-ice module available
- Water drainage system



Systems for LNG, FPSO applications needing extended availability

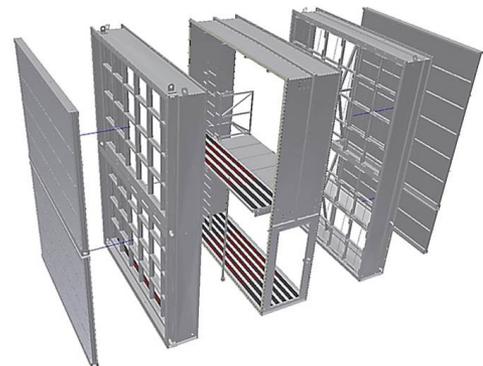


We know that any downtime equals lost revenue. The main requirement from a turbine operator is often the ability to run for months at a time, to keep production steady. We design systems that do just that, with on-stream filter change outs available so you don't have to shut down to change filters.

Modular Filter Houses for Lean Applications

Utilizing a scalable concept, our modular filter house design can accommodate a multitude of requirements depending on your application.

- LNG, offshore and pipeline applications
- Building bricks modules for gas turbines of up to 200 MW
- OSHA compliance
- Footprint and envelope model details available to help you develop your package
- Standard 3 stage or 4 stage
- Downstream guard for extended availability
- Designed for **altair** 12", 17" and 24" vCells for extended life and availability
- F8, F9, E10, E12 and H13 performance



Selecting the Correct Filter System for the Environment

Extended operation availability

Keep your filter house online longer, without the need for unplanned filter change outs.

Reliability ensured

Harsh environments such as those created by a dust storm or even poor fuel quality can be managed effectively by appropriate filter selection.

Compact footprint

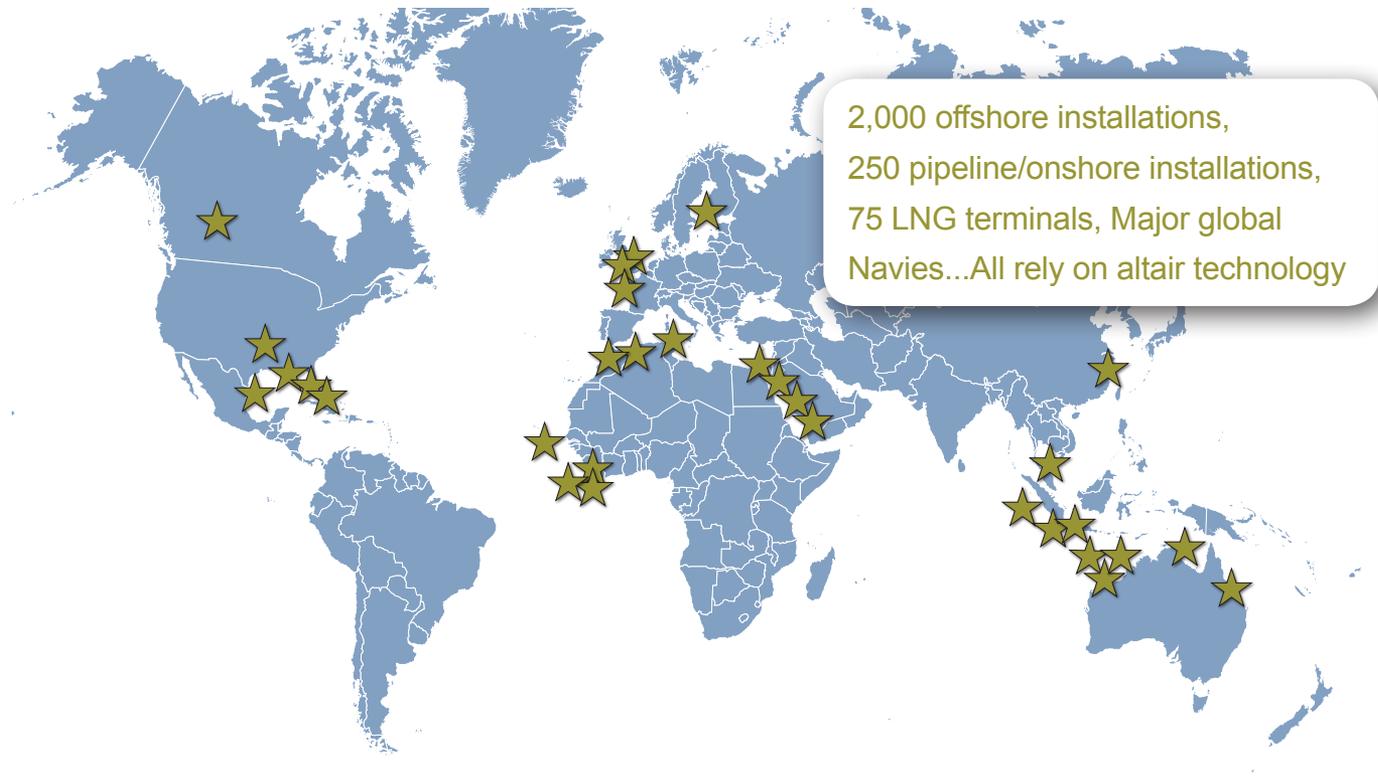
A small space doesn't mean reduced performance. Our compact filter system still delivers excellent salt removal and water management capability for producers across the world, while fitting nicely within the confines of the platform.

GT efficiency delivered

What you are measured on, we can deliver a filter system solution, whether that be clean compressors, reduced water washes, or a consistent output.

Consider these key factors when determining which filter system is most appropriate for your operating status.

Environment		Gas Turbine Power	Filter System	System Attributes		
Site Location	Climate Type	MW	CLARCOR Industrial Air Filter System	Filter Type	Filterhouse Construction	High Efficiency Filter Rating
Platform, FPSO, FLNG	Marine	<25	altair System2	Static	Single Module	M5-F7
		20 – 45	altair System4	Static	Single Module	F8-E10
		>20	altair Static Offshore (E10-E12)	Static	Modular	E10-E12
Coastal and Land based	Low - Medium dust	>20	altair Static - Multistage	Static	Modular	F9-E12
			altair Static - Multistage with EPA	Static	Modular	
			altair Static - Multistage with EPA and Guard	Static	Modular	F9-E12 + G4
	Dusty Coastal	All	altair Hybrid	Self-Clean + Static	Modular	F8-F9 + EPA
	Dusty	All	altair Pulse	Self-Clean (cross flow)	Modular	F8-E11
Cold	All	Self-Clean (upflow)		Modular	F8-E11	



Decades of Worldwide Experience — And It Shows

We can help you select the right filter system, just like we've been doing for oil companies and GT producers for years. Our experience list contains almost every environmental challenge and location across the globe. So when we say we've got the technology and history to solve your problems, it's proven by experience.

Availability		Reliability	Size & Weight	
GT Efficiency	Extended GT Operation	Supports Low Fuel Quality	GT Part Load Standby	Compact Filterhouse
			Excellent	Standard
Good	Good	Excellent		Standard
Excellent	Excellent	Excellent		Optional
Good			Excellent	Standard
Excellent	Good			Optional
Excellent	Excellent			
Excellent	Excellent			
Excellent	Good		Good	Optional
Good (Arctic Conditions)	Good			

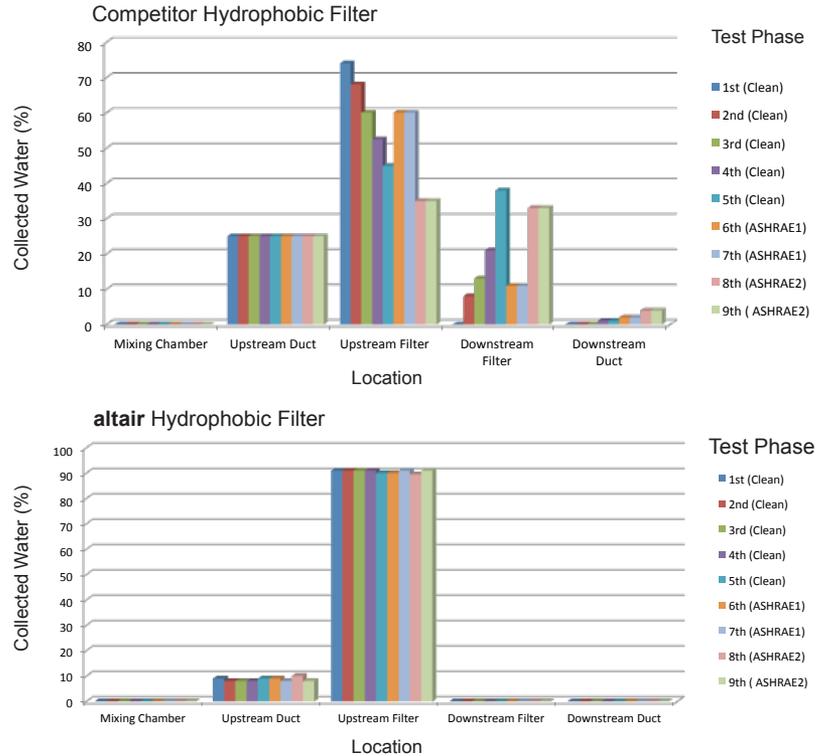
Hydrophobic Expertise — It's In Our DNA

Stringent hydrophobic testing is the only way to reveal which filters truly stop water – and which filters don't. CLARCOR Industrial Air has the technology and expertise to develop hydrophobic filters that withstand extreme conditions, where performance can't be compromised at any cost.

Our strengths come from:

- Hydrophobic-treated microglass media
- Optimized pleating
- Fully potted media
- Flexible potting glue to prevent cracking

Testing Shows the True Difference

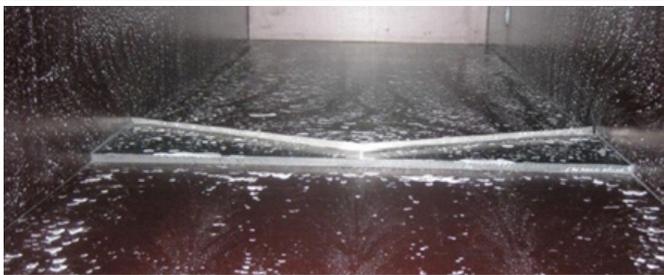


As displayed in the graphs, the **altair** hydrophobic filter removed all water from penetrating the downstream filters and ducts, demonstrating the importance of knowing if the filter you are buying is truly 100% hydrophobic.

Sophisticated Hydrophobic Technology

The filtration experts at CLARCOR Industrial Air jointly developed a hydrophobicity test to better understand and evaluate a filter's salt water removal performance. The test works by trying to migrate salt through the filter via multiple cycles in which the salt is changed from liquid to solid -- only filters that pass this stringent test are considered as truly hydrophobic. Through our technology we have learned which medias work best, how to pleat them and how to seal them in the frame. This significantly improves our ability to manage salt and water.

Side by side comparison - altair vs. competitor filter



A downstream view of a competitor's hydrophobic filter.



A downstream view of the **altair** hydrophobic filter from CLARCOR Industrial Air.

World-Class Technical Facilities & Capabilities

Fully equipped laboratories enable CLARCOR Industrial Air engineers to perform sophisticated product development and thoroughly challenge the filter system before it is released to our customers. We consider all likely airborne hazards such as water, salt, sand, dust, hydrocarbons, snow and ice to help extend time between compressor water washes. This is a critical part in reducing operating costs, especially on rotating machinery tasked with delivering to your customer.

Tests performed in our laboratories include:

- Pressure loss
- Dust holding capacity with ASHRAE and ISO A2 fine
- EN779 performance
- Combined (prefilter and final filter) dust holding capacity with ASHRAE and ISO A2 fine
- Wet saturation test
- Fog and mist testing
- 72 hour wet loss of efficiency and burst
- Humidity testing
- Media hydrostatic head testing, flat sheet and pleated
- Heat aging evaluation
- Adhesive pull testing
- Filter “bucket” testing
- We can test hot to 135° C (275° F)
- We can test cold to -70° C (-94° F)
- Dry salt testing
- Wet salt testing
- Gasket hydrostatic head testing
- ARAMCO testing
- Transportation/rough handling
- Acoustic testing

Our filters are externally verified and come with an independently validated test certificate.

- External EN779 2002 on discharged filter
- External EN779 2012
- External EN1822 2009 where applicable, on discharged filter
- External ASHRAE 52.2 initial efficiency on discharged filter
- External GE 10 day hydrophobic test
- External shaker table transportation load testing



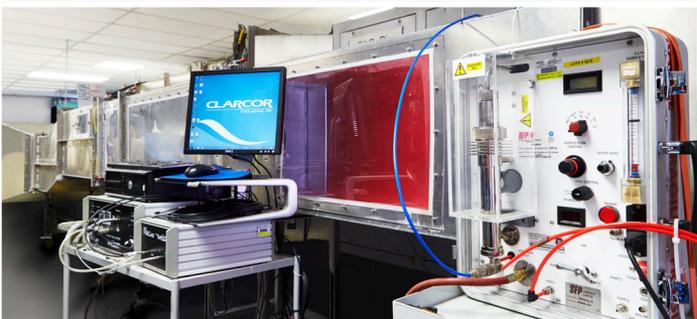
Our mobile test rig helps customers evaluate environment and filter technology on-site, in any condition, including this high dust scenario.



Our outside test rigs allow us to evaluate filters for up to 6 months and measure a variety of factors, including initial DP, fractional efficiency, and reaction to mist and fog.



The Neptune test rig allows us to test for water removal capability, a key concern for those located offshore or in a tropical location where heavy rainfall is a factor.



The hydrophobic test rig, where CLARCOR Industrial Air verifies that a filter is truly hydrophobic.



For more information, contact your **altair** representative at **CLARCOR Industrial Air**:
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