PALL CORPORATION

Pall Filtration Solutions for Wind Turbines

Onshore and Offshore

Why Filtration is Important?

For manufacturers and operators of wind energy generating turbines, reliability, efficiency, remote monitoring, and ease of scheduled component maintenance are critical factors in their successful and viable operations.

The promise of clean, unlimited wind energy presents many technical challenges for the components in the wind turbine nacelle. As with all types of mechanical equipment maintaining them means the basic principles of asset maintenance apply. Often located in extremely remote locations and tens of meters in the air, components need to be compact and lightweight yet provide exceptional service life in the most demanding of operating environments.

Only with efficient and effective filtration can components such as the gearbox and turbine bearings sustain years of trouble-free operation under these conditions, including:

- **Wide variations in rotor loads (transferring to the gearbox), vibration and temperatures**
- **Potentially high ingression of contaminants, either solid (dust), liquid (aerosols or rain), or gaseous (moist air)**
- **Limited access for unscheduled maintenance**

All these factors contribute to increased levels or wear in the gearbox and bearings unless suitably protected using high performance, high efficiency filtration.

Pall Working to *Make Greener Cleaner*

Safety, Quality & Environment

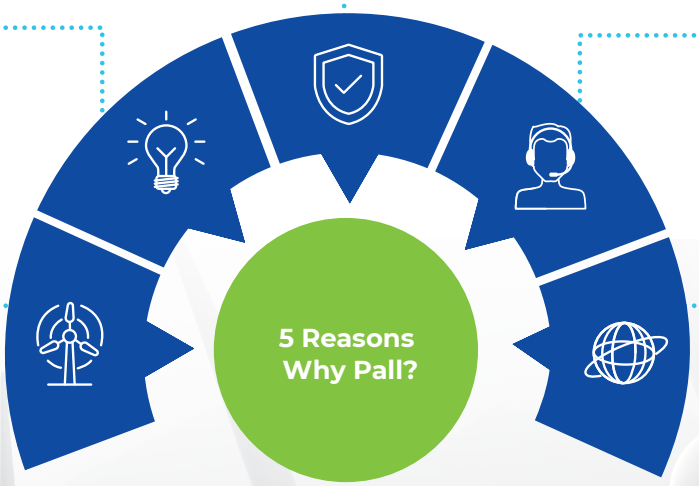
We enable our customers to succeed by delivering products and services that advance safety, improve quality, and directly enable people to live healthier, longer lives in a cleaner, better environment.

Innovation

Product Development Engine that creates robust, differentiated, quality products that increase reliability, performance, and operational life, reduce maintenance costs and extend service intervals

Local Technical & Service Support

Customer focused local technical, service & commercial support.
Assisting customers with process integration by on site work, best practice training, process optimization.



Proven Track Record

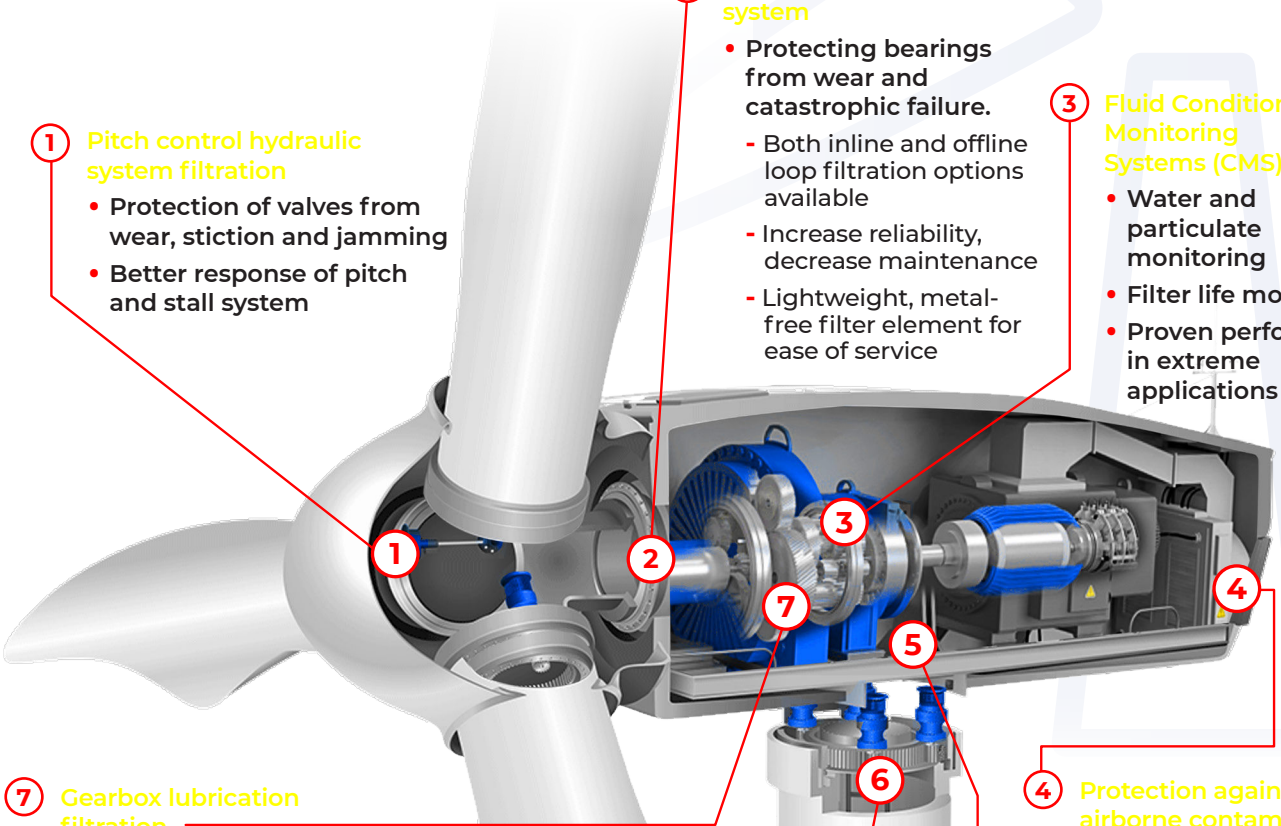
Pall's High performance hydraulic and lube oil filters have proven extremely capable of protecting wind turbine equipment with fitments in over thousands of turbine locations globally.

Global Player

Global provider of filtration and separation sciences enabling technology serving over 75 years with presence over 100+ countries.

Pall Solutions for Wind Turbines

Together we deliver Wind Energy powered by innovation



1 Pitch control hydraulic system filtration

- Protection of valves from wear, stiction and jamming
- Better response of pitch and stall system

2 Hub bearing lubrication system

- Protecting bearings from wear and catastrophic failure.
  - Both inline and offline loop filtration options available
  - Increase reliability, decrease maintenance
  - Lightweight, metal-free filter element for ease of service

3 Fluid Condition Monitoring Systems (CMS)

- Water and particulate monitoring
- Filter life monitoring
- Proven performance in extreme applications

4 Protection against airborne contaminants

- Air filtration providing nacelle protection from moisture and salt in Offshore WEG's
- Reservoir mounted air breather protecting against ingress of environmental contamination and moisture

5 Hydraulic brake system

- Protection of pumps, motors, valves against wear, stiction and jamming

6 Yaw drive hydraulic system filtration

- Protection of pumps, motors, cylinders, valves from wear, stiction and jamming

7 Gearbox lubrication filtration

- Protection from wear for gears, bearings, and pumps, with both inline and offline loop filtration options available
- Low clean differential pressure drop and long element life using innovative media and pleat designs
- Consistent performance and resistance to extreme conditions
- Lightweight, metal-free filter element for ease of service
- Varnish prevention and removal
- Free and dissolved water removal

The Pall Solutions

Primary Application: Hub bearing, Gearbox protection, All pitch, yaw and brake hydraulic controls

Protection from harmful solid contaminants that can cause valve blockage & accelerate pump & bearing wear. Inline filters should be selected for continuous use, to remove harmful contaminants effectively under arduous operating conditions (i.e. variable flow rates, vibration, and fluid viscosity changes), in a single pass, and have sufficient capacity to capture and retain contaminants for the scheduled service interval.

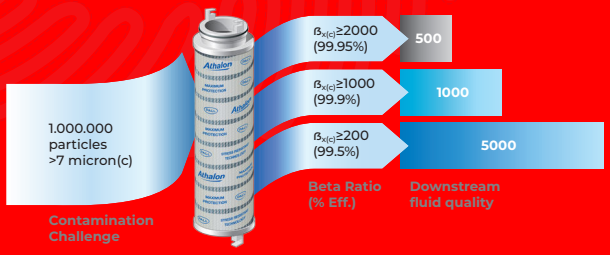
Pall's high performance ($\beta_{x(c)} \geq 2000$) **Athalon® filters** provide the required level of reliably consistent protection to the bearings, for the full-service life of the filter. In-built stress resistant technology ensures the filter element's ability to operate under high viscosity and improves protection in the most critical phases of start-ups and shutdown.

The filters unique laid over pleat configuration maximizes the available filter media area enabling a smaller filter footprint, and promotes an even fluid flow distribution.

Users experience improved lube oil cleanliness (typically 2 ISO codes cleaner) which is proven to extend bearing life by a factor of 2 to 3 and translates to a decrease in bearing and gearbox failure with additional savings on O&M costs.

Fast System Clean-up to Achieve Desired Fluid Cleanliness

Athalon Filters have a Beta ≥2000 rating for superior control of particulate contaminants



2X better particle removal efficiency compared to $\beta_{x(c)} \geq 1000$ rated filters and 10X better efficiency than common $\beta_{x(c)} \geq 200$ rated filters

Significantly fewer passes required to reach target cleanliness level

Reduces equipment maintenance and unscheduled downtime costs

More filtration area

Protects against pleat collapse and bunching

Primary Application: Gearbox protection

Critical protection from harmful solid, gelatinous & water contamination that can cause gradual or accumulated harm (varnish coating, sludge forming, corrosion etc.) in the gearbox.

Pall filter modules provide efficient removal of contaminants at a lower flow rate, often with auxiliary pumps & controls, to enable steady state fluid conditions, maximizing capture and storage. They provide continuous clean-up of the tank to ensure cleanliness specifications are met, regardless of turbine operation.

These lightweight, long-service life filters are not as susceptible to pressure drop limits and fine filtration is therefore possible. Servicing is also simple as the filter system is independent of the turbine.

"You can't manage what you can't measure"

To ensure the filtration solution is providing the protection required, it is important that frequent (preferably continuous) monitoring of fluid cleanliness and condition is undertaken.

This can be invaluable in alerting of imminent failure before forced downtime (planned rather than reactive repair) and in optimizing fluid and filter change-out to maintain effective operation (predictive maintenance rather than fixed interval).

Pall monitoring solutions include fluid cleanliness monitors and filter condition indicators.

Additionally, Pall in-line water sensors provide real-time measurement of dissolved water content in oils, warning of the potential formation of damaging free water in the gearbox and lube oil system. Pall can also apply years of accumulated knowledge to help translate raw data into meaningful information.

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