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Threats to Helicopter Engines

- Engine power loss (compressor erosion or damage)
- Blade corrosion
- Turbine blade glazing
- FOD or bird strike damage

Solution – the PUREair system
- Increased operational availability & reduced downtime
- Increased engine reliability
- Safe operation
- Protection against engine erosion
- Reduced maintenance & operational costs
Effects

- Erosion of rotating components, especially compressor blades
- Blockage of turbine blade cooling passages
- Turbine blade glazing
- Fouling of Combustion chamber
- Accumulation in inner shaft causing imbalance and unwanted vibration
Brownouts have claimed more helicopters in recent military operations than all other threats combined. (Rotor & Wing, 2005)

- Brownout is the term used to describe the result of helicopter rotorwash as it kicks up a cloud of dust while landing.
- Brownout causes accidents during helicopter landing and take-off operations in desert terrain, dust storms or general vehicle movements that create suspended sand/dust.
Foreign Object Damage (FOD) damage to a Lycoming LTS-101 turboshaft engine in a Bell 222 helicopter

Effects

- Serious damage to rotating & static engine components
  - Potential for catastrophic component failure
Threats to Helicopter Engines – Ice

Effects

In-flight icing results from super-cooled water droplets impacting aircraft surfaces and freezing

Solid ice contamination can form in the helicopter engine air inlet duct due to the lower temperature created by the inlet depression

- If ingested into engine air system, ice has same impact as FOD, causing serious damage to the engine compressor
- Ice build-up in air intake can cause air starvation to engine
- Ice build-up on flight surfaces can cause flight instability
Threats to Helicopter Engines – Heavy Rain

**Cause:**

- In certain conditions, rain can accumulate on the fuselage at a stagnation point upstream of the engine air inlet. Periodically this water can be ingested as a slug.

**Effect:**

- A mere half cup-full of water, ingested as a slug is enough to cause **engine flame out**.
- Helicopter engine air inlets with a flat surface in the air entry point are more prone to this problem
- In some countries, helicopters are grounded in heavy rain
**Cause:**

- Wet Snow can accumulate in the fuselage in front of the engine air inlet, which can then be ingested into the engine as concentrated slush

**Effect:**

- Potential for compressor damage
- Potential for Engine Flame-Out if sufficient snow is ingested into the combustor system
- Dry Snow is generally not a problem
Threats to Helicopter Engines – Salt Spray

**Effects**

- Formation of salt deposits on engine components (compressors, etc.)
  - Engine component corrosion damage
  - Fouling of passages in engine air system
  - Rotating component (compressor) imbalance due to salt deposits
  - Power loss due to above
Hot gas ingestion occurs when the engine exhaust gases are re-ingested into the engine inlet air system:
- Attitude and flight direction of helicopter
- Wind direction – tail winds

Effects and Potential Impact on engine operation:
- Significant increase in engine inlet gas temperature
- An increase of 40° F in inlet temperature can lead to a reduction in engine power of 15 %
- Temperature and flow distortion in engine inlet gas stream at compressor entry plane
- Spatial or temporal temperature/flow distortion can lead to compressor stall and potential for engine failure
Principles of Operation

1. Contaminated air enters the Vortex Tube
2. The Vortex tube imparts a swirl
3. Particles and water are separated to the outside
4. Contamination is removed from the system by scavenge airflow
5. PUREair travels to the engine

   The principle is simple … optimizing the system is critical for max performance
First *PUREair* Engine - Designed by Pall in the late 60’s (previously known as Centrisep EAPS).

Continuous improvements in Technology and Design have translated into dramatic progress in overall performance & efficiency in a given space envelope.

Latest aerodynamic designs offer optimal overall protection to latest generation of high tech helicopter engines.
Benefits:

- Self cleaning device, virtually maintenance free.
- Excellent F.O.D. protection. => Improved Flight Safety
- Protects engine by removing harmful solid and liquid contamination
- Excellent Snow / Icing protection.
- Easy user installation with available installation kit.
- Increased engine MTBUR for erosion… substantial increase in engine compressor erosion life. (reduced component wear)
- Reduced unscheduled engine removals
- Increased aircraft availability
- Pall’s Engineering experience provides optimum performance in given space envelope
Proven Dust & Sand Separation Efficiency - RTM322 engine test

**PUREair Systems vs. Inlet Particle Separators (IPS)**

Compressor blade “as good as new” with *PUREair* system

Compressor blade erosion with IPS

<table>
<thead>
<tr>
<th>Test Contaminant</th>
<th>MIL-E-5007C</th>
<th>ISO Coarse Test Dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical <em>PUREair</em> Efficiency (%)</td>
<td>96.5</td>
<td>95.5</td>
</tr>
<tr>
<td>Typical IPS System Efficiency (%)</td>
<td>92</td>
<td>75</td>
</tr>
<tr>
<td>Compressor wheel service life increase with <em>PUREair</em> system compared to IPS</td>
<td>2.3</td>
<td>5.5</td>
</tr>
</tbody>
</table>
Tiger Engine Test

Challenge: Engine had to survive 10 hrs in brownout conditions with a power degradation of < 5%

Total Dust Fed | 156Kg (344 lbs)
---|---
Power Loss after test | Only 3%

This shows only 1/10 of the test dust actually injected into engine air inlet (156kg).

Trial was equivalent to a minimum of 300 landings in brownout!
Oil Wetted Barrier Filter - Dirt Holding Capacity

By contrast, the same test with an oil wetted inlet barrier filter\(^1\) (IBF)

- IBF would have required cleaning \textbf{300 times} during the test.
- IBF would have required replacement \textbf{at least 20 times}
- The test would have \textbf{stopped every 2 minutes} for barrier filter maintenance. With the \textit{PUREair} system, it went all the way through without interruption.

\[
\text{Pall PUREair system} = 156\text{kg} \\
\text{IBF} = 0.46\text{kg}
\]

Barrier filter maintenance is a serious burden for the operator.

\(^1\) Based on barrier filter with dirt holding capacity of 0.46 Kg (AP23207) and maximum 15 cleanings
Performance Comparison - 30 year old Design and latest Design

2006 Trans-African Rally

Compressor as good as new after 100 hours and 98 desert landings on unprepared sites in the Sahara with the new PUREair system.

Old design
- Large amount of dirt in Inner shaft

New design
- Tiny amount of dirt in Inner shaft

Standard PUREair system:
- 74 Flight Hours
- 76 Landings
- 8.7g of dust in hollow shaft

New PUREair system:
- 100 Flight Hours
- 98 Landings
- 0.6g of dust in hollow shaft
Pall \textit{PUREair} system has good operational capability in \textbf{Snow} and \textbf{Ice} conditions.

This fully de-iced helicopter was forced to land, not because of \textit{PUREair} system blockage, but through the rotor blades icing up.
Pall PUREair - Cold Weather Operation

Vortex tube (Hover Condition)

Diagram and photo show ice accretion in hover.
Diagram and photo show ice accretion in forward flight.
Barrier Filters - Cold Weather Operation

- Barrier filters tend to get blocked by Ice / Snow.

- When blocked by ice or snow, engines rely on by-pass doors.

- By-pass doors have to be reliable and designed in such a way that ice/snow does not accumulate on them.

- Our competitor now provides coarse screens to replace their barriers on some helicopter models for winter operation.
Scavenge Systems

Scavenge is achieved either by P2 air activated ejector or scavenge fan.
Over 9000 *PUREair* units have been supplied to date.

**Customers include:**

- US Army
- UK RAF
- Royal Netherlands Air Force
- Egyptian Air Force
- Royal Australian Navy
- NAMSA
- Heli Union
- Maverick Helicopters
- Eurocopter
- AgustaWestland
- Bell
- Boeing
- Sikorsky
- Kazan
- Ulan Ude
- Mil Helicopter Plant
- MD Helicopters
Over 50 Helicopter Air Intake Solutions
Pall **PUREair** Applications – EC135

*Photo Courtesy Pierre-Yves Jan*
Pall PUREair Applications – CH-47 Chinook
Pall PUREair Applications – MIL Mi8 / 17
Pall PURElair Applications – Sea King / S61
Pall **PUREair** Applications – Bell 427

(c) Jeff Swaze
Pall PUREair Applications – AS332 Super Puma
Pall PUREair Applications – SA315 Lama

(Photo Courtesy Girish Thorat)
Pall PUREair Applications – AW139
Pall PUREair Applications – NH90

Courtesy Martin Eadie
Pall PUREair Applications – Mi24