Maintenance Differences
Between Single Stage and Turbo Blowers
Objective:

To give an overview on the maintenance requirements between the following blower Technologies

- Integral Geared Blowers
- Magnetic Bearing Blowers
- Air Bearing Turbo Blowers

What are the maintenance differences between single stage vs. conventional technologies
What Every Engineer/Plant Operator Should Know

Maintenance = downtime and $

- Scheduled maintenance, daily, weekly, monthly, annually?
- Overhaul requirements and costs for parts, process of inspection, travel or internal expenses?
- Local off the shelf items or proprietary?
- Guarantee availability of parts for how long?
- What spare parts should you have at your facility?
- Service warehouse and repair facility location?
- Is there monitoring of blower performance for preventative maintenance?
- Recording of operating conditions and alerts?
Enclosure
APG-Neuros
ABS
Hoffman
HSI
Turblex
Core/ Internal Assembly
AIR BEARING SINGLE IMPELLER
Air Bearing - Dual Impeller Core

**Impeller**
Highly advanced computation fluid dynamic programming allows for performance design to truly offer an advancement in efficiency.

Each impeller vane configuration is matched with its own specific volute to optimize aerodynamic efficiency. Matching the specific speed with the diameter of the wheel assures the utmost capability for power savings.

HSI's design team has more than 20 years of experience allowing for custom designed impellers to reach maximum efficiencies possible for any application.

**Double suction symmetrical structure**
- Impellers at both ends of a common shaft counterbalance thrust load in the axial direction (axial load=0)
- Superior stability and durability
- Improved efficiency over single impeller designs
- Reduction of local stress or twisting

**Motor/Frame**
- Highly efficient and reliable motor design
- Specifically designed for high speed service
- Designed for high heat environments
- Air or Liquid cooled

**Bearings**
- Individually layered bearings are assembled in the housing to support the shaft
- As the shaft rotates at high speed, an air film is formed between the shaft and the bearings which achieves friction free floating without the use of lubricants
- No additional cooling required
- Suitable for high speed; bearing load capability increases with higher RPM.

**Superior durability**
- Little or no wear after 35,000 continuous on/off cycles
- Possible to operate under extreme environment (max. 250°C)
- Little to no vibration or noise
PACKAGING — INSIDE OF A MAGNETIC BEARING BLOWER

- Cabinet Disconnect
- C-H (Vacon) Frequency converter
- Control terminal connections
- Cabinet Cooling Air Outlet
- Impeller
- RFI
- AC Choke
- Magnetic Bearing controller
- Induction Motor
- Motor Cooling Air Outlet
- Motor and Cabinet Cooling Air Outlet
Core Assembly for Integral Gear
Motor and Bearing Overhaul
## Motor Overhaul

<table>
<thead>
<tr>
<th>Motors</th>
<th>Life of Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent Synchronous Magnet Motor</td>
<td>Design 10- 20 years</td>
</tr>
<tr>
<td>High Speed Induction Motor</td>
<td>Design 10 years</td>
</tr>
<tr>
<td>Brushless D/C Permanent Magnet</td>
<td>Design 10 years</td>
</tr>
</tbody>
</table>
Permanent Synchronous Motor Advantages

LOWER HEAT GENERATION AND SMOOTHER OPERATION

**PMSM**

**Phase Difference = 0 deg.**

**Phase Difference = 30 deg.**

**Other type**

![Graphs showing waveforms for PMSM and other types with phase differences of 0 and 30 degrees.](image-url)
Bearing Maintenance
CORE TECHNOLOGY - AIR BEARING

- **Air Bearing**
  - Leaf air bearing, bump foil air bearing
  - No lubricating oil or associated maintenance
  - No contact during operation - reduced noise and vibration
  - Low Bearing Preload – Low start up torque to high start up torque
  - Bump foil Air Bearing - Endurance test of 25,000 cycle of start and stops to test resulted in bearing components and shaft having no damage!
BUMP AIR FOIL BEARING
DURABILITY DEMONSTRATED THROUGH 25000 STARTS

ENDURANCE TEST

**RPM Profile**

**Vibration (Shaft Disp.)**

**Shaft Surface**

**Journal Bearing Surface**

**NO Damage**

**NO Damage**
Magnetic Bearing

- High load, lower rpm
- No lubricating oil or associated maintenance
- No contact during operation at any time - reduced noise and vibration
- Low start up torque
- Touch Down Bearing, Most commonly is are magnetic ball bearings – Back up in case of Magnetic Bearing Control failure
- Mean Time Between Failure Magnetic Bearing Controller 100,000 hrs
MAGNETIC BEARING

High speed unit details:

- Impeller
- Labyrinth seal
- Upper and lower axial and radial magnetic bearing
- Cooling fan
- Upper and lower position sensor
- Motor rotor
- Upper touchdown bearing
- Lower touchdown bearing
Magnetic Bearing

Magnetic Bearing Controller
<table>
<thead>
<tr>
<th>Blower Type</th>
<th>Method of Lubrication</th>
<th>Maintenance</th>
</tr>
</thead>
</table>
| Fluid Film Bearing-Integral Gear | Oil                   | • MTB Failure of Bearing is 10-12 Years  
 Daily- Check oil levels through sight windows  
 Weekly- Check grease bearings  
 Monthly- Change gearbox oil |
| Magnetic Bearing            | None- Air             | Inspection 7, 10, 15, 20 years  
 • Mean Time Between Failure -Magnetic Bearing Controller around 100,000 hours  
 • MTB Overhaul of Bearing- 40,000 (Pillar)- 150,000 hours  
 • MTB Replacement of Touch Down Bearings- 30 touch downs  
 • Need Back Up Power Supply for Power Outage |
| Air Bearing                 | None-Air              | Inspection 10-20 years, overhaul 10, 15, 20 years  
 • MTB Overhaul 100,000-150,000 hours  
 • MTB Failure 200,000-300,000 hours  
 • No back up power supply needed for power outage |
| PD                          | Oil                   | Daily- Check oil levels through sight windows  
 Weekly- Check grease bearings  
 Monthly- Change gearbox oil |
| Multi Stage                 | Oil                   | Daily- Check oil levels through sight windows  
 Weekly- Check grease bearings  
 Monthly- Change gearbox oil |
Impeller
<table>
<thead>
<tr>
<th></th>
<th>Forged</th>
<th>Cast</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>SUS 630 Aluminum 7075 Titanium</td>
<td>SUS 630</td>
<td>Anti-corrosion, anti-explosion available</td>
</tr>
<tr>
<td>Mfg.</td>
<td>Machined Forging (5-axis NC Machining)</td>
<td>Casting (Lost Wax)</td>
<td>5-axis machining for better higher efficiency &amp; better quality, at higher manufacturing cost.</td>
</tr>
<tr>
<td>Eff.</td>
<td>84% - 76% Depending on Impeller Size</td>
<td>78% - 72%</td>
<td>&gt; by 6-8%</td>
</tr>
<tr>
<td>RPM</td>
<td>17,000 - 32,000</td>
<td>30,000 - 40,000</td>
<td>larger impeller diameter “from forging” allows lower speed operation for higher efficiency</td>
</tr>
</tbody>
</table>
Impeller Design

Forged Material Cross-section

Cast Material

Forged Impeller

Cast Impeller

Source: NASA
Filter Element Maintenance
## Filter Maintenance

<table>
<thead>
<tr>
<th>Blower</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integral Gear</td>
<td>Weekly Inspection on intake filters, depending on blower size can have 12 filters</td>
</tr>
<tr>
<td>Turbo Blower- Air Bearing</td>
<td>Check monthly. Typically 2 filters, changed monthly- long as 6 months</td>
</tr>
<tr>
<td>Turbo Blower- Magnetic Bearing</td>
<td>Check monthly. Typically changed every month</td>
</tr>
</tbody>
</table>
Cooling
## System Cooling

<table>
<thead>
<tr>
<th>Methods of Cooling</th>
<th>Redundancy</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Fan</td>
<td>Redundancy Recommended</td>
<td>Check power source, make sure functioning</td>
</tr>
<tr>
<td>Process Air</td>
<td>No Redundancy Needed</td>
<td>No maintenance</td>
</tr>
<tr>
<td>Glycol Cooling Internal (internal heat exchanger)</td>
<td>Redundancy Recommended</td>
<td>Filling Water Tank 1-2 times a year. Draining</td>
</tr>
<tr>
<td>External Heat Exchanger</td>
<td>Redundancy Recommended</td>
<td>Every 3 years for Integral Gear blowers</td>
</tr>
<tr>
<td>Eject Heat to Blower Room</td>
<td>No Redundancy Available</td>
<td>Monitoring temperature levels of blower room due to blower</td>
</tr>
</tbody>
</table>
Eject Head to Room: Cooling System

① Complex/Expensive Package

② Maximum Efficiency

- Main Air through main air filter
- Inverter Air through inverter Air filters
  (Filters are on rear side)

- Compressed Air

- 4kW Motor Cooling Air
- 76kW Shaft power to impeller
- 3kW Inverter Cooling Air

- 83kW W

Proprietary Information
INTEGRATED COOLING SYSTEM

COOLING UNIT

- Inverter
- Water Tank
- Pump
- Radiator
- Motor
- Tank of Cooling Water
- Level Gage of Cooling Water
## Misc. to Technology

<table>
<thead>
<tr>
<th>Blower</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integral Gear</td>
<td>Gear Box- Monthly- Check belt for dry areas or cracks, check tension&lt;br&gt; Inlet and Discharge Guide Vanes- Inspection 18,000 hour, overhaul 36,000 hours&lt;br&gt; Vibration Check- Quarterly Basis</td>
</tr>
<tr>
<td>Turbo Blower- Air Bearing</td>
<td>Variable Frequency Drive- 7-10 years life, no scheduled inspection</td>
</tr>
<tr>
<td>Turbo Blower- Magnetic Bearing</td>
<td>Variable Frequency Drive- 7-10 years life, no scheduled inspection&lt;br&gt; Bearing Controller-replacement every 100,000 hours</td>
</tr>
<tr>
<td>Multi Stage</td>
<td>Check for cracks in enclosure&lt;br&gt; Quarterly Vibration check and analysis</td>
</tr>
</tbody>
</table>
## Service of Parts

<table>
<thead>
<tr>
<th>PD</th>
<th>Multi Stage</th>
<th>Integral Gear</th>
<th>Magnetic Bearing</th>
<th>Air Bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most maintenance of blower can be done on site, downtime can vary</td>
<td>Most maintenance of blower can be done on site, downtime can vary</td>
<td>Maintenance is done in the field but depending on the complexity may need to be shipped to the factory.</td>
<td>Replacement of Magnetic Bearing and Touch Down Bearings, these will need to be replaced at the factory. Bearing Controller can be replaced in the field.</td>
<td>Depending on the manufacturer, parts are generally able to be replaced in the field. There are proprietary items such as the VFD and PLC in some cases, a service technician would have to visit the site directly</td>
</tr>
</tbody>
</table>
Controls
BLOWER PACKAGE AND BUILT IN CONTROL SYSTEM

- Blower Core
  - Includes PMSM
- Line Reactor & Sinus Filter
- Adjustable Feet
- VFD
  - By KEB America
  - Low heat generation
  - High Efficiency
- PLC
  - Options:
    1. Allen Bradley
    2. GE
    3. Siemens
    4. Cimon
    5. Schneider
Integrated PLC Advance Control

- Complete system to control blowers & control components
- Optimize efficiency and operational flexibility

Operate Multiple blowers based on input command

- DO Control
- Pressure Control
- Flow Control
SMART CONTROL – ADVANCE TECHNOLOGY PLC

CONTROL, MONITOR & DIAGNOSTICS

NX TURBO BLOWER MONITORING
LIMIT BAR GRAPH

NX TURBO BLOWER MONITORING
LIVE PERF. CURVE
Advantages of Master Control Panel

- Gives the plant SCADA system one point of contact for:
  - All blower data.
  - All aeration control set points.
  - All aeration control process data.

- Automatically control up to 12 Blowers

- Automatically stages blowers on and off as needed for process control

- Keeps the blowers out of surge conditions and nuisance trips

- Manages start, stop, and minimum speed for all combinations of blowers

- Allows for manual or automatic rotation of blowers based on run time
Understand the process which you are trying to control and have a clear well thought out control strategy before you start the SCADA/MCP programming.

Minimum flow / speeds depends on basin level and effects of line loss and pressure spikes / transients. These are usually set in the field by empirical testing.

Failure to properly manage minimum speed/flow with multiple blowers running can result in the BOV opening, nuisance trips, blowers surging and may ultimately lead to blower core damage.

The lower the discharge pressure, the higher the turn-down ratio; in other words, the blower can be operated at a lower minimum flow. This also saves energy!
The blowers must always run to the right of the surge line; plan on running at least 200 SCFM to the right of the surge line.

Become familiar with the performance curves for your blowers and know what process conditions you will be running at. Pressures and flows will vary depending on season and time of day.

Get the performance curves for both winter and summer conditions as the surge line will move with ambient temperatures.

Familiarize yourself with the sequencing logic of the APG-Neuros blowers.

Understand the control limitations of the APG-Neuros blowers.
To avoid nuisance trips make small increment changes (0.1% or less) to the blower operating speed no faster than once every 10 to 60 seconds. This will vary with the type of control that you are doing. DO control loops tend to be very slow and can have update rates from once every 20 seconds to several minutes. Flow and pressure control loops will be faster and have update rates from 10 to 30 seconds.

Avoid erratic, rapid, and widely swinging set point changes that can cause blower instability and result in the BOV opening, nuisance trips, blowers surging and ultimately blower core damage.
Impacts On Maintenance Activity or Process Revisions

- For the most efficient use of turbo blowers we recommend maintaining a minimum discharge pressure of at least 4 psig. This would correspond for a water depth of approximately 9 feet. In case the water depth is below 9 feet, valves on the discharge should be throttled to create sufficient backpressure.

- Operation below 4 psig is possible but not as efficient.

- Cleaning or Changing filters when the filter there is a pressure drop of .2 at the inlet or as indicated.

- On larger 200 HP and higher models, that have glycol, ensure solution is filled when needed. Drain tank every 2-3 years, and screw cap tightly shut to avoid evaporation.
Lessons Learned from other WWTPs

- Relatively slow control loop is recommended to effectively control the level of DO.
- Recommend running the blowers in speed control and implementing the process control (DO, Flow or Pressure) in the master PLC.
- When running more than one blower, run all blowers at same speed.
- When running multiple blowers, recommend alternating blowers starting sequence to try to even the starts between units.
- Recommend running a pressure optimization routine or most open valve algorithm to keep header pressure at as low as possible to reduce power consumption.
- Watch for pressure spikes induced by down stream cyclic valves.
BLOWERS INSTALLATIONS

Brightwater Project – 7 NX300

Hollister, CA – 9 NX100/NX150