Vessel Management Solution

Advanced Predictive Maintenance
with very early stage warning of emerging faults

Neptunus Power Plant Services Pvt Ltd
www.neptunus-power.com
The Context

Operations & Maintenance:

- Engine is a complex mechanical equipment
- Time-based scheduled preventive maintenance is expensive
- Conventional linear vibration measurement provides macro level diagnostic that too at a later stage of fault development
- Getting cylinder specific diagnostic of a running engine is critical but no easy solution available

So what’s the way forward?
A stitch in time saves nine... Neptunus’ solution will enable detection of an emerging fault MUCH EARLIER compared to conventional maintenance methods such as linear vibration accelerometers. So you get MORE TIME to plan & take preventive / corrective action.
Our Vision of Maintenance Cycle

- NEPTUNUS EXTENDED CYCLE
- OEM RECOMMENDED CYCLE
- SELF-EXTENDED CYCLE

EQUIPMENT HEALTH vs. TIME
Why This Solution?

- Cost effective solution
- User-friendly
- Easy to use – quick to install
- No need to open machine for routing checks
- Robust & reliable
- Uncomplicated reports with detailed information (what to fix)
- Local and remote access – on-line - 24/7
- Management concept for a full fleet
- Essential tool for predictive diagnostics
- ROI in less than 6 months
- Huge savings on maintenance
- Increased efficiency of manpower
How do we enable it?

- Use of advanced technology which is easy to use on the shop floor and puts the power in the hands of the operators.
- Solution has two main technology pillars:
  #1: Torsional Vibration
  #2: Oil Management
- Real time measurement & remote monitoring facility through cloud
- IIoT ready and integrates perfectly in your Industry 4.0 strategy
#1 Torsional Vibration alphaSYSTEM

- **Most advanced** Predictive Diagnostic Tool for Rotating equipment
- Uses **Torsional Vibration**, which is the most sensitive for early warning detection of an emerging fault. Detects much earlier than the conventional practice of linear vibration measurement
- **Non-invasive measurement**, no need to open the equipment
- **Power in the hands of operator** with simple go-no go user interface
- Enables on-site, over the network or remote cloud based connectivity for real time monitoring of machine health **anytime and from anywhere**
How does alphaSYSTEM work? (1/2)

**Indicators**
- Mechanical Health
- Engine Efficiency
- Injection
- Bearing
- Misfiring
- Twist Angle
- Mounts
- Compression
- Mech. Stresses
- ...

**Time Domain**
- Angular
  - Acceleration
  - Velocity
  - Displacement
- Mean
- Variance
- Skewness
- Kurtosis

**Frequency**
- Frequency distribution
How does alphaSYSTEM work?

Theoretical Signal (Carrier Frequency)

- Measured Signal
- Difference signal (A-B)

Hilbert transform (velocity)

Angular Displacement
Phase difference between Hilbert transform & carrier signal

Angular Velocity
Magnitude of Hilbert transform

Angular Acceleration
Derivative of velocity

Stochastic computation of statistical moments:
- Mean
- Variance
- Skewness
- Kurtosis

Harmonics appearance or disappearance phasing

Indicators
Application Modules

- **alphamotor**: Diagnostic system for traction and other electric motors
- **alphatorque**: Torque measurement and diagnostic system
- **alphabearing**: Bearing diagnostics system for rolling-element (ball and roller) bearings, plain (journal and sleeve) bearings
- **alphagearbox**: Diagnostic system for gearboxes
- **alphaengine**: Combustion engine diagnostics
  - Any type of diesel, natural gas and petrol engines
  - 2/4 stroke, inline/V type, up to 30 cylinders
- **alphacomp**: Diagnostic system for compressors, e.g., integral reciprocating compressors

- Considerable savings in fuel consumption & overall efficiency
- Eliminate catastrophic breakdowns
- Extend overhaul intervals safely
- Easy to install & retrofit
- Reduce operational costs – ROI in less than six months
Resulting analysis is a 2, 4 or 6-cylinder engine, with speed up to 3000 rpm or 6000 rpm.

Main parameters to be measured:
- Speed sensor
- Crankshaft
- Camshaft (4-stroke) or TDC (2-stroke)
- Firing order
- Number of teeth on gear wheel (At least 60 pulses per revolution)
- Engine type: V type or inline
- Fuel type: Diesel or natural gas

Specialised in maintenance diagnostics for engines: Diesel or natural gas, inline or V-type, up to 30 cylinders or up to 11 indicators.
alpha engine - capabilities

● A revolutionary predictive diagnostic system with powerful diagnostic functions and huge cost savings potential.
● Ability to analyze all kinds of combustion engines and turbochargers.
● Provides “cylinder specific” engine performance indicators.
● The analysis is based on torsional vibration measured by the crankshaft speed sensor.
● Anomalies can be detected early in order to keep your assets on track.
Diagnostic Dashboard
Engine Health Indicators

- Overall **mechanical health** of the engine.
- How **efficiently** the engine is running.
- Presence of **unexpected stress pulses** in the crankshaft twist.
- **Engine imbalance** due to non-optimal thermal health and inertial resistance of moving parts.
- **Dynamic torsion** in the crankshaft.
- Indication of **power loss** or efficiency of the engine.
- Information about **injection timing** & fuel atomization.
- **Dynamic behavior of bearings** and all moving parts.
## Engine Cylinder Specific Indicators

<table>
<thead>
<tr>
<th>Cylinder Specific Indicators</th>
<th>Compression</th>
<th>Injection Timing</th>
<th>Injection Condition</th>
<th>Bearing</th>
<th>Misfiring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Information</td>
<td>27%</td>
<td>0%</td>
<td>0%</td>
<td>83%</td>
<td>100%</td>
</tr>
<tr>
<td>Cylinder 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinder 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinder 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinder X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
This module is available as an option to alphaengine.

Requirements
- At least 6 pulses per revolution

Indicators
- Compression
  - Speed variation due to bearing friction
  - Mechanical efficiency of turbine compressor and rotor shaft
- Mechanical Stress
  - Detection of shocks
  - Mechanical damage of turbine compressor and rotor shaft
**alpha**torque Torque Measurement

**Requirements:**
- At least 60 pulses per revolution
- Optical or speed sensors (coil or Hall-effect)
- Two flywheels on shaft with speed sensor on each
- Minimum distance between two flywheel: 500mm

**Provided output:**
- Shaft RPM
- Shaft Static Torque
- Shaft Dynamic Torque
- Power transferred by the shaft

**alpha**engine calculates dynamic and static torque based on measurement from two targets in any desired position on shaft or other rotating part.
alpha\textsc{torque} Marine Application

<table>
<thead>
<tr>
<th>Function</th>
<th>Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque Measurement</td>
<td>1,2,3,5</td>
</tr>
<tr>
<td>Propeller Analysis</td>
<td>1</td>
</tr>
<tr>
<td>Propeller Bearing Analysis</td>
<td>1</td>
</tr>
<tr>
<td>Engine Diagnosis</td>
<td>4,5</td>
</tr>
<tr>
<td>Engine Power Calculation</td>
<td>5,6</td>
</tr>
<tr>
<td>Gearbox Diagnosis</td>
<td>2,3</td>
</tr>
</tbody>
</table>
Other Equipments: Compressor

Needed components:

- Two speed sensors:
  - on crankshaft having a target with at least 60 pulses per revolution installed close to first cylinder
  - one to get a signal if one cylinder is at Top Dead Center (TDC) for pinpointing of cylinders
- For correct pinpointing: phase shift of each cylinder being at TDC.
Other Equipments: Motor

Requirements
- At least 60 pulses per revolution
- One speed sensor close to motor
- Optical or speed sensors (coil or Hall-effect)
- Usable in all kind of applications (railway, industry, etc.)

The Basics of Motor Faults
- Defects in motors can be caused, inter alia, by following reasons:
  - Over-Current
  - Over heating
  - Vibration
  - Low resistance
  - Dirt
Why oil is important?

- 54% of machine failures are caused by poor lubrication
- Lab oil analysis, being widely practiced is slow and inaccurate
- Absolute or nominal filter ratings are vague and unreliable
- Post installation, it is difficult to evaluate oil quality in real time - forcing a costly premature oil change
Why is filtration really important?

90% of particulate matter is less than 5 microns
70% of particulate matter is less than 1 microns
## Noria Corp. Oil Tribology Studies

### LEM - MOISTURE Level

<table>
<thead>
<tr>
<th>Current Moisture Level, ppm</th>
<th>Life Extension Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>50,000</td>
<td>12,500</td>
</tr>
<tr>
<td>25,000</td>
<td>6,250</td>
</tr>
<tr>
<td>10,000</td>
<td>2,500</td>
</tr>
<tr>
<td>5,000</td>
<td>1,250</td>
</tr>
<tr>
<td>2,500</td>
<td>625</td>
</tr>
<tr>
<td>1,000</td>
<td>250</td>
</tr>
<tr>
<td>500</td>
<td>125</td>
</tr>
<tr>
<td>260</td>
<td>63</td>
</tr>
<tr>
<td>100</td>
<td>25</td>
</tr>
</tbody>
</table>

1% water = 10,000 ppm. 
- Estimated life extension for mechanical systems utilizing mineral-based fluids.

**Example:** By reducing average fluid moisture levels from 2500 ppm to 156 ppm, machine life (MTBF) is extended by a factor of 5.
# Noria Corp. Oil Tribology Studies

## LET – Cleanliness Level
ISO Codes, Complete

<table>
<thead>
<tr>
<th>Current Machine Cleanliness (ISO Code)</th>
<th>Expected Cleanliness level (ISO Code)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21/19/16</td>
</tr>
<tr>
<td></td>
<td>20/18/15</td>
</tr>
<tr>
<td></td>
<td>19/17/14</td>
</tr>
<tr>
<td></td>
<td>18/16/13</td>
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<tr>
<td></td>
<td>17/15/12</td>
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<tr>
<td></td>
<td>16/14/11</td>
</tr>
<tr>
<td></td>
<td>15/13/10</td>
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<tr>
<td>24/22/19</td>
<td>2.1</td>
</tr>
<tr>
<td>23/21/18</td>
<td>1.5</td>
</tr>
<tr>
<td>22/20/17</td>
<td>1.3</td>
</tr>
<tr>
<td>21/19/16</td>
<td>1.3</td>
</tr>
<tr>
<td>20/18/15</td>
<td>1.3</td>
</tr>
<tr>
<td>19/17/14</td>
<td>1.3</td>
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<tr>
<td>18/16/13</td>
<td>1.3</td>
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<tr>
<td>17/15/12</td>
<td>1.3</td>
</tr>
<tr>
<td>16/14/11</td>
<td>1.3</td>
</tr>
<tr>
<td>15/13/10</td>
<td>1.3</td>
</tr>
</tbody>
</table>

### Notes
- Hydraulics and Diesel Engines
- Rolling Element Bearings
- Journal Bearings and Turbo Machinery
- Gear Boxes and others

Source: Noria Corp.
Current practices & challenges

- Lack of focus on critical small particles (< 5 mic.) that cause more damage
- Only solid particle filtration is considered ignoring parameters such as water
- Real-time oil monitoring is ignored / compromised with lab analysis
- Oil replacement periods are decided by OEMs (often over designed leading to wastage of good oil) or done intuitively without qualitative evidence (leading to risk of equipment damage)
- Overall not enough awareness / knowledge on the “oil hygiene” and its importance & impact on machine health
What is required to be done?

- Do **complete oil management**
  - microfiltration + online continuous monitoring of oil
- You cannot manage what you do not measure
- Remove sources of oxidation and keep the oil continuously clean
- Follow the optimal oil replacement period
- Get detailed oil quality data based on several key oil quality indicators.
- Provide remote accessibility of oil health data
The Neptunus Solution

Advanced **Continuous Oil Quality Management System**

**Micro filtration system (RRR)**

- Provides absolute filtration till 3μ with β3 >400 and
- Removes all types of contaminants (including water)

**Real-time oil condition monitoring system (Tan Delta)**

- Will accurately measure & indicate the oil quality in real-time & also provides optimal oil change time
RRR: deep micro filtration

- Trusted Japanese technology with 40 years of experience
- Due to low pressure and constant flow within the cellulose filter (patented), performance of the system is highly efficient (more than 99.75% of all contaminants greater than 3μ are captured)
- Capable of removing water, solid particles, resins, oxidation sludge, varnish and other organic contaminants from oil
- RRR is an offline oil filtration system that employs:
  1. Bypass loop (kidney loop) to increase the effectiveness of filtration
  2. Depth filtration technology to capture maximum number of contaminants
More on Technology

Axial Flow
solids are trapped as they progress through multi-layered media

Radial Flow
Greater chance of particles passing through the media or premature plugging
Beta Ratio Explained

- Upstream Particles- 1,000,000
- Downstream Particles- 5,00,000
- Resulting Beta Ratio of 2 and efficiency of 50%

<table>
<thead>
<tr>
<th>Contaminant Challenge (particles/ml)</th>
<th>Downstream Fluid Quality (particles/ml)</th>
<th>Beta Ratio</th>
<th>Percent Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000,000</td>
<td>500,000</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>1,000,000</td>
<td>50,000</td>
<td>20</td>
<td>95</td>
</tr>
<tr>
<td>1,000,000</td>
<td>13,000</td>
<td>75</td>
<td>98.7</td>
</tr>
<tr>
<td>1,000,000</td>
<td>5,000</td>
<td>200</td>
<td>99.5</td>
</tr>
<tr>
<td>1,000,000</td>
<td>1,000</td>
<td>1,000</td>
<td>99.9</td>
</tr>
</tbody>
</table>

\[
\beta_X = \frac{\text{Number of particles greater than } X \text{ microns upstream}}{\text{Number of particles greater than } X \text{ microns downstream}}
\]

\[
\beta_5 = \frac{10}{1} = 10
\]

Fluid in

1 particle >5 microns (upstream of filter)

Fluid out

Filter

10 particles >5 microns (downstream of filter)
Tan Delta Online Oil Monitoring

- Unique and patented European technology and global leader in real-time oil condition monitoring products and solutions.
- Gives real time early warning signals on oil quality to make go/no go decision on oil change and also helps in machine health condition monitoring.
- Can be integrated to remote monitoring system (IIoT / cloud technologies).
- Uses oil quality sensors (OQSx) to detect oil condition in real-time using patented technology, that measures the capacitance of the oil & compares with the pre-fed oil signature database of more than 485 commonly used oil types (more can be generated / customized) to calculate a unique Tan Delta Number (TDN) on a scale of 0 to 1200 (higher TDN = better oil quality).
Real time Oil Condition Monitoring

TDN

1200
750
500
250
0

Oil Condition Deteriorates

1200
1000
500
250
0

Oil quality

Sensor in air / No oil detected
New
Good
Worn
Severely worn
End of life

Alarm (HIGH)
Warning (HIGH)
Warning (LOW)
Alarm (LOW)
Local Display Unit

- Oil Status LED
- Oil Status key
- Power LED
- Bluetooth LED
- Side flange/mounting holes
- Tan Delta OQSx sensor connector
- Oil Quality
- Rate of Change
- Rate of Change time period
- Oil Temperature
- Tan Delta power/data connector
The sensor will detect the following failure modes:

- Oxidation
- TAN changes
- TBN changes
- Additive depletion
- Particulate contamination
  - Wear debris
  - Process related (product)
  - Environment related (dust, sand)
  - Partially burnt fuel
  - Soot
- Fluid contamination
  - Water/Coolant ingress
  - Process related (product)
  - Fuel dilution
- Major viscosity changes
- Poor oil changes
- Incorrect oil type

ANY CHANGE IN THESE PARAMETERS, SINGULARLY OR IN COMBINATION WILL ALTER THE CHEMICAL FINGERPRINT OF OIL AND WILL BE DETECTED & INDICATED BY THE SENSOR.
Remote monitoring of ship engines

Advanced Predictive Maintenance solutions with cloud connectivity for monitoring engine’s health on real time basis from any remote location

Fault Code Transmitted  Reports Stored  Customer Notification  Urgent and Direct Communication  Detailed Report  Regular Reporting for Every Asset
Remote Engine Monitoring Solution Architecture
Vessel Monitoring Dashboard

ALPHA SYSTEM CYLINDER SPECIFIC INDICATORS

700 KW

LOAD (KW)

ALPHA SYSTEM GLOBAL INDICATORS

OIL TEMPERATURE

INTERNAL TEMPERATURE

OIL CONDITION

SFC VS LOAD

LOAD (KW)

SFC VS LOAD

NEPTUNUS
The Machine Reliability Expert

OIL CONDITION (ENGINE)

LUBE OIL PRESSURE IN ENGINE

COOLING WATER TEMPERATURE

NAUTICAL MILES TRAVELED IN A DAY

02043

22°C
In Summary

- Take a step ahead with advanced predictive maintenance using torsional vibration measurement & oil management solutions from Neptunus.
- Make real time measurement and take real time decisions.
- Stay connected 24x7 with your assets for remote management.
- Put the power in the hands of operators and decision makers.
- Reduce operational costs & downtime. Save more, gain more!
Way Forward

- Start Small. Establish Credentials with Customer.
- Do a one-off Service Job or a Paid Pilot (Rental)
- No Cure No Pay Guarantee
- Then, scale to one vessel, and then fleet of vessels
Why Neptunus

- **23+ years** in the business of delivering reliable solutions
- More than **2000 assignments** completed
- A strong & committed team of **~100 people**
- Serving customers in **25 countries** across Europe, Asia & Africa
- HQ & workshop in India & warehouse in UAE
The Neptunus Way

Assess Need / Pain-point ➔ Solution Engineering ➔ Value Creation

We deliver the solutions that work & saves $

➔ O&M experience brings practical user’s perspective

➔ Opex vs Capex balance

➔ Solutions with life-cycle considerations for Long term benefits

➔ Customer-centric & responsive service
Our Solutions

#1 Advanced Predictive Maintenance Solutions
- Condition based maintenance
- Oil monitoring & management
- Engine life-cycle management

#2 EPC & Turnkey Project Solutions
- Detailed Design & EPC of diesel & gas powered back-up/ captive power plants
- MEP, HVAC, Fire Protection System, Fuel Management packages
Value System

Teamwork

Safety

Integrity

Excellence

Accountability

Stakeholder Delight
Certifications & Awards

- ISO 9001:2015 certified by LRQA
- Rated BBB long term and A2 short term by ICRA and Crisil
- Featured, "Leading SMEs of India 2017" by Dun & Bradstreet and RBL Bank
- Awarded the India SME 100 Award by the Government of India by the Ministry of MSME and Axis Bank in 2016
Global Technology Partners
You can count on us for delivering RELIABLE solutions!

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