



Oil Debris Monitoring:

An effective tool for Operations

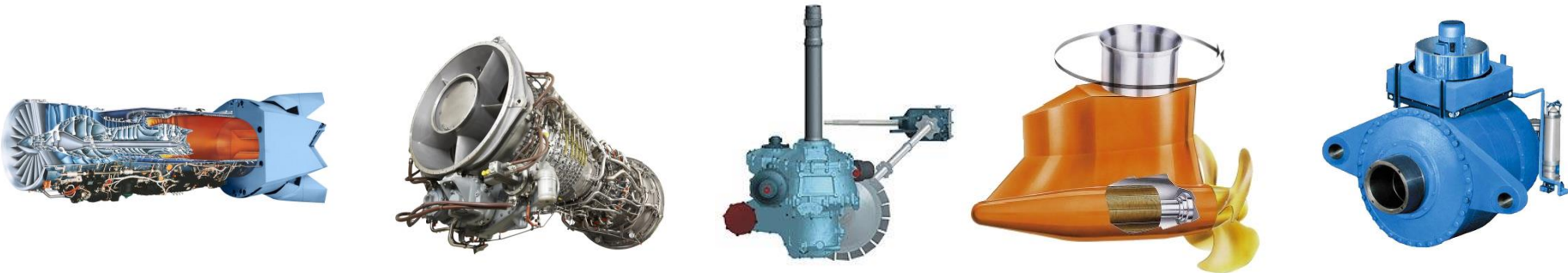
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PHM 2013 Wind Energy Workshop

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Why Bother?...



Reduce Repair Costs

- Avoid catastrophic failure
- Contain the damage
- Minimize repair time

Reduce Business Interruption Costs

- Schedule repair support on-site before shutdown
- Minimize lost revenue & penalties

Extend Overhaul Intervals

- Enable true Condition Based Maintenance



VERY COSTLY



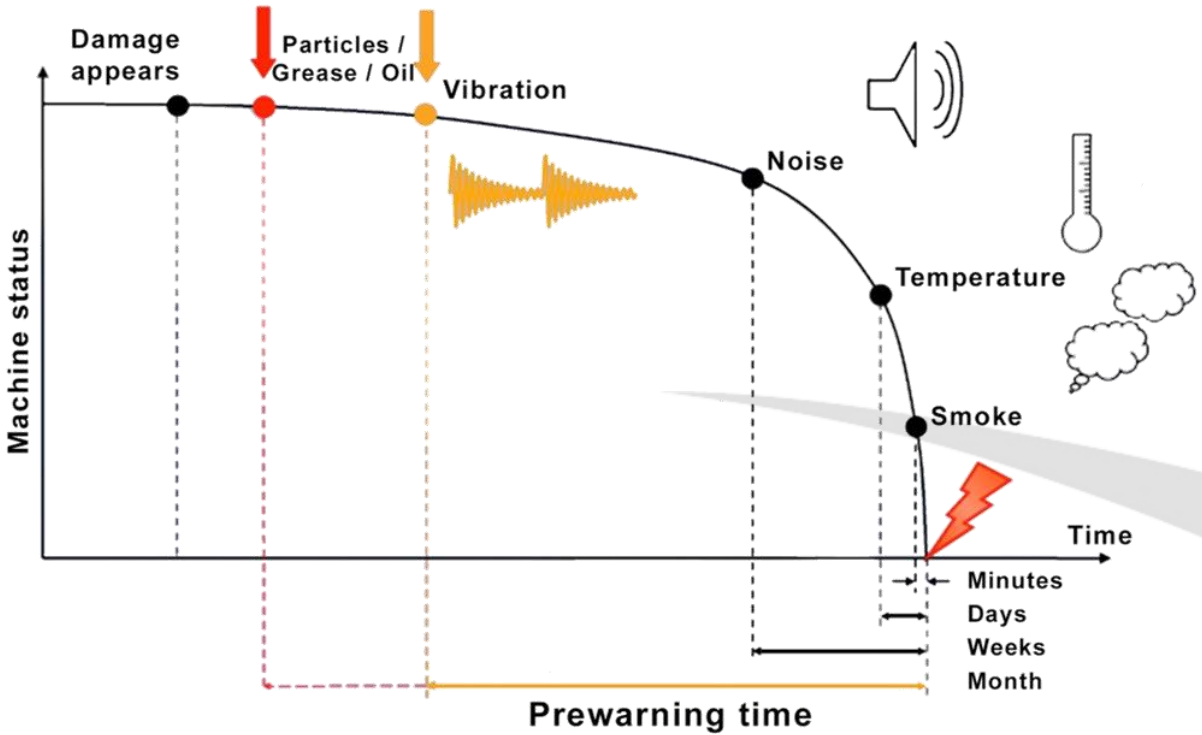
LESS COSTLY

...Save \$\$ = Reduced Net Cost Of Energy

It's all about Early Warning...



Early detection of machine damage using ...



...Condition Monitoring!

Where Does Oil Debris Monitoring Fit In?



Metallic particles appear when there is component damage

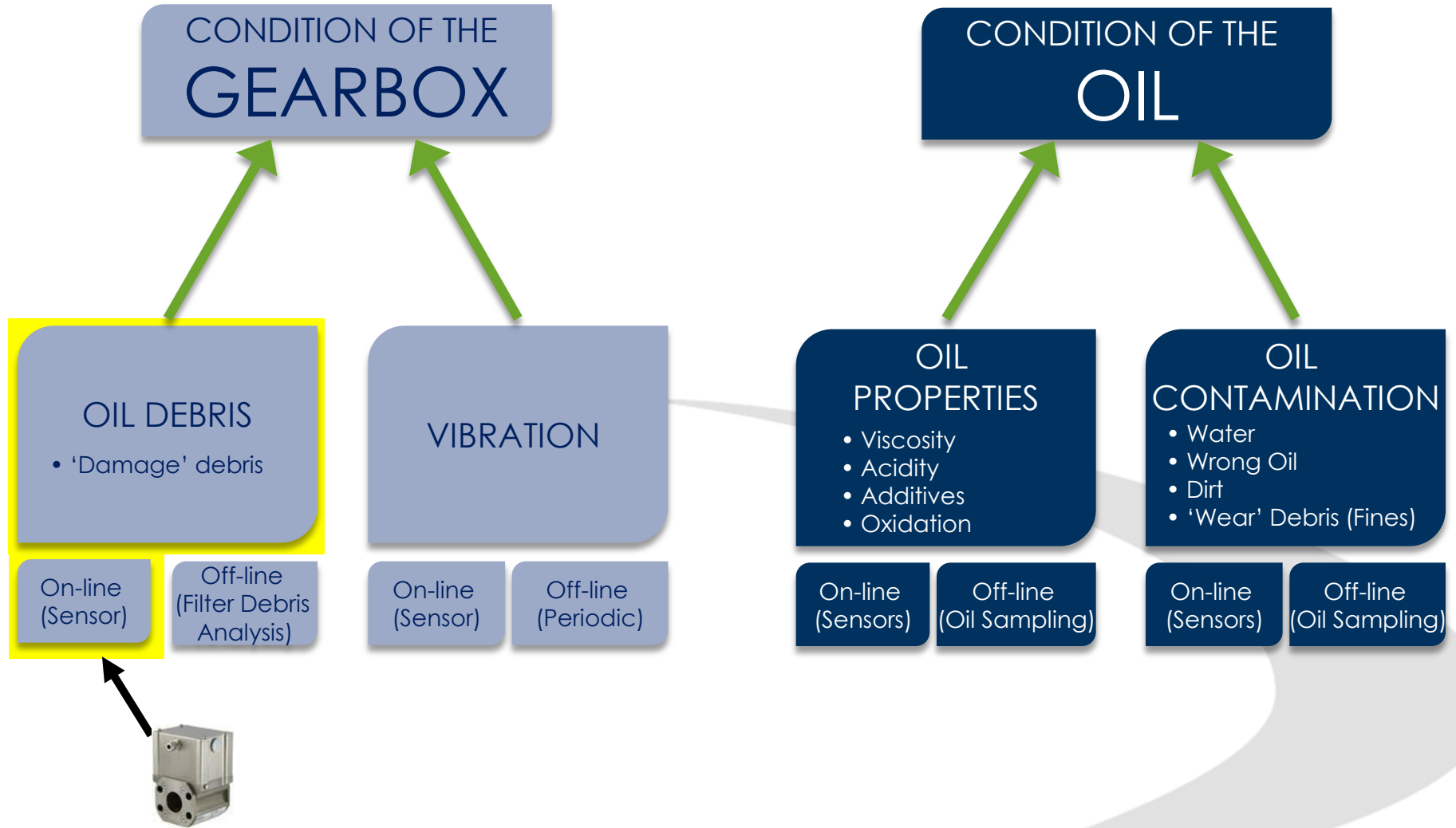
Particles are transported through the lube system by the oil

On-line sensor detects these metallic particles
(both ferrous & non-ferrous)

Identifies the **Initiation** and monitors the **Progression** of bearing/gear damage

Provides a key measurement for reliable indication of Gearbox Condition

Gearbox Condition and Oil Condition



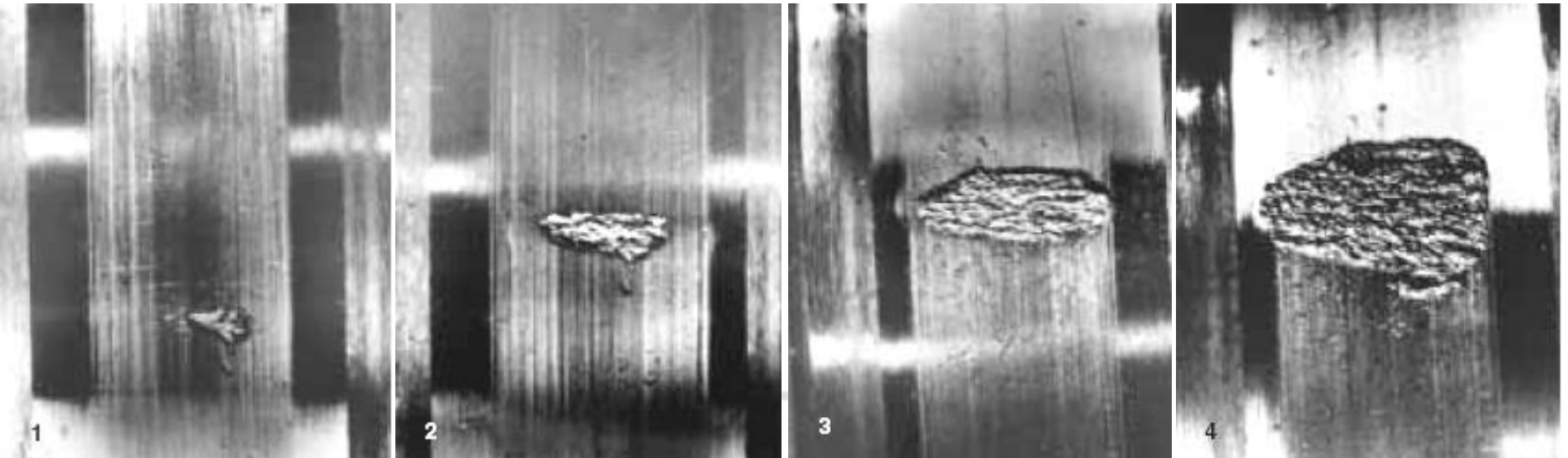
Oil Debris Monitoring and Vibration Analysis



	Oil Debris Monitoring	Vibration Analysis
Detection of Early Damage on High-Speed Stage	Yes	Yes
Detection of Early Damage on Planetary Stage	Yes	No
Able to Isolate Location of Damage	No	Yes
Easy to Interpret Data	Yes	No (Requires expert interpretation)
Detection of Gear Tooth Crack	No	Yes (on High Speed)

...Complementary Technologies

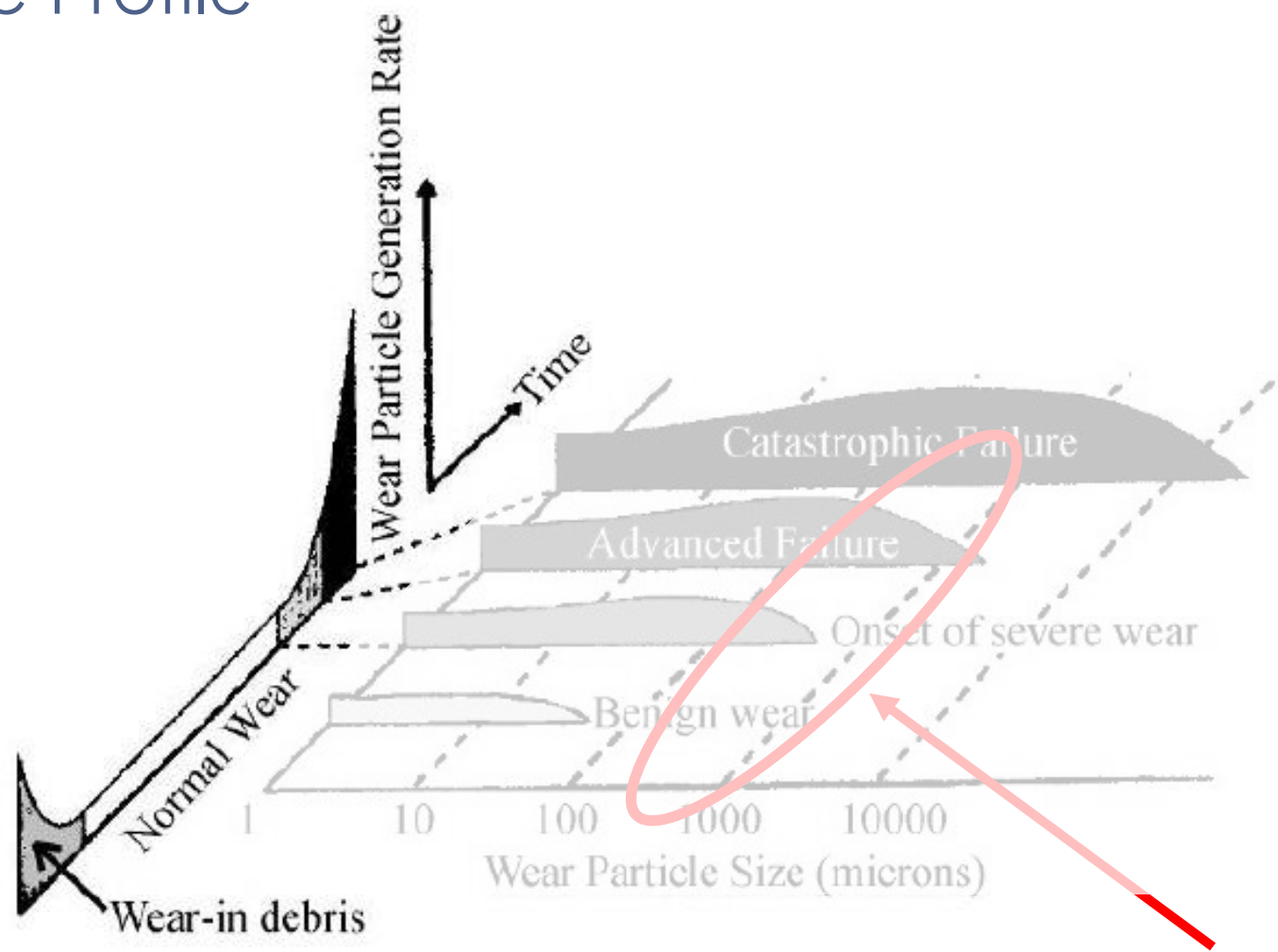
Bearing Spall Progression



Spall Propagation

Reference: "Bearing Failures and their Causes", SKF Product Information 401; and
"Rolling Bearing Analysis 3rd edition", Harris T.A., John Wiley & Sons Inc., 1991

Particle Profile

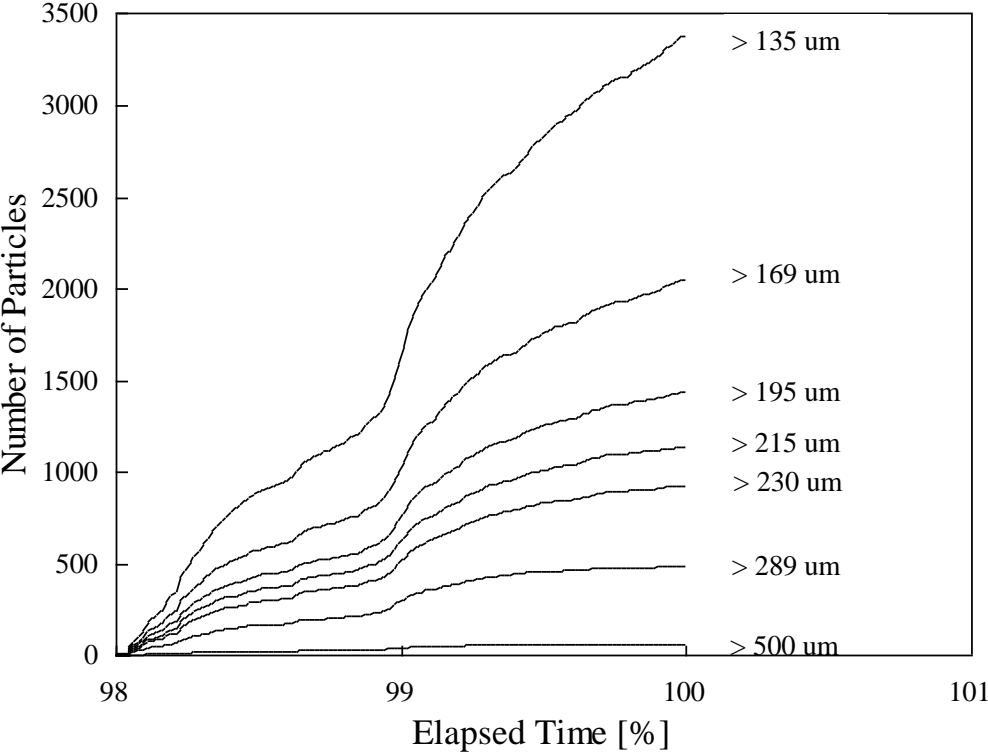


**Ideal Detection Area for
Damage Indication**

Reference: "Condition Monitoring for Offshore Wind Farms (CONMOW)", ECN Doc # ECN-E—07-044 / CORR0701

ODM Results - Bearing Spall Investigations

Seeded fault test data



Small-scale bearing test (D=40 mm)



Reference : "In-Line Oil Debris Monitor (ODM) for the Advanced Tactical Fighter", SAE 961308, Muir D et al

ODM Results – Gear Pitting Investigations

Seeded fault test data

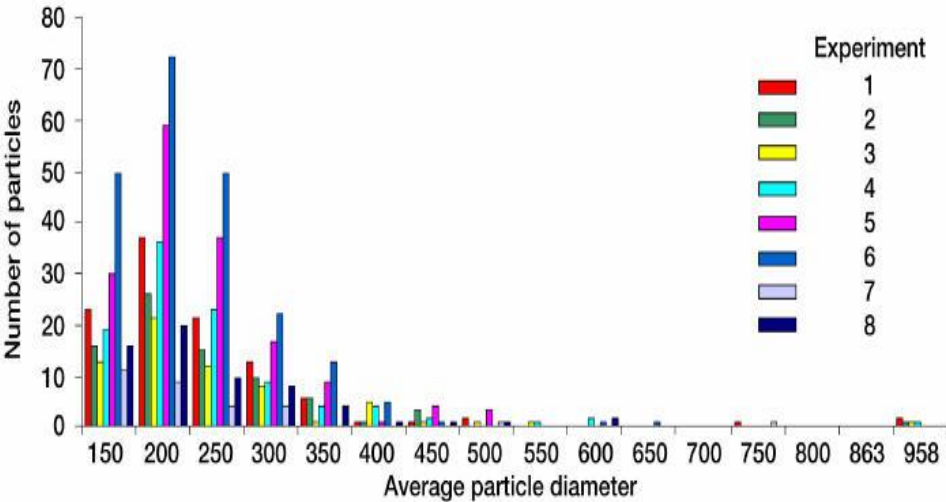
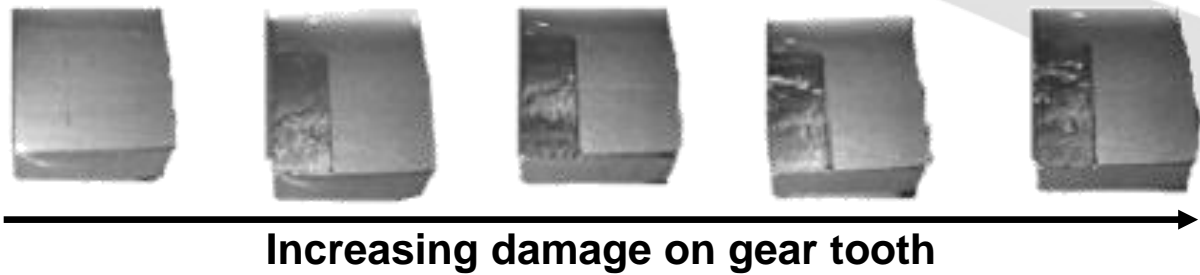
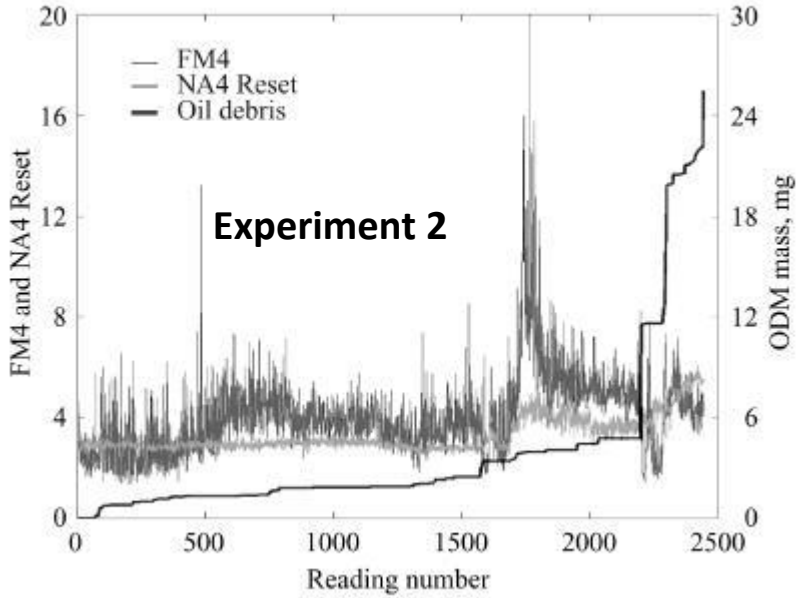


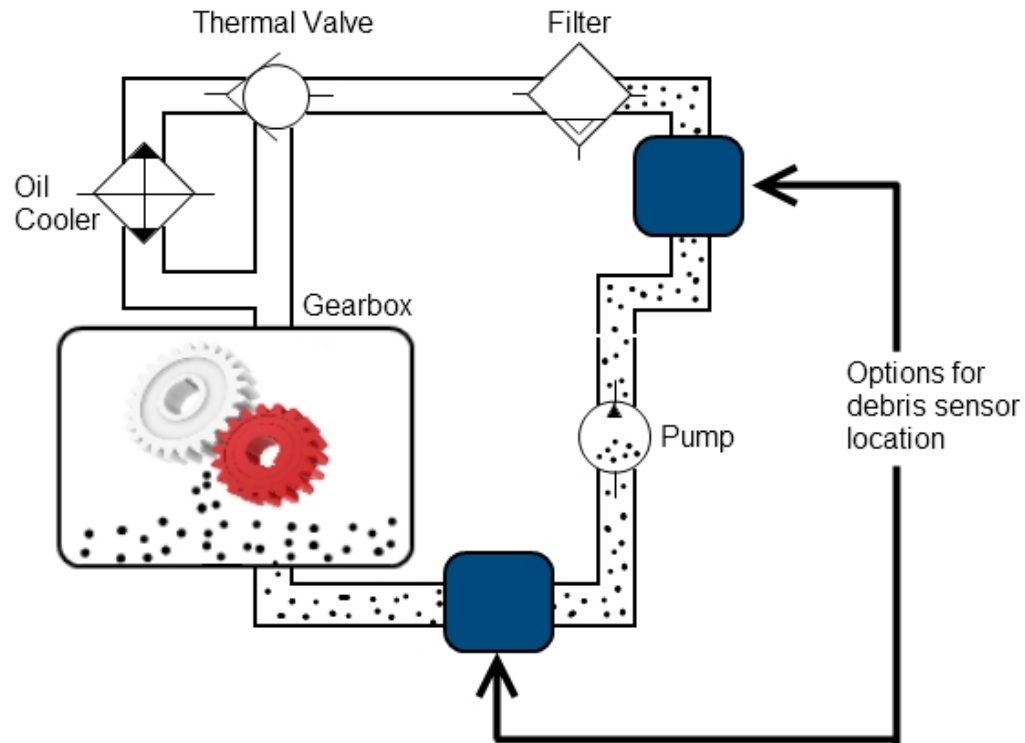
Figure 5.—Spur rig experiment after pitting damage was observed.



Reference : “Investigation of Gear and Bearing Fatigue Damage Using Particle Distributions”, NASA/TM – 2004-212883, Dempsey P et al

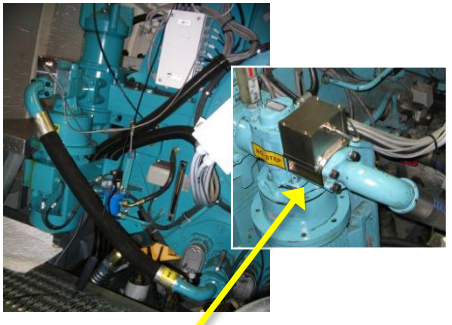
Lubrication System Interface

- Fitted to the oil circulation system **after** the gearbox and **before** the filter
- Typically pump suction or pump discharge



Oil Debris Sensor Installation Examples...

GE 1.5



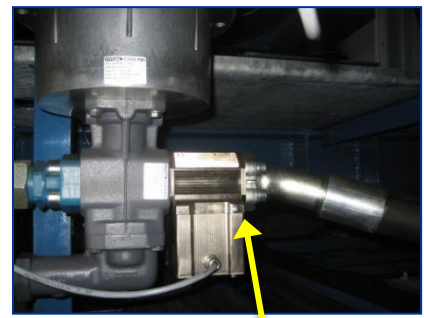
Sensor on pump intake

GE 2.5



Sensor on pump intake

Nordex
N80/90/100



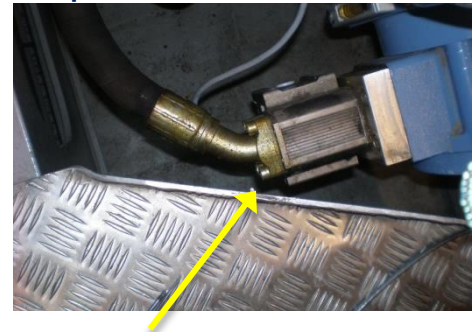
Sensor on pump intake

REpower MM82



Sensor on pump discharge

REpower MM92



Sensor on pump discharge

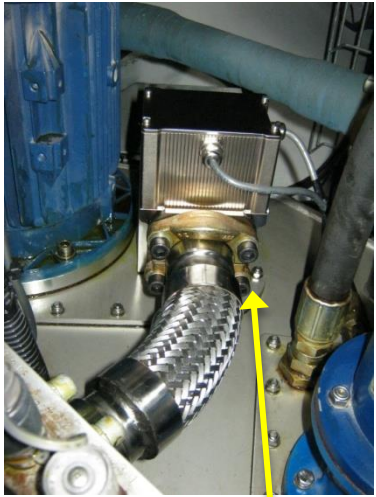
Siemens SWT2.3



Sensor on pump discharge

Oil Debris Sensor Installation Examples...

Vestas V90-3MW



Sensor on pump discharge

Vestas V80



Sensor on pump discharge

Vestas V52



Sensor on pump discharge

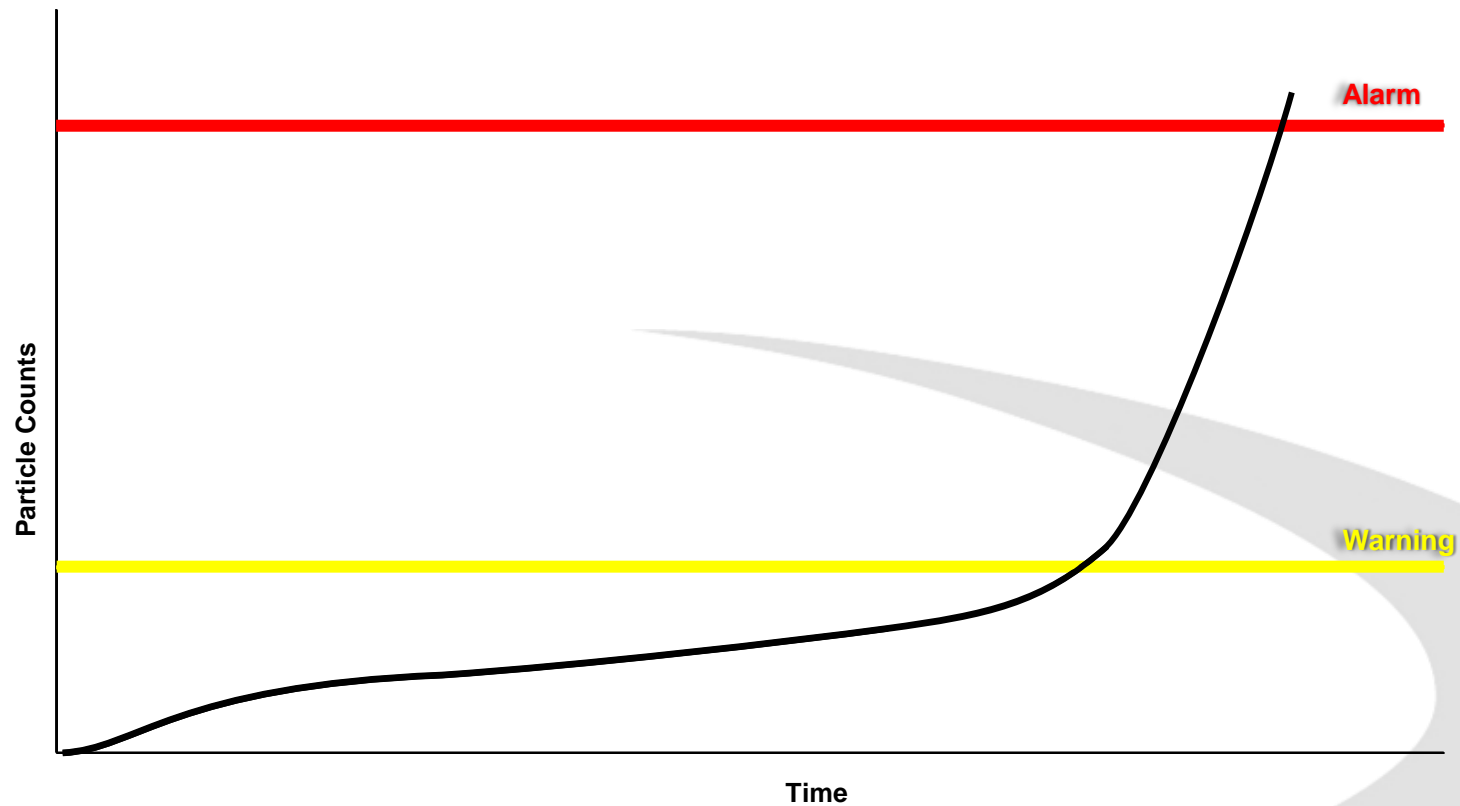
Vestas V47



Sensor on pump discharge

How To Use the Data...

1. Where am I in the life of my bearing/gearbox?
2. How much longer can I operate?

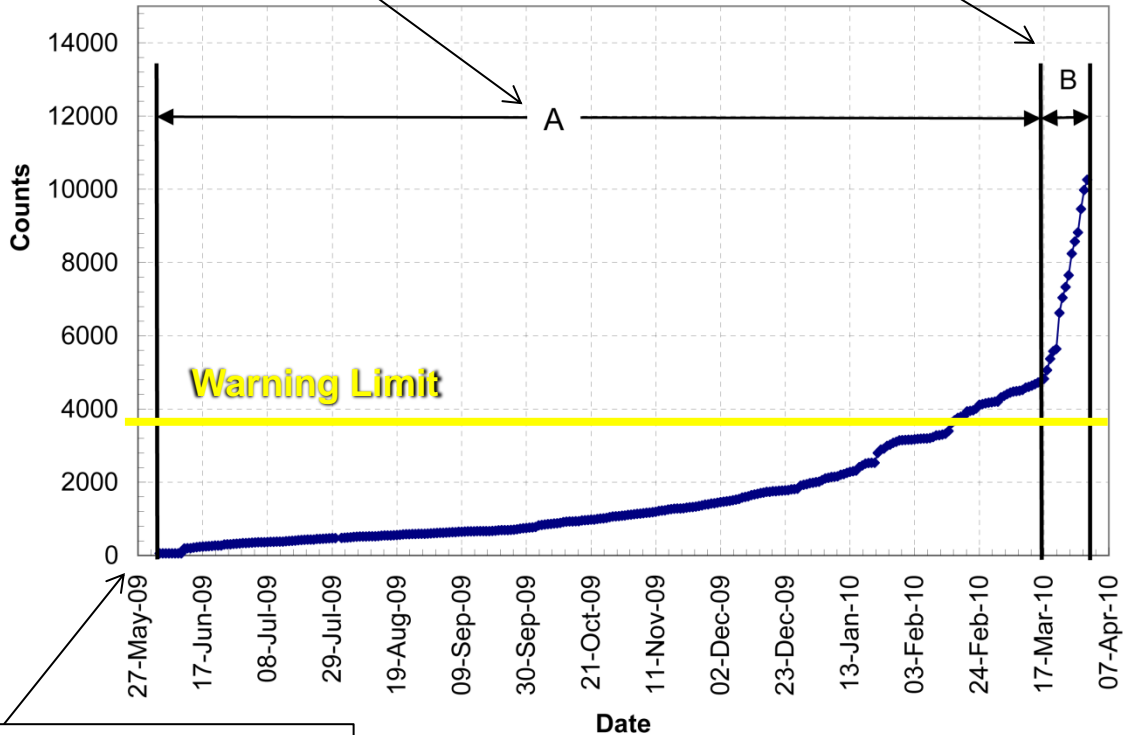


Field Data – Planetary Gear Tooth Damage

A) Debris increases at a moderate rate for more than a year.

B) Rate of debris accumulation increases significantly, triggering inspection.

- Video scope confirmed damage
- Turbine shut-down
- Gearbox replaced



On-line Debris Monitor Sensor Installed



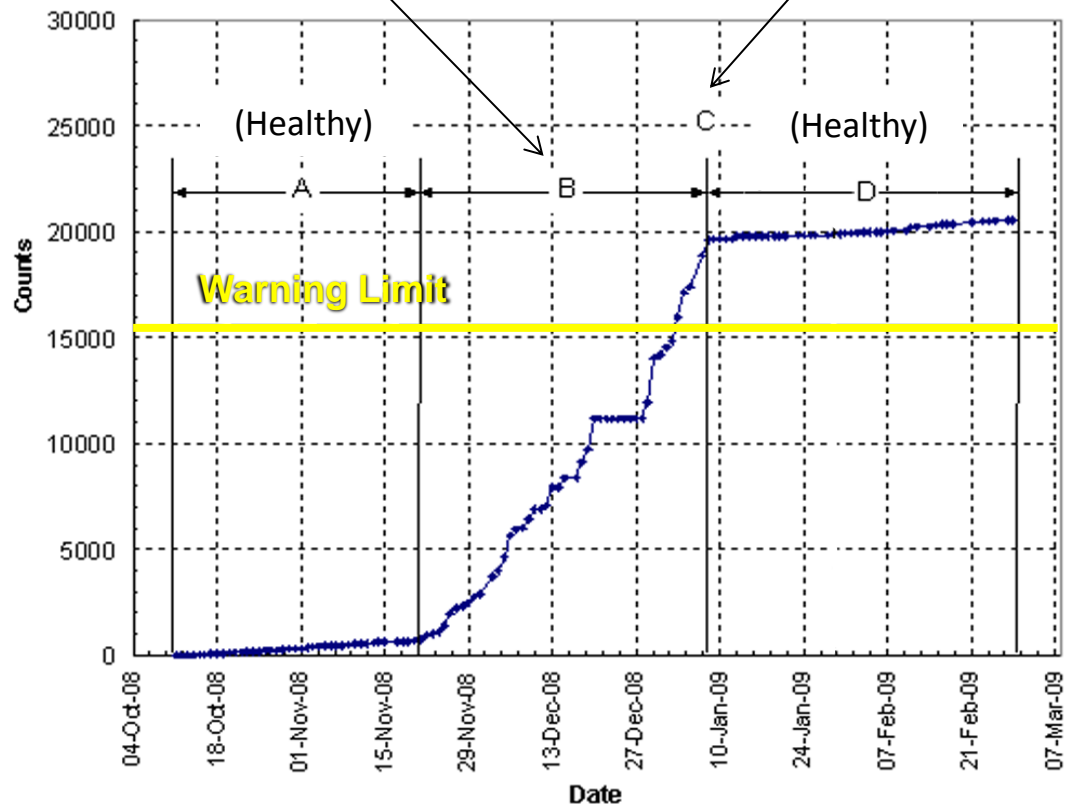
BENEFITS to the OPERATOR

- Maximized production revenue through event
- Avoided secondary damage & minimized repair cost

Field Data – High Speed Bearing Failure

B) Warning crossed & High Accumulation rate suggests high-speed bearing damage

C) Damage confirmed via scope & bearing replaced up tower.



- BENEFITS to the OPERATOR**
- Avoided secondary damage & minimized repair cost
 - Up tower repair
 - Minimized downtime

Oil Debris Monitoring – an Effective Tool



- Robust on-line indicator of gearbox condition
 - *Reduced Repair Costs*
 - *Reduced Business Interruption Costs*
 - *Reduced Maintenance Costs*
- Provides damage Indication & **Trending**
- Very easy to interpret - no expert required
- Monitors the gearbox - not the condition of the oil
- Complementary to Vibration Analysis



VERY COSTLY



LESS COSTLY

Manage damage events & Save \$\$

Oil Debris Monitoring – an Effective Tool



Be confident in your maintenance decisions.