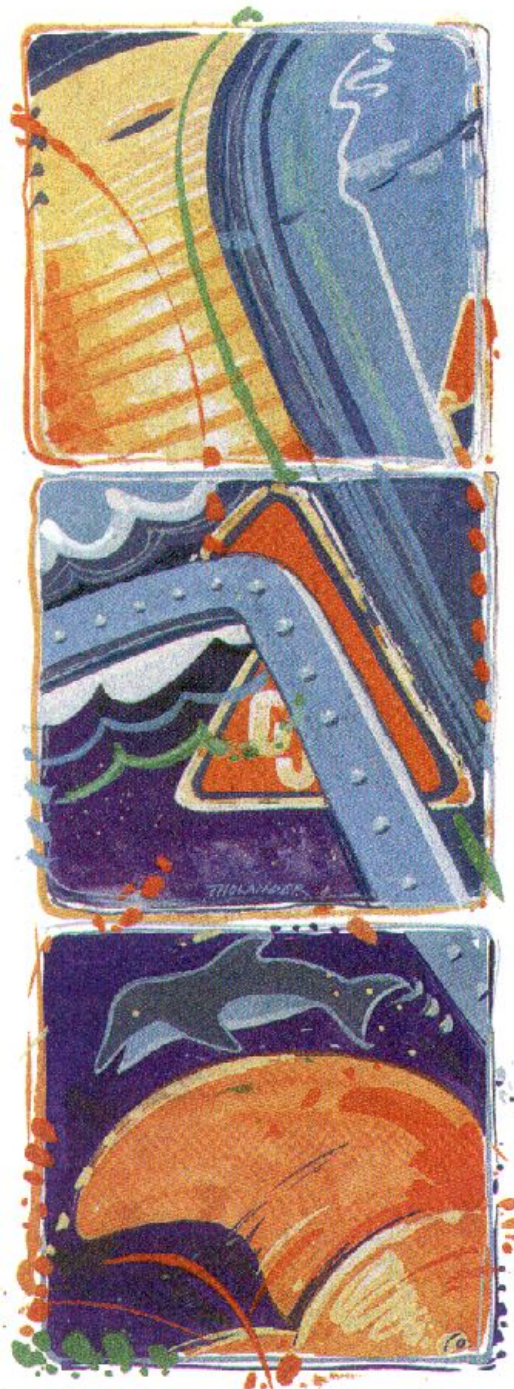




C.C. JENSEN





Clean Oil - Longer Lifetime of the Gearbox

by Thomas Møller Andersen, C.C.JENSEN A/S

AGENDA

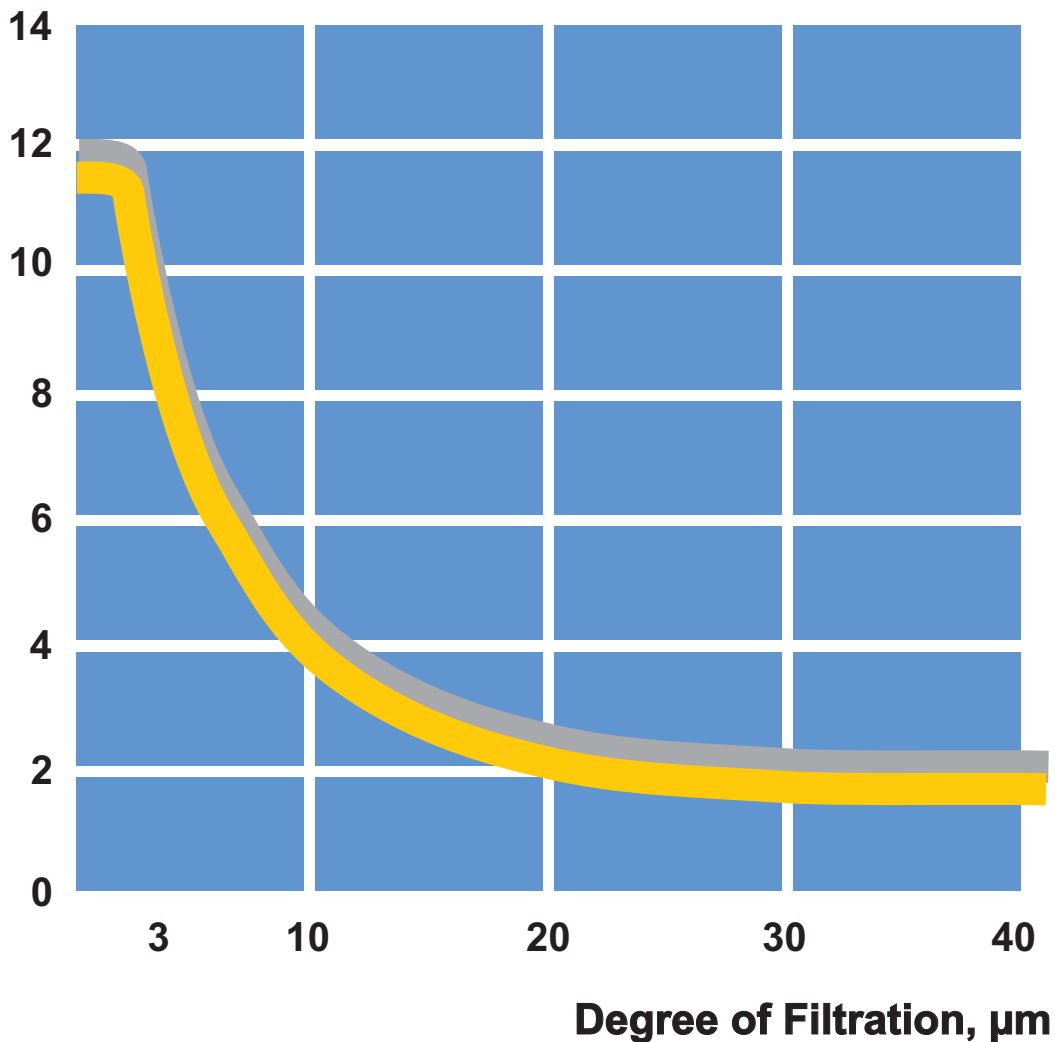
- **Clean Oil**
- **Off-line oil filtration**
- **Benefits**
- **References**



The Importance of Small Particles

MacPherson Graph

Testing period, 10^6 revs

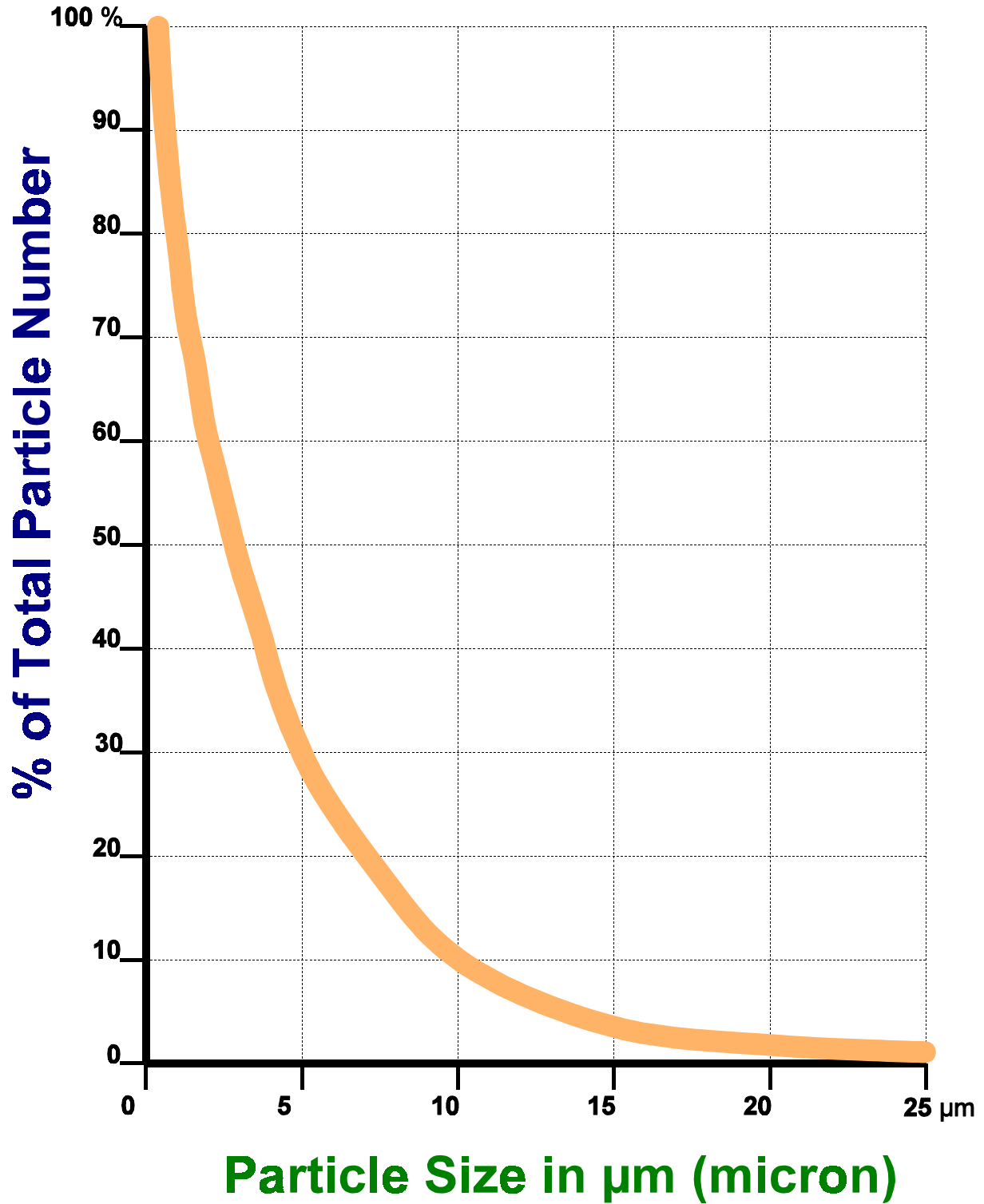


The MacPherson Graph is based on an accelerated test of 10 roller bearings
The lubricating oil was contaminated with dirt from gearboxes



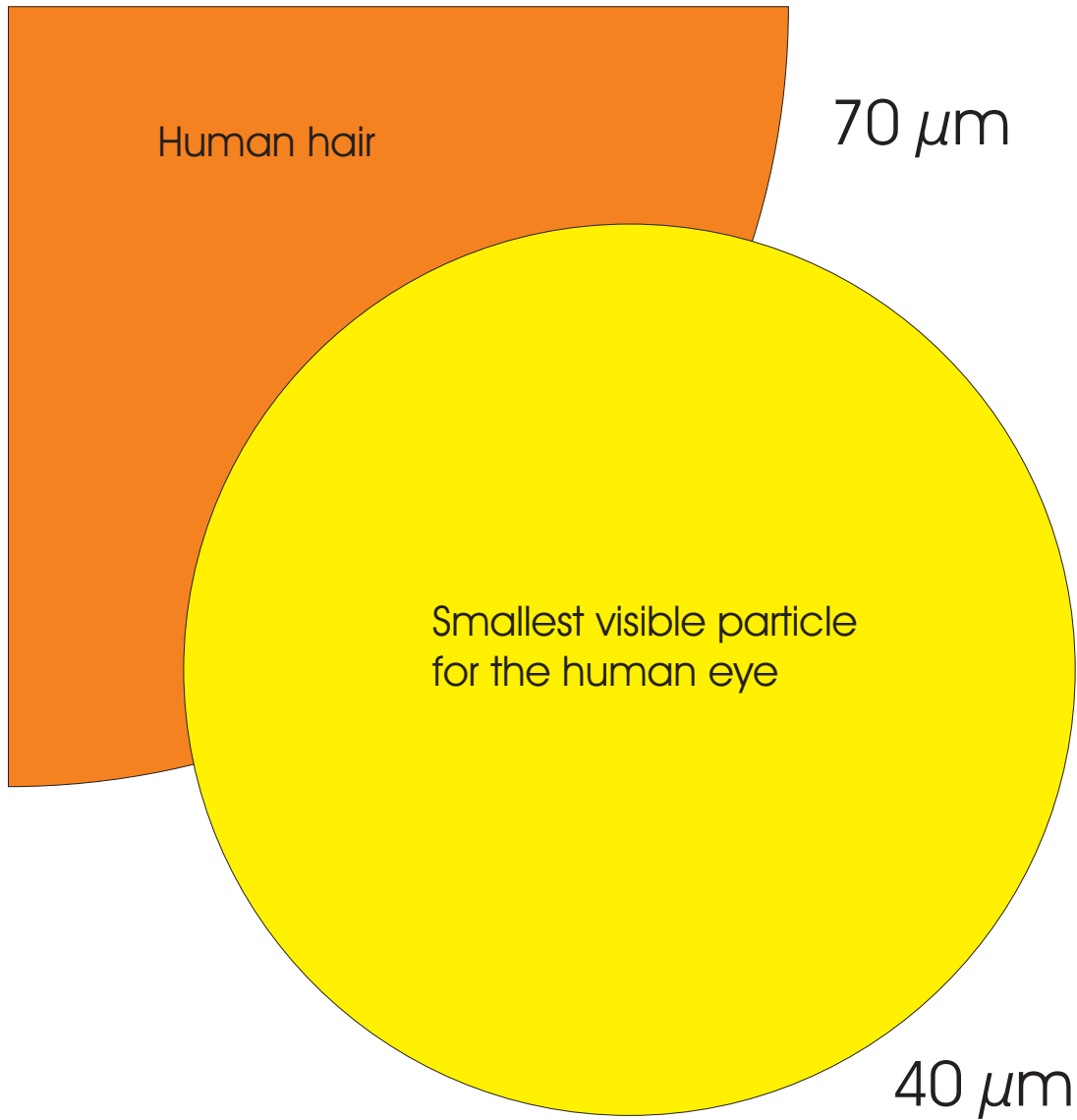
Particle Size Distribution

Observed average in medium charged system oils



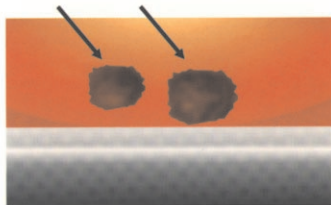


PARTICLE SIZES

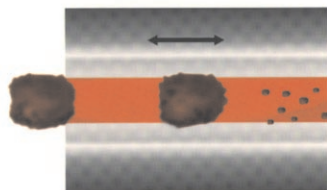
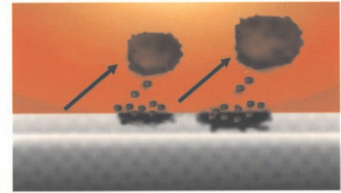
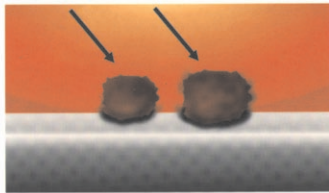




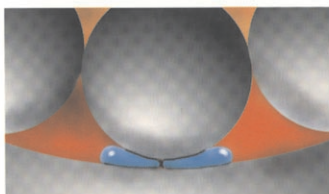
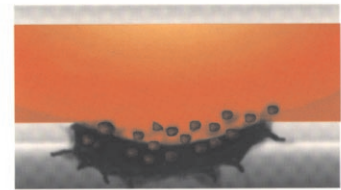
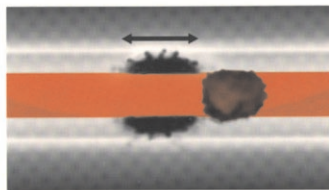
The most common sorts of
WEAR
caused by contamination



"Sand Blasting"



Grinding

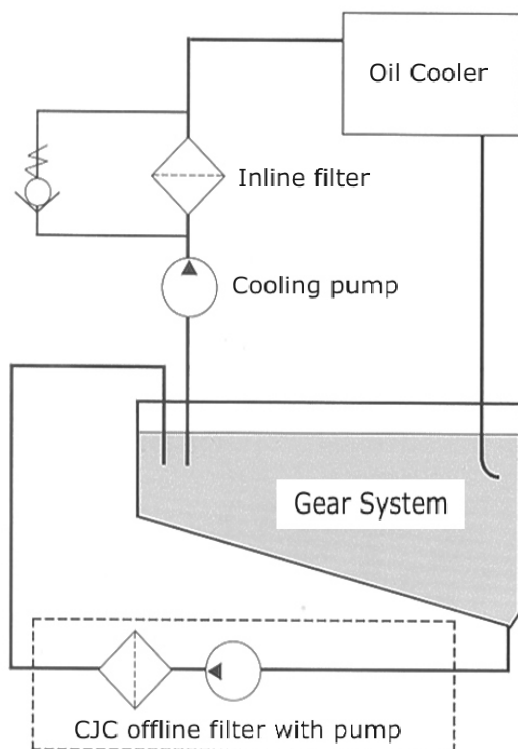


Formation of Rust





The Installation



HDU 15/25 PV





CJC Filter Element

Deep Filtration



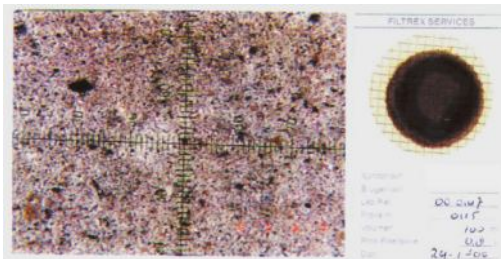
Cut-down in used CJC filter insert type
HDU 27/27



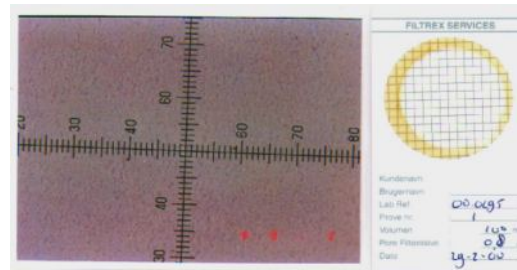
Wind Turbine Transmission Test

CJC Offline Oil filter

Application Wind Turbine - 600 kW
Oil type Tribol 1710/320
Oil volume 220 liters



Before Filtration



After Filtration

| Filtration time: | 0 hours | 48 hours | 1 month |
|--------------------------------|----------------|-----------------|----------------|
| Particles 2 μm | 1.443,178 | 29.975 | 6.774 |
| Particles 5 μm | 298.681 | 14.652 | 2.204 |
| Particles 15 μm | 17.893 | 1.549 | 356 |
| ISO 4406 Code | 21/19/15 | 15/14/11 | 13/12/9 |
| Water content | 1.240 | 109 | 76 |
| Colour of membrane filter disc | black | light | white |



Life Extension Method (LEM) - Rolling Element Bearings

Life Extension Factor (LEF)

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--------------|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| 26/23 | 22/19 | 20/17 | 18/15 | 17/14 | 16/13 | 15/12 | 15/12 | 14/11 | 14/11 |
| 25/22 | 21/18 | 19/16 | 17/14 | 16/13 | 15/12 | 14/11 | 14/11 | 13/10 | 13/10 |
| 24/21 | 20/17 | 18/15 | 17/14 | 16/13 | 15/12 | 14/11 | 13/10 | 13/10 | 12/9 |
| 23/20 | 19/16 | 17/14 | 15/12 | 14/11 | 13/10 | 13/10 | 12/9 | 11/8 | 11/8 |
| 22/19 | 18/15 | 16/13 | 14/11 | 13/10 | 12/9 | 11/8 | 11/8 | | |
| 21/18 | 17/14 | 15/12 | 13/10 | 12/9 | 11/8 | 11/8 | | | |
| 20/17 | 16/13 | 14/11 | 13/10 | 11/8 | | | | | |
| 19/16 | 15/12 | 13/10 | 11/8 | | | | | | |
| 18/15 | 14/11 | 12/9 | | | | | | | |
| 17/14 | 13/10 | 11/8 | | | | | | | |
| 16/13 | 12/9 | | | | | | | | |
| 15/12 | 11/8 | | | | | | | | |
| 14/11 | 11/8 ¹ | | | | | | | | |
| 13/10 | 11/8 ² | | | | | | | | |
| 12/9 | 11/8 ³ | | | | | | | | |

Current Machine Cleanliness (ISO)

(1) Life Extension factor = 1,8

(2) Life Extension Factor = 1,5

(3) Life Extension Factor = 1,3

Source: Diagnostics, Inc.



Benefits

- **higher production security**
- **higher return on investment**
- **longer product life time**

Pay-back time

| | | |
|----------------------------------|------------|------------------|
| 900 kW turbine | kWh | 1.700.000 |
| Price kWh (DK) | \$ | 0.125 |
| Off-line filter installed | \$ | 2.000 |
| Pay-back time in Denmark | | 7 days |



Major Customers

Bonus Energy A/S

NEG Micon A/S

Vestas Wind Systems A/S

Bazan Turbines S.A.

Gemesa Eólica

- more than 3.000 filters delivered in 2000/01