T-shore Education

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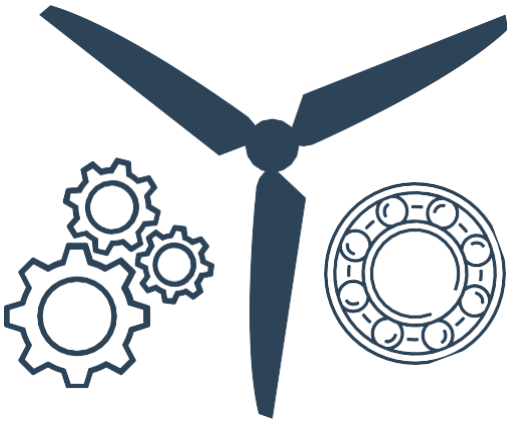
Theory Exercises

Module:
Gearbox and Bearing Maintenance
Learning scenario:
Gearbox inspection



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Document Author Partners: Fagskolen Rogaland, Energy Innovation, Dalane college

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Noorderpoort		World Class Maintenance	
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0.2	26.05.2025	Document Update

Table 1. Participant overview

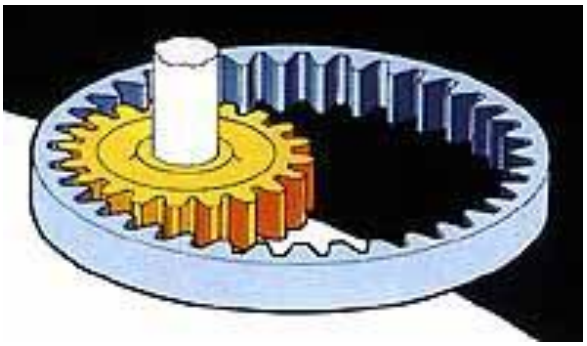
Name and surname	
Evaluation exercise 1	
Evaluation exercise 2	
Evaluation exercise 3	

1 Theory

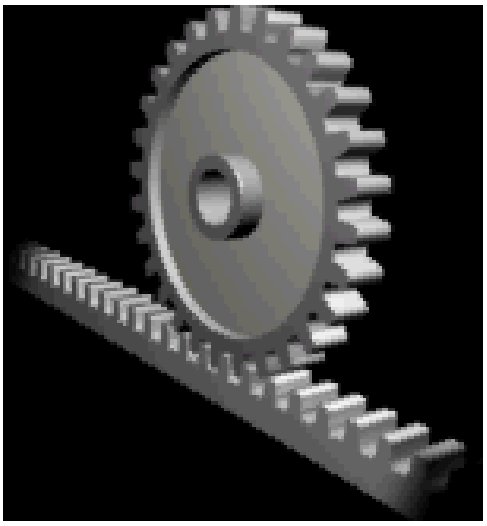
1.1 Exercise 1: Gear types

Description: Match the correct names to the pictures of various types of gears.

Answer: _____



Answer: _____



Answer: _____

Answer: _____

Answer: _____

Answer: _____

Answer: _____

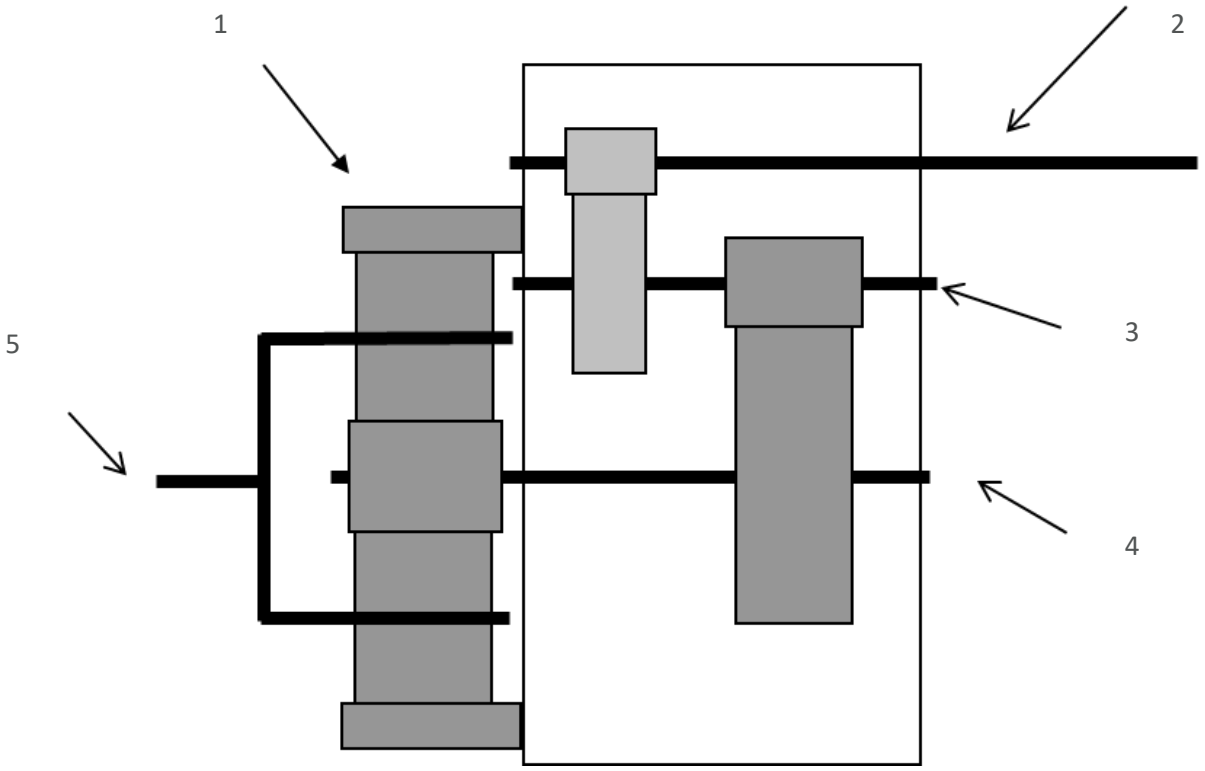
Answer: _____

Answer: _____

1.2 Exercise 2: Gear types

Description: Name the correct parts of the gearbox structure.

1. Name of shafts



Answer 1:_____

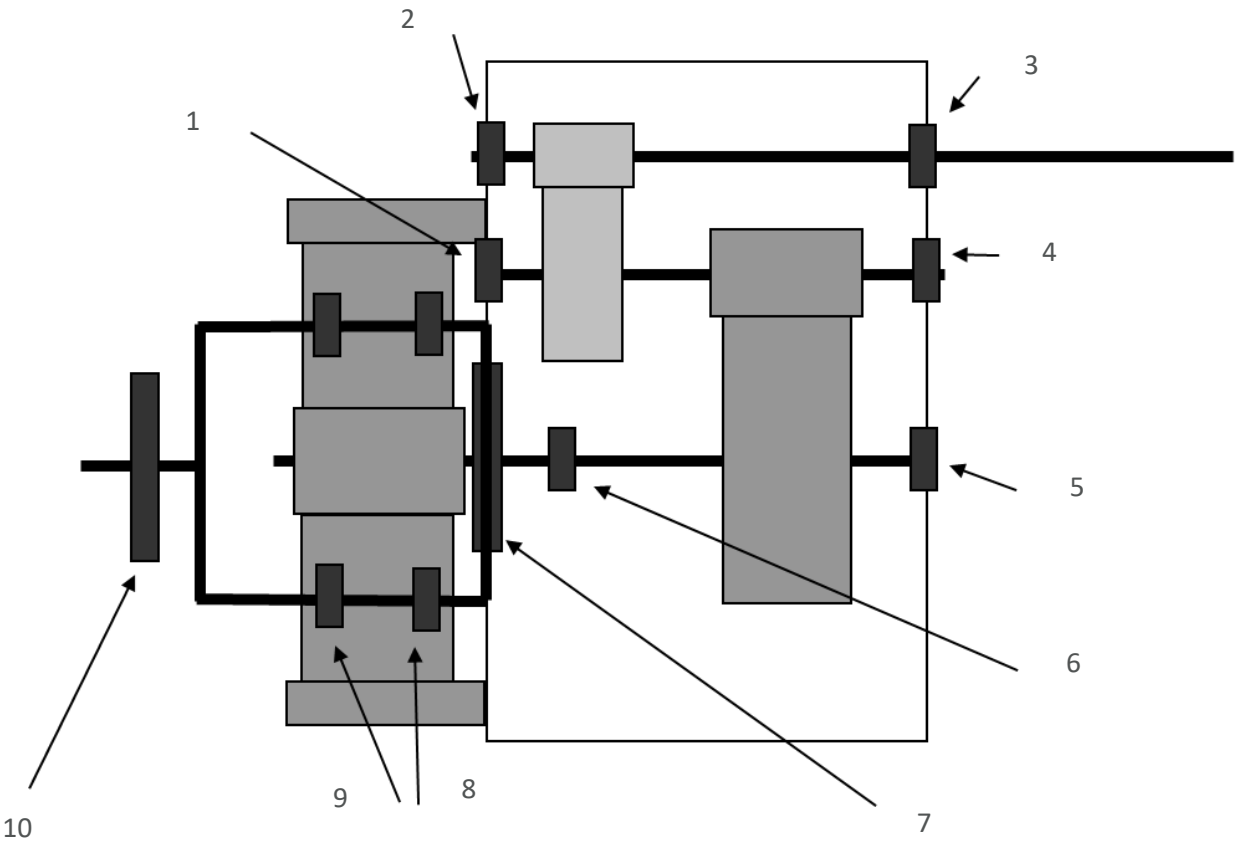
Answer 2:_____

Answer 3:_____

Answer 4:_____

Answer 5:_____

2. Name of bearings



Answer 1:_____

Answer 2:_____

Answer 3:_____

Answer 4:_____

Answer 5:_____

Answer 6:_____

Answer 7:_____

Answer 8:_____

Answer 9:_____

Answer10: _____

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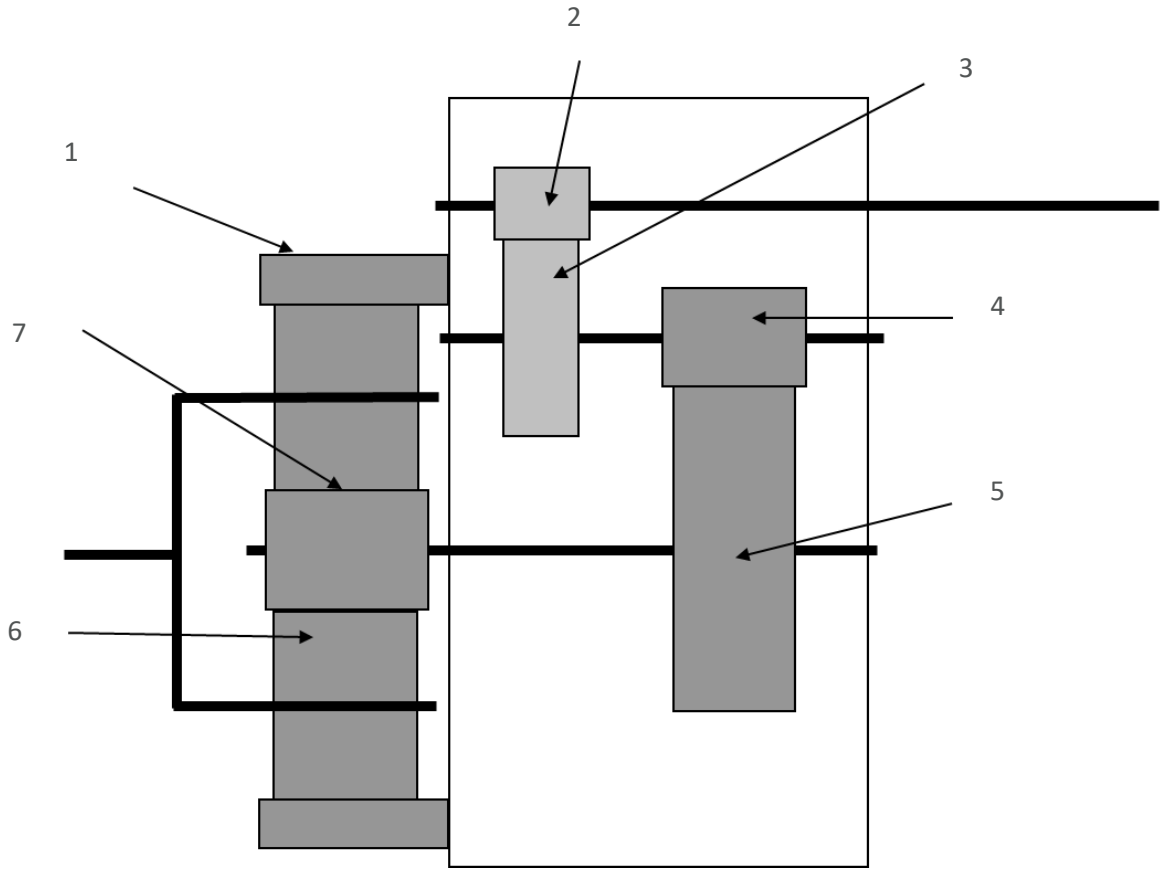
3. Name of Gears



Answer 1:_____

Answer 2:_____

Answer 3:_____

Answer 4:_____

Answer 5:_____

Answer 6:_____

Answer 7:_____

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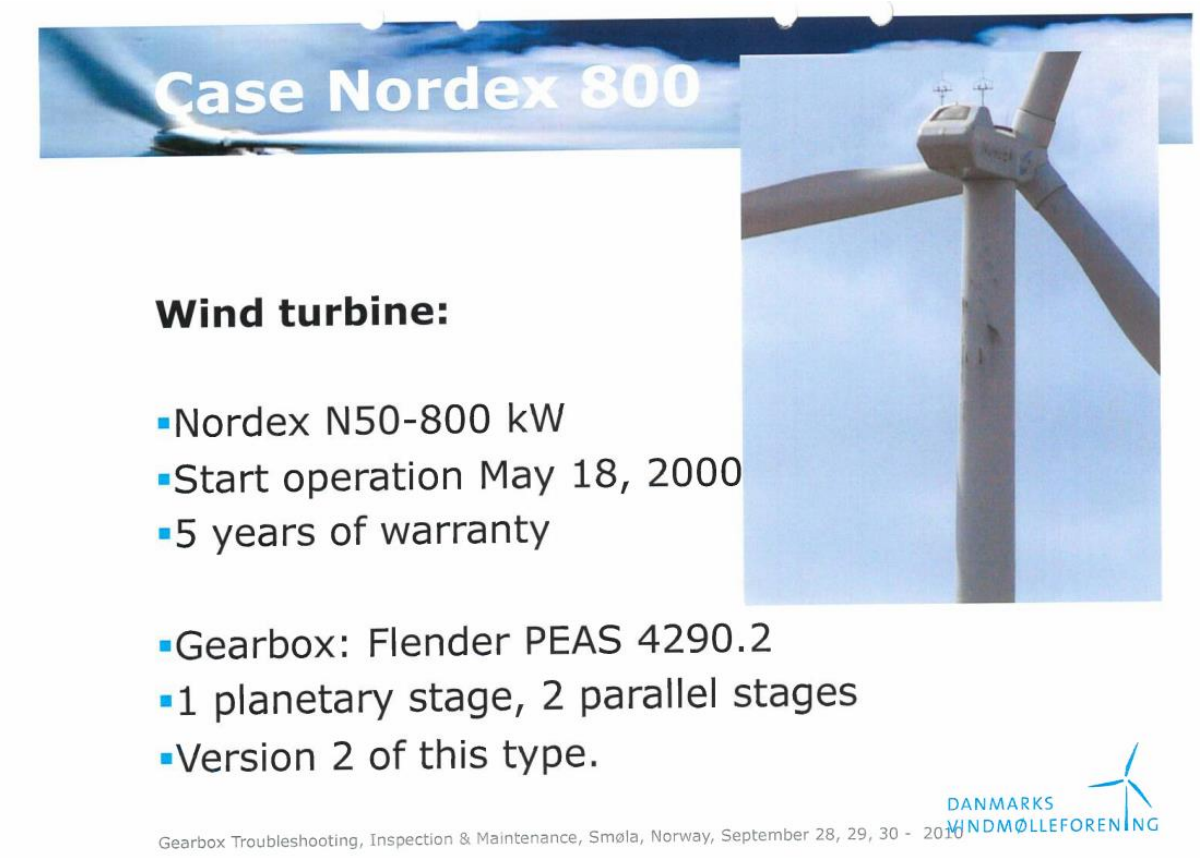
1.3 Exercise 3: Case study

Description: Familiarise yourself with the materials related to Case Study 1 and Case Study 2 concerning gearbox repairs and inspections. Present your opinion and thoughts in a few sentences.

1.3.1 Case study 1.



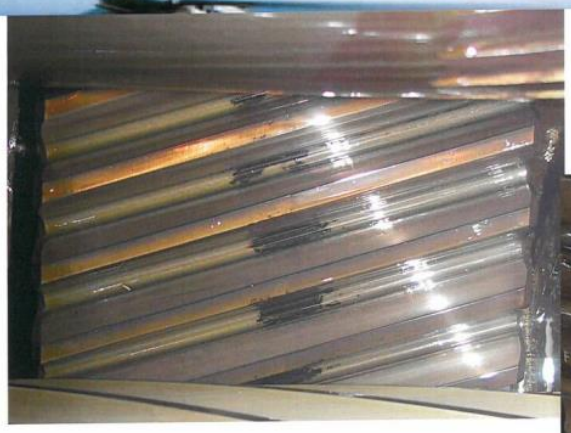
Case Nordex 800

Inspection 1

- Inspection on August 20, 2003 (after 3¼ years operation)
- Visual inspection of gearbox through inspection cover.
- Nordex control system:
- The hand terminal in the nacelle does not always function.
- When it does not function, the brake cannot be released and the gears can only be inspected in one position.

DANMARKS VINDMØLLEFORENING

Case Nordex 800



LSIMS Wheel
Normal running in wear

HSIMS pinion
Indentation marks and scuffing
from particles

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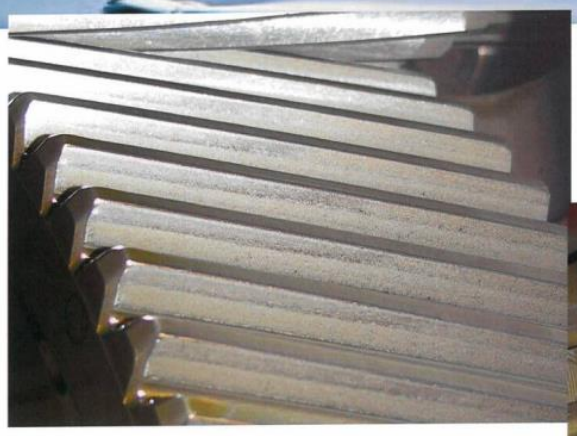
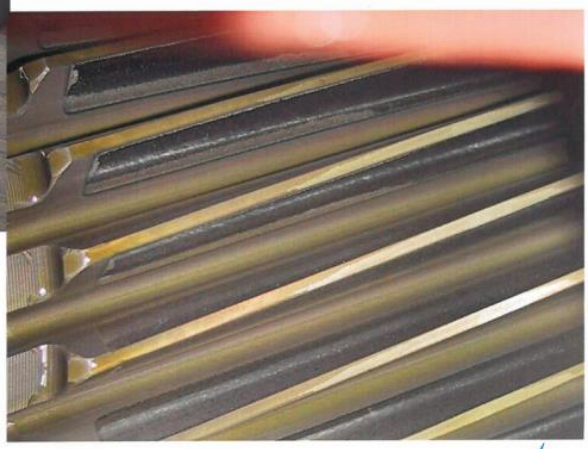
Case Nordex 800



HS IMS Wheel
Micro pitting
Two coloured appearance



HS pinion
Micro pitting on the inner half.

Gearbox Troubleshooting, Inspection & Maintenance, Smøla, Norway, September 28, 29, 30 - 2010

DANMARKS VINDMØLLEFORENING

Case Nordex 800

Inspection 1

What can be concluded from this inspection ?

- Wear occurs in the gearbox on the wheel on IMS and the HSS pinion.
- Claim to the manufacturer.
- Inspect the gearbox before end of warranty.

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DANMARKS VINDMØLLEFORENING

Case Nordex 800

Inspection 2

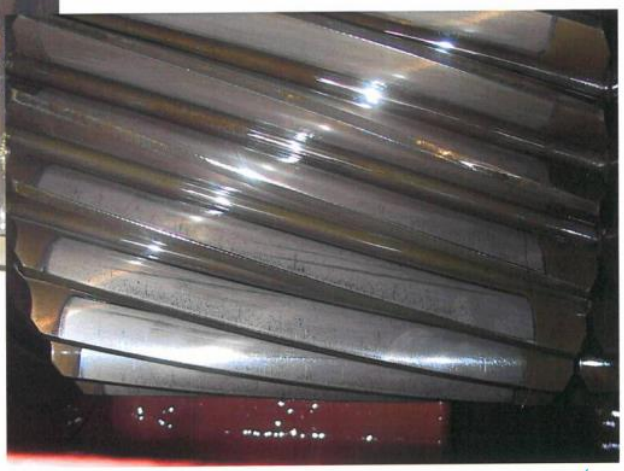
Inspection on April 5, 2005 before end of warranty

- Visual inspection of gearbox through inspection cover.
- Nordex control system:
- The hand terminal in the nacelle does not always function.
- When it does not function, the brake cannot be released
- and the gears can only be inspected in one position.

DANMARKS VINDMØLLEFORENING

Case Nordex 800

LS IMS Wheel
Normal running in wear



HS IMS pinion
Stand still marks
Indentation marks and scuffing
from particles

DANMARKS VINDMØLLEFORENING

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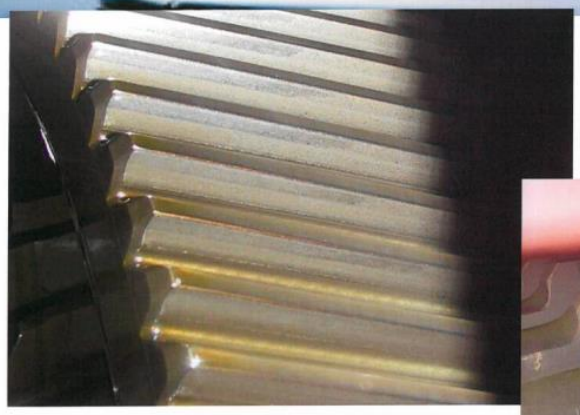
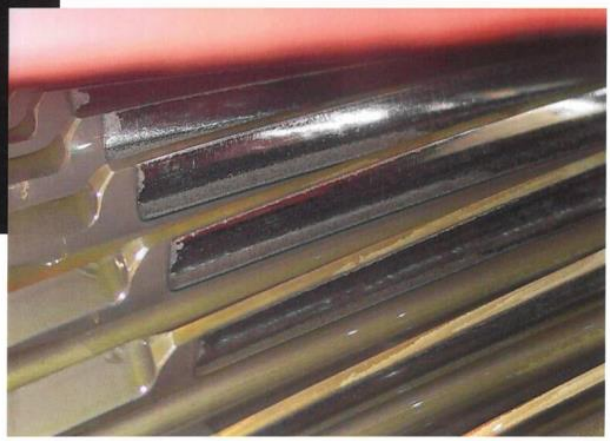
Case Nordex 800



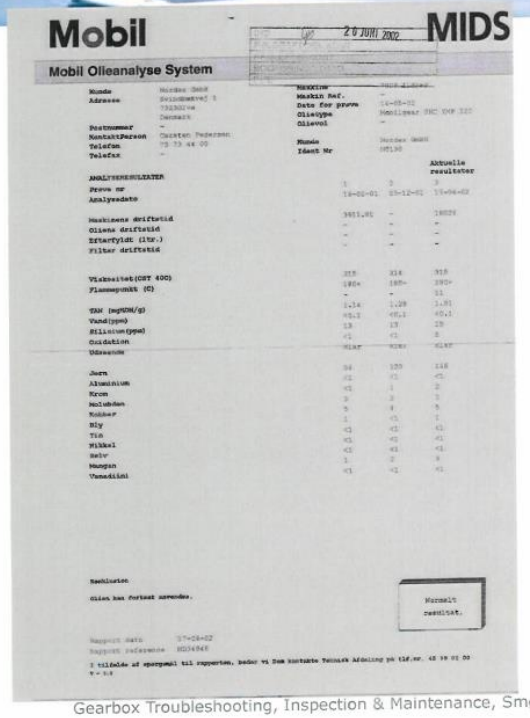
HS IMS Wheel
Micro pitting
Two coloured appearance



HS pinion
Micro pitting on the inner half.

DANMARKS VINDMØLLEFORENING

Case Nordex 800


Mobil MIDS
Mobil Oileanalyse System

Oil analyses from 2001 and 2002

Sample no.	1	2	3
Date of analysis	16-02-2001	03-12-2001	17-04-2002
Fe ppm	54	120	146

DANMARKS VINDMØLLEFORENING

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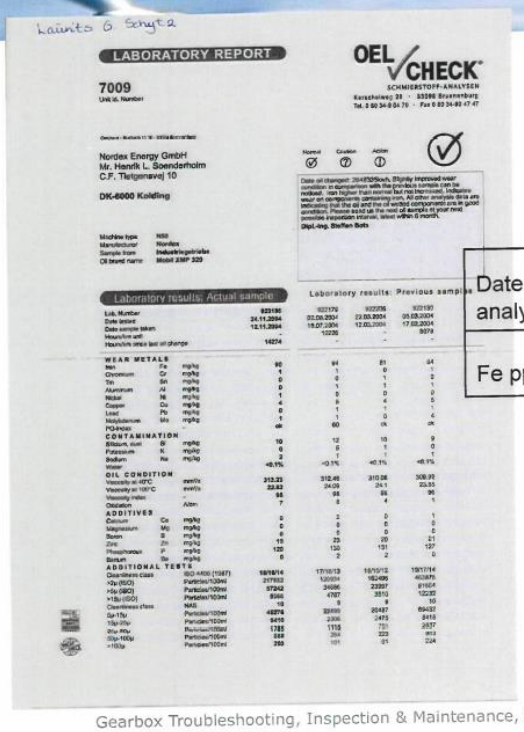
Case Nordex 800


LABORATORY REPORT

OEL CHECK
SCHMIERSTOFF-ANALYSEN

7009

Nordex Energy GmbH
Mr. Henrik L. Soendergholm
C.F. Tietgensvej 10

DK-6000 Kolding

Laboratory results: Actual sample

Laboratory results: Previous sample

Oil analyses from 2004

Date of analysis	05-03-2004	22-03-2004	02-08-2004	24-11-2004
Fe ppm	84	81	94	90

Off-line filter is mounted on February 27, 2004

The logbook did not have any notes on oil changes

DANMARKS VINDMØLLEFORENING

Case Nordex 800

Inspection 2

What can be concluded from this inspection and the oil analyses ?

- Unacceptable wear occurs in the gearbox.
- Claim to the manufacturer: The gearbox shall be replaced on the warranty.
- But…..
- Nordex evaluates that the wear is not above normal level and that the wear rate is not increasing. The oil samples from Oelcheck proves this….
- Nordex will not replace the gearbox on the warranty.

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After Inspection 2

- The owner started a legal proceeding against Nordex.
- A technical experts was found to evaluate the questions about the Gearbox:
- Was the condition of the gearbox at the time of end of warranty in a state that could be expected after 5 years of operation ?
- If not, what is the reason ?

Inspection 3

Inspection on May 2, 2007 by the expert

- Nordex staff dismantled the top of the gearbox.
- Nordex staff used a hand pump to loosen the brake.
- Visual inspection of gearbox. Endoscope available.

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Case Nordex 800

HS IMS pinion
Marks from two running positions

HS IMS pinion
Marks from two running positions

DANMARKS VINDMØLLEFORENING

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Case Nordex 800

Particles found in the bottom of the gearbox with a magnet.

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Case Nordex 800

Roller cage with heavy damage.
Collar on NJ-bearing broken off.

Gearbox Troubleshooting, Inspection & Maintenance, Smøla, Norway, September 28, 29,

Case Nordex 800

Inspection 3

What can be concluded from this inspection ?

- The wheel is loose on IMS.
- The wheel has probably been loose since installation. This is the cause of the two-coloured appearance micro pitting and the high iron content.
- The collar on the NJ-bearing on IMS has broken off.
- When the wheel is loose the axial forces on the teeth will force the wheel towards the rotor-end bearing giving extra load on the collar.

DANMARKS VINDMØLLEFORENING

Gearbox Troubleshooting, Inspection & Maintenance, Smøla, Norway, September 28, 29, 30 - 2010

Case Nordex 800

Inspection 4

In workshop after disassembly

HS IMS wheel.
Fretting corrosion on the bore surface +0,2 mm

DANMARKS VINDMØLLEFORENING

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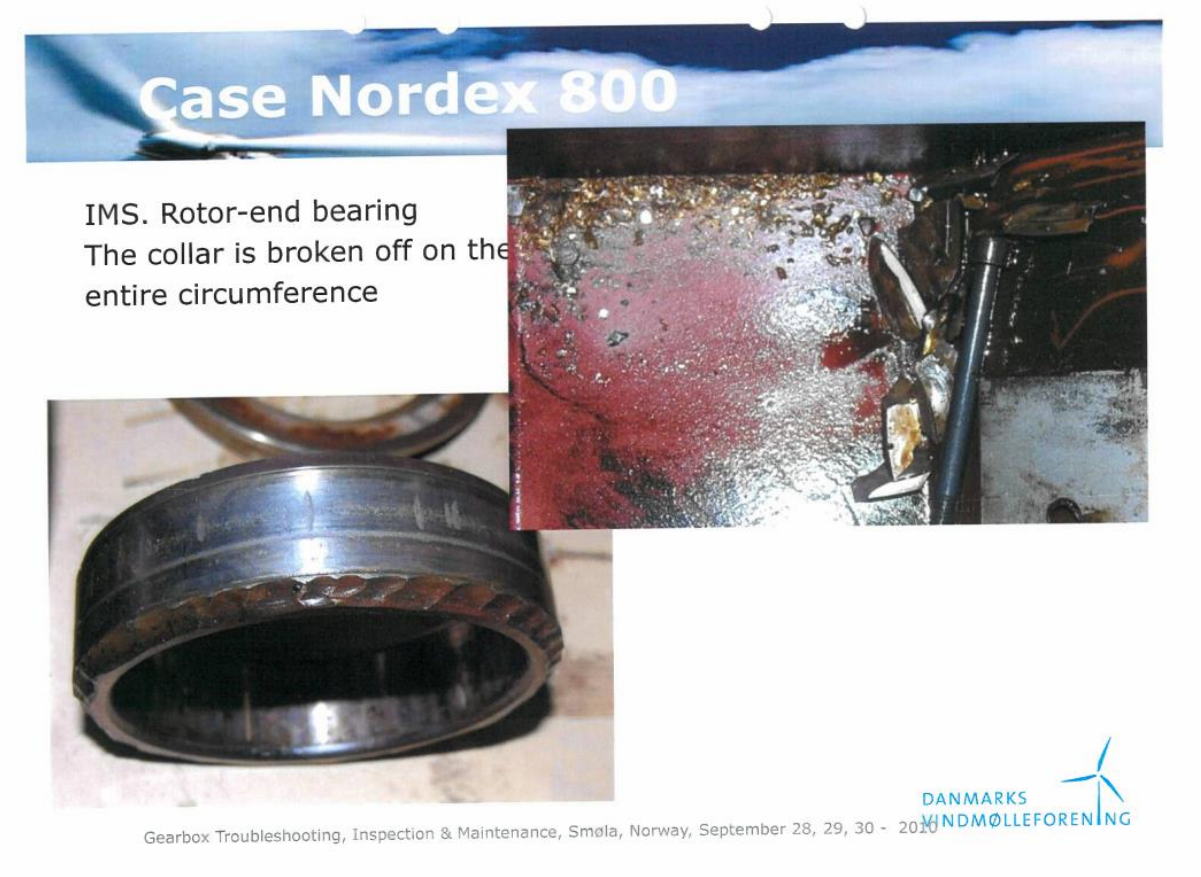
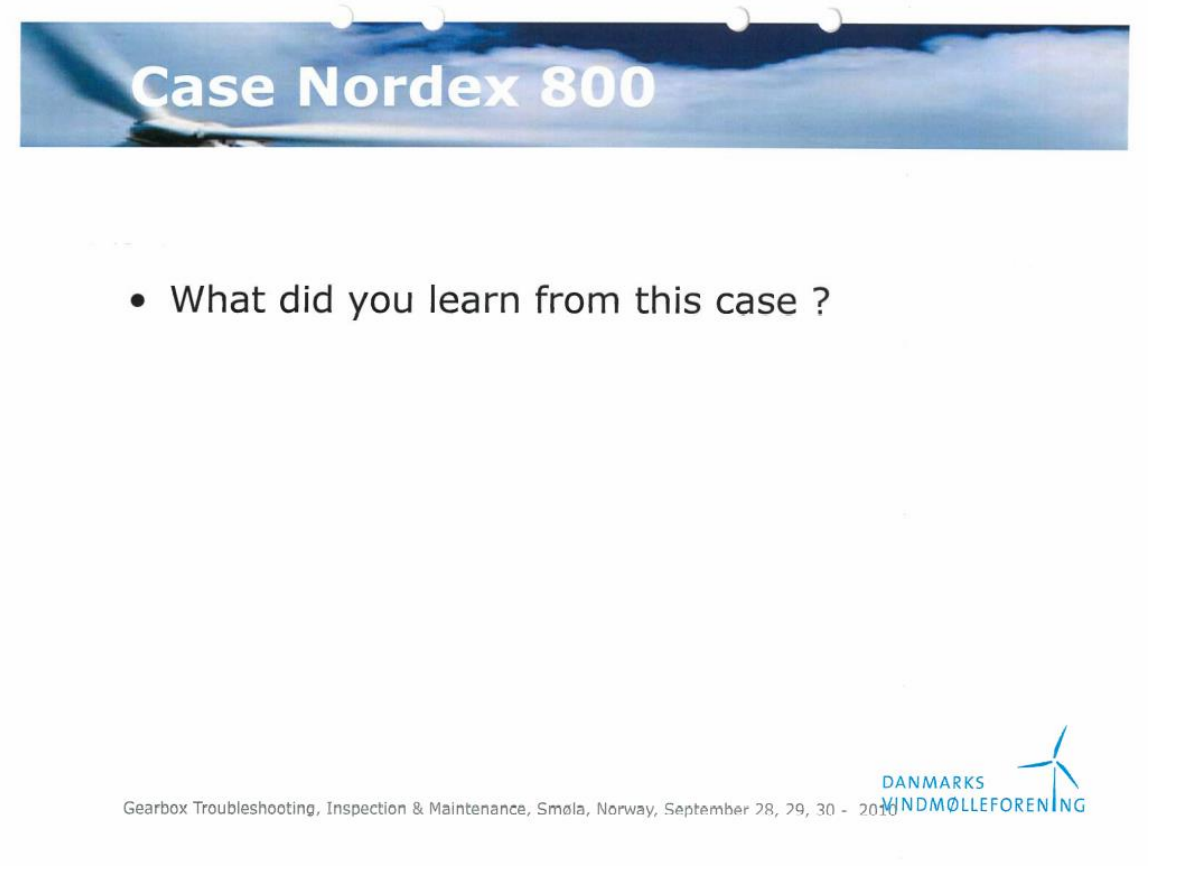
Case Nordex 800

HS IMS.
Fretting corrosion on the surface

DANMARKS VINDMØLLEFORENING

Gearbox Troubleshooting, Inspection & Maintenance, Smøla, Norway, September 28, 29, 30 - 2010


Case Nordex 800
IMS. Rotor-end bearing
The collar is broken off on the
entire circumference
Gearbox Troubleshooting, Inspection & Maintenance, Smøla, Norway, September 28, 29, 30 - 2010
DANMARKS VINDMØLLEFORENING


Case Nordex 800
• What did you learn from this case ?
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DANMARKS VINDMØLLEFORENING

Case study 2.

Case Nordex 1300

- Nordex N60-1300 kW
- Gearbox: Eickhoff CPNHZ-190 G 043780X
- Gearbox is damaged and replaced
- Gearbox is taken apart in Eickhoffs workshop
- Inspection by owners representative and insurance company

Case Nordex 1300

HS IMS wheel
Scuffing in bore.

The wheel is pressed on the shaft, and no key is used.

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Case Nordex 1300
HS IMS Pinion.
Damage on 2 teeth.
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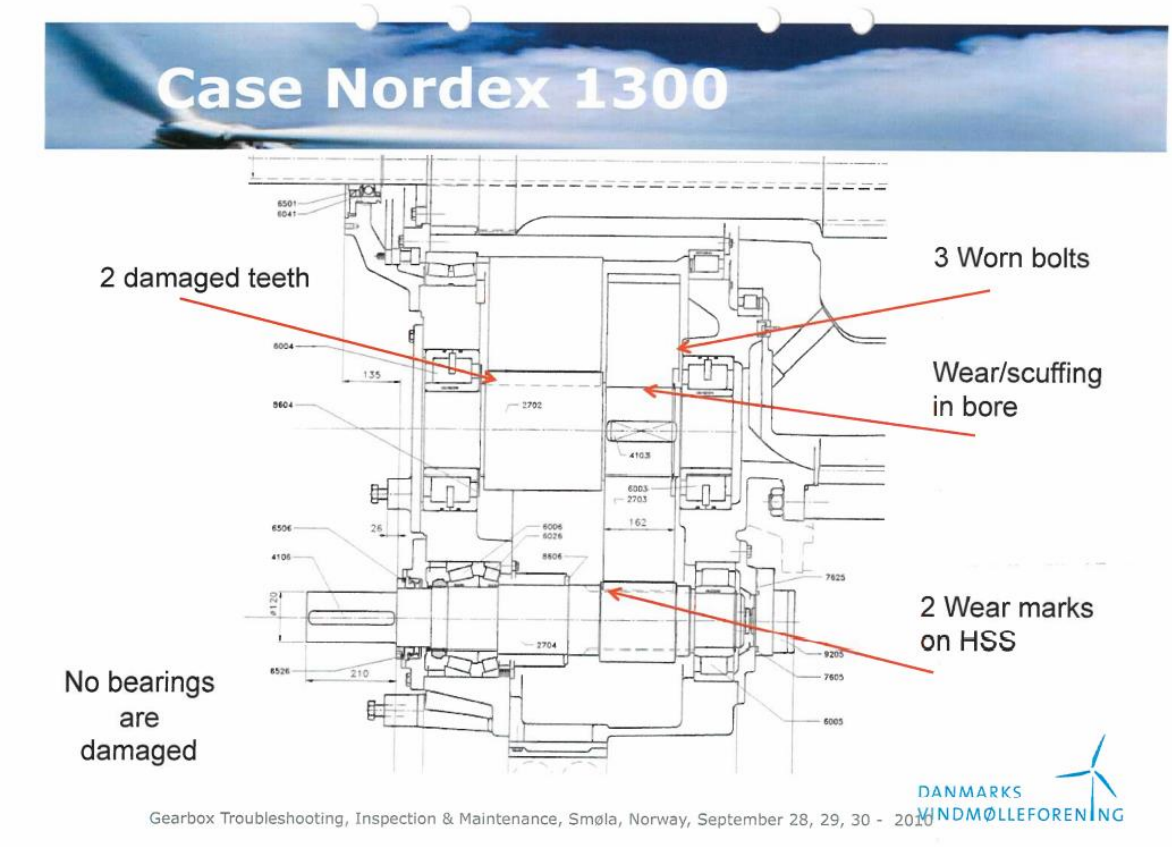
Case Nordex 1300
HS IMS wheel has worn 3 bolt heads ~10 mm.
DANMARKS VINDMØLLEFORENING
Gearbox Troubleshooting, Inspection & Maintenance, Smøla, Norway, September 28, 29, 30 - 2010


Case Nordex 1300
High speed pinion
DANMARKS VINDMØLLEFORENING
Gearbox Troubleshooting, Inspection & Maintenance, Smøla, Norway, September 28, 29, 30 - 2010


Case Nordex 1300
2 damaged teeth
3 Worn bolts
Wear/scuffing in bore
2 Wear marks on HSS
No bearings are damaged
DANMARKS VINDMØLLEFORENING
Gearbox Troubleshooting, Inspection & Maintenance, Smøla, Norway, September 28, 29, 30 - 2010

Insurance company claims:

- The wheel has been loose on the shaft
- The bearings on the LSIMS are not damaged
- The bolt are worn 10 mm, so the wheel have moved on the shaft several times
- The damage on the 2 teeth is started with pitting and the material has cracked off due to this pitting
- The damaged is not covered by insurance

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DANMARKS VINDMØLLEFORENING

Owners representative claims:

- The wheel has moved on the shaft only once. After that the damage in the bore show that the 2 parts are grated together
- The missing material has scaled off first, and then the pitting is formed. One extreme load has deformed the teeth and started cracks
- The extreme load has deformed the casing, which explains the 10 mm wear on the bolt heads
- The marks on the HSS proofs only one move of the wheel
- The insurance company covered the damage

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DANMARKS VINDMØLLEFORENING

- What did you learn from this case ?

Answer for both Case study 1 and Case study 2: _____

_____

_____

_____

_____

_____

_____

_____

_____

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_____

_____

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The T-shore project is funded through the the Erasmus+ Centres of Vocational Excellence (CoVEs) call 2021

Acknowledgements

We would like to extend our sincere thanks to all the project partners for their invaluable contributions to this report and their dedicated work on the T-shore project.
Our deepest appreciation also goes to all T-shore stakeholders, particularly the members of the regional Centres of Vocational Excellence (CoVEs), whose ongoing efforts are instrumental in driving the success of this initiative.

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