

Error statistics for the gearbox in drive trains of WEC

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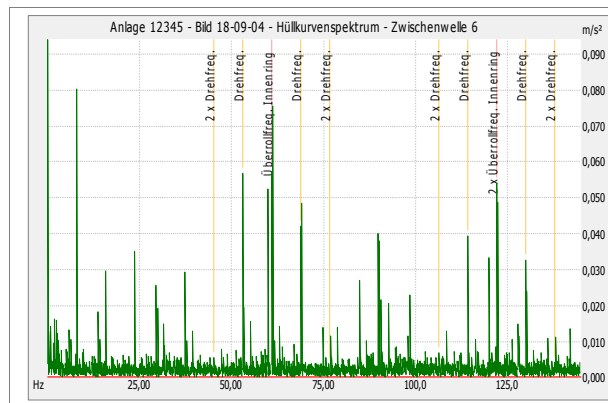
Since 2004, the experts of the 8.2-group (www.8p2.de) executed more than 170 visual inspections of gearboxes by video endoscope and more than 190 analyses of drive trains of megawatt turbines by offline vibration measurement. Out of those 80 turbines were examined combining both methods at the same time. So the results of the vibration measurements were evaluated / verified by the endoscope inspection and vice versa, what makes the 8.2 technology one of the most reliable in this field. So the customer receives reliable information of the condition of the gearbox. The combination of both, the visual and the acoustic method give the best impression of the condition and a base for further decisions of maintenance.

The lecture will give an overview of the so far received results and will show detailed pictures and graphics of 3 to 5 exemplary cases to compare and comment both detection methods.

Results video endoscope:



Results vibration analysis:



Statistic analysis of the examined gearboxes show following incidence of loss at gearboxes:

Manufacturer gearbox	Type of gearbox	Number of examined boxes	Videoendoscope	Bearing damages planetary stage	Gear damages planetary stage	Bearing damages spur stage	Gear damages spur stage	Vibration analysis	Bearing damages planetary stage	Gear damages planetary stage	Bearing damages spur stage	Gear damages spur stage	Miscellaneous
A	AA	N1	N11	...%	...%	...%	...%	N21	...%	...%	...%	...%	...%
	AB	N2	N12	...%	...%	...%	...%	N22	...%	...%	...%	...%	...%
B	BA	N3	N13	...%	...%	...%	...%	N23	...%	...%	...%	...%	...%
	BB	N4	N14	...%	...%	...%	...%	N24	...%	...%	...%	...%	...%
...	...	NX	N1X	...%	...%	...%	...%	N2X	...%	...%	...%	...%	...%
Σ			170	...%	...%	...%	...%	190	...%	...%	...%	...%	...%

Remarks: For matters of secrecy the gearboxes are not named by type and manufacturer. The actual results will be available in the lecture.

Error statistics for the gearbox in drive trains of WEC

by Jürgen Holzmüller, 8.2 Office Aurich

8.2-Group



Technical experts
at present 11 offices
since 1995
more than 8.000
technical inspections
independent technical
expertises



Reliability

Cost efficiency

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www.8p2.de

Method of inspection



Inspection of
gearboxes
through available
inspection apertures

Methode of inspection



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Listening of
drive train
with electronic
stethoscope

Methode of inspection



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Vibration analysis
of drive drain

Offline-Measurement
8-channel
additional rpm-signal

Method of inspection



Videoendoscopy of Gearbox

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Reasons for inspection



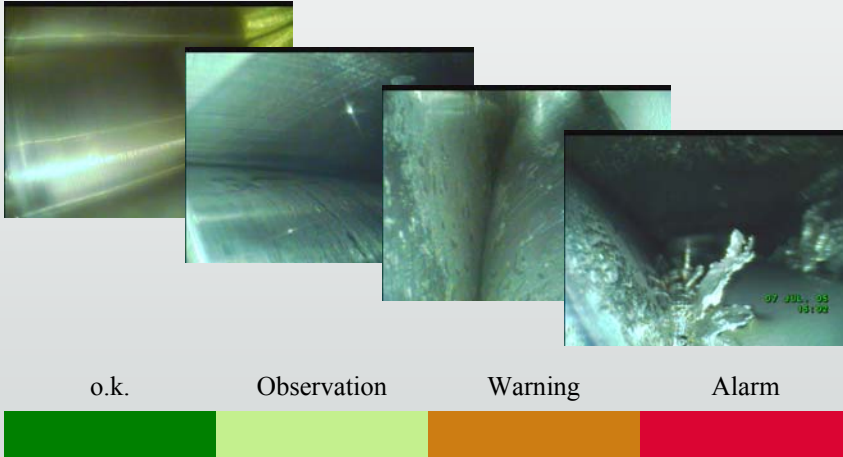
Technical inspections before
end of guarantee
Technical inspections to
detect actual condition
Damage expertise
Expertise for court cases
Value assessment

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Categories of damage



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Data base



Data Base of the following summary tables:

- 417 reports
- $P \geq 1.000 \text{ kW}$
- 3-stage gear boxes
(1 planetary / 2 spur gear)
- since 1998

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Summary table I

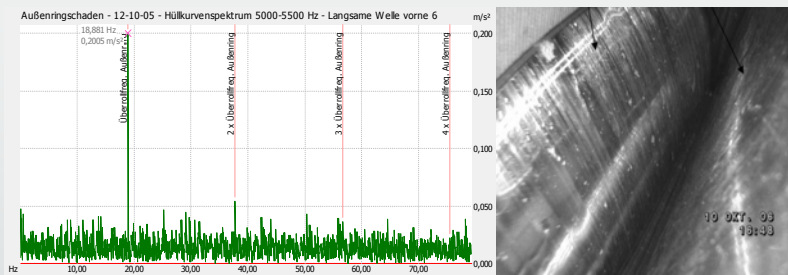
Inspection method category	Visual inspection & Stethos.				Endoscopy				Vibration analysis			
	Obs.	Warn.	Alarm	Σ	Obs.	Warn.	Alarm	Σ	Obs.	Warn.	Alarm	Σ
Gearbox generally	9%	5%	0%	14%	1%	1%	3%	5%	1%	0%	0%	1%
Planetary stage	1%	0%	0%	1%					6%	3%	0%	9%
Plan. stage bearing					31%	9%	7%	47%	6%	2%	1%	9%
Plan. stage teeth					28%	21%	11%	60%	32%	14%	1%	47%
LSS bearing	1%	0%	0%	1%	33%	8%	5%	46%	5%	1%	1%	7%
LSS teeth	25%	3%	0%	28%	23%	7%	3%	33%	6%	1%	0%	7%
MSS bearing	0%	0%	0%	0%	22%	7%	4%	33%	20%	7%	2%	29%
MSS teeth	21%	3%	0%	24%	27%	8%	4%	39%	16%	1%	0%	17%
HSS bearing	8%	7%	0%	15%	38%	9%	13%	60%	30%	12%	8%	50%
HSS teeth	29%	3%	0%	32%	22%	3%	4%	29%	23%	5%	1%	29%

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Exemplary Case 1: bearing damage



Damage of outer ring / LSS

Visual inspection & Stethoscope: no indication of damage ■

Videoendoscopy: damage of category 'Warning' ■

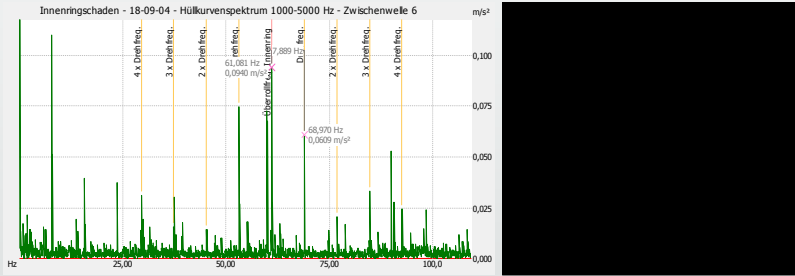
vibration analysis : damage of category 'Warning' ■

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Exemplary Case 2: bearing damage



Damage of inner ring / bearing MSS

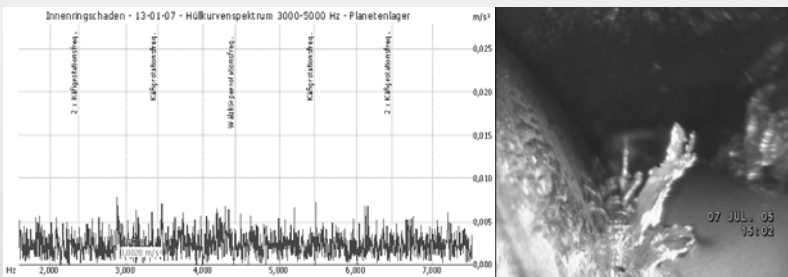
Visual inspection & Stethoscope:	no indication of damage	■
Videoendoscopy:	no access to the bearing	■
vibration analysis :	damage of category ‚Warning‘	■

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Exemplary Case 3: bearing damage



Damage at planetary wheel

Visual inspection & Stethoscope:	no access to the bearing	■
Videoendoscopy:	damage of category ‚Alarm‘	■
vibration analysis:	no indication of damage	■

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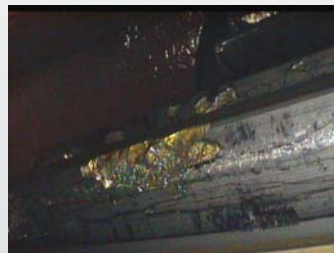
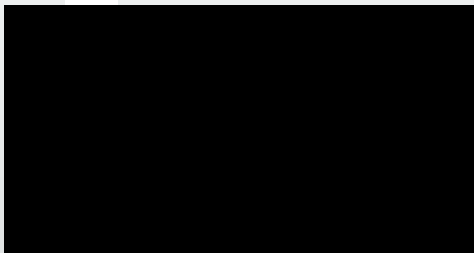
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Summary table I

Inspection method category	Visual inspection & Stethos.				Endoscopy				Vibration analysis			
	Obs.	Warn.	Alarm	Σ	Obs.	Warn.	Alarm	Σ	Obs.	Warn.	Alarm	Σ
Gearbox generally	9%	5%	0%	14%	1%	1%	3%	5%	1%	0%	0%	1%
Planetary stage	1%	0%	0%	1%					6%	3%	0%	9%
Plan. stage bearing					31%	9%	7%	47%	6%	2%	1%	9%
Plan. stage teeth					28%	21%	11%	60%	32%	14%	1%	47%
LSS bearing	1%	0%	0%	1%	33%	8%	5%	46%	5%	1%	1%	7%
LSS teeth	25%	3%	0%	28%	23%	7%	3%	33%	6%	1%	0%	7%
MSS bearing	0%	0%	0%	0%	22%	7%	4%	33%	20%	7%	2%	29%
MSS teeth	21%	3%	0%	24%	27%	8%	4%	39%	16%	1%	0%	17%
HSS bearing	8%	7%	0%	15%	38%	9%	13%	60%	30%	12%	8%	50%
HSS teeth	29%	3%	0%	32%	22%	3%	4%	29%	23%	5%	1%	29%

Exemplary Case 4: gear damage

**Damage at gear planet wheel**

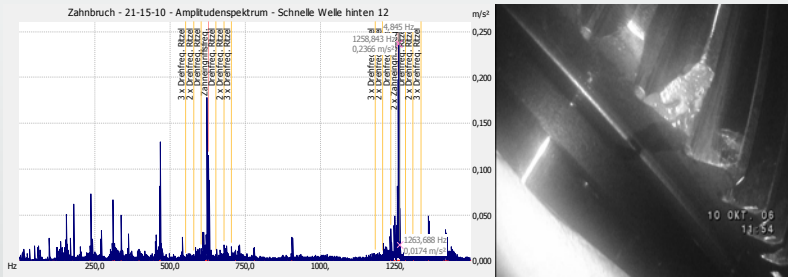
Visual inspection & Stethoscope: no access

Videoendoscopy: damage of category „Alarm“

vibration analysis : not ordered



Exemplary Case 5: gear damage



Damage at gear / HSS

Visual inspection & Stethoscope: damage of category 'Warning' ■
 Videoendoscopy: damage of category 'Warning' ■
 vibration analysis: no indication of damage ■

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Summary table II

Manu- facturer of gearbox	Type of gearbox	Bearing planetary carrier	Bearing planetary wheel	Teeth ring gear	Teeth planet & sun wheel	Bearing spur stage LSS	Bearing spur stage MSS	Bearing spur stage HSS	Teeth spur stage
A	I	0%	0%	0%	20%	0%	0%	0%	0%
A	II	0%	9%	21%	17%	14%	4%	33%	17%
A	II*	0%	0%	0%	12%	0%	0%	0%	0%
B	III	0%	17%	14%	12%	6%	3%	21%	3%
B	III*	0%	0%	0%	21%	0%	9%	10%	0%
B	IV	0%	0%	0%	11%	43%	0%	0%	0%
C	V	11%	9%	0%	14%	0%	10%	67%	22%
D	VI	0%	0%	22%	11%	0%	0%	13%	28%
E	VII	0%	0%	5%	0%	0%	0%	19%	6%
E	VIII	0%	41%	12%	0%	0%	0%	26%	0%
F	IX	0%	0%	0%	15%	0%	0%	0%	0%
Ø		1,0%	6,9%	6,7%	12,1%	5,7%	2,4%	17,1%	6,9%

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Manufacturer of gearbox	Type of gearbox	Bearing planetary carrier	Bearing planetary wheel	Teeth ring gear	Teeth planet & sun wheel	Bearing spur stage LSS	Bearing spur stage MSS	Bearing spur stage HSS	Teeth spur stage
A	I	0%	0%	0%	20%	0%	0%	0%	0%
A	II	0%	9%	21%	17%	14%	4%	33%	17%
A	II*	0%	0%	0%	12%	0%	0%	0%	0%
B	III	0%	17%	14%	12%	6%	3%	21%	3%
B	III*	0%	0%	0%	21%	0%	9%	10%	0%
B	IV	0%	0%	0%	11%	43%	0%	0%	0%
C	V	11%	9%	0%	14%	0%	10%	67%	22%
D	VI	0%	0%	22%	11%	0%	0%	13%	28%
E	VII	0%	0%	5%	0%	0%	0%	19%	6%
E	VIII	0%	41%	12%	0%	0%	0%	26%	0%
F	IX	0%	0%	0%	15%	0%	0%	0%	0%
Ø		1,0%	6,9%	6,7%	12,1%	5,7%	2,4%	17,1%	6,9%

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A	I	0%	0%	0%	20%	0%	0%	0%	0%
A	II	0%	9%	21%	17%	14%	4%	33%	17%
A	II*	0%	0%	0%	12%	0%	0%	0%	0%
B	III	0%	17%	14%	12%	6%	3%	21%	3%
B	III*	0%	0%	0%	21%	0%	9%	10%	0%
B	IV	0%	0%	0%	11%	43%	0%	0%	0%
C	V	11%	9%	0%	14%	0%	10%	67%	22%
D	VI	0%	0%	22%	11%	0%	0%	13%	28%
E	VII	0%	0%	5%	0%	0%	0%	19%	6%
E	VIII	0%	41%	12%	0%	0%	0%	26%	0%
F	IX	0%	0%	0%	15%	0%	0%	0%	0%
Ø		1,0%	6,9%	6,7%	12,1%	5,7%	2,4%	17,1%	6,9%

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A	I	0%	0%	0%	20%	0%	0%	0%	0%
A	II	0%	9%	21%	17%	14%	4%	33%	17%
A	II*	0%	0%	0%	12%	0%	0%	0%	0%
B	III	0%	17%	14%	12%	6%	3%	21%	3%
B	III*	0%	0%	0%	21%	0%	9%	10%	0%
B	IV	0%	0%	0%	11%	43%	0%	0%	0%
C	V	11%	9%	0%	14%	0%	10%	67%	22%
D	VI	0%	0%	22%	11%	0%	0%	13%	28%
E	VII	0%	0%	5%	0%	0%	0%	19%	6%
E	VIII	0%	41%	12%	0%	0%	0%	26%	0%
F	IX	0%	0%	0%	15%	0%	0%	0%	0%
Ø		1,0%	6,9%	6,7%	12,1%	5,7%	2,4%	17,1%	6,9%

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Summary

- Results are depending on inspection method
- First indications of reliability increase can be observed
- Damage causes have to be investigated further
- Retrofits have to include improvements

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**Thank you
for your
attention**

