

GfM Gesellschaft für Maschinendiagnose mbH

# Explanations

## for the machine diagnosis report

These explanations describe the approach to the measurement, signal analysis and the creation of the report.

They are destined for the explanatory transfer to the customer.

### 1 Data collection

The data collection is carried out by employees of the GfM or by external purchasers, e.g. by maintenance staff. Therefore the eight channel data collection device PeakStore is used.

The vibration data are collected with a sampling rate of 50 kHz / channel (resolution = 16 bit, sample & hold, band with 22 kHz). Measurement times ca. 26.2 s, ca. 52.4 s ca. 188.7 s as well as a not defined measurement time are available. The original signal is stored. Simultaneously the speed is collected as a time signal with a sampling rate of 5 kHz.

For the data collection the vibration of the drive is collected from different measurement points in several groups by the use of 8 channels. At first eight accelerometers are placed by means of magnetic clamps at the drive, and the first measurement is activated. During the measurement the speed is controlled at the display of the PeakStore and it is checked if the effective value of velocity is in a plausible value range. The data are stored and if necessary a third measurement is executed in the same way with a changed accelerometer arrangement.

Alternative to the accelerometers inductive travel sensors can be connected. This is reasonable for the analysis of especially slowly running rolling bearings.

After the data collection all data exist as time signals.

### 2 Measurement data analysis

The time data of the collected channels have to undergo a spectral analysis. Therefore the spectrum and the envelope spectrum of the signal are created at first. By using the speed signal, the order spectrum and the envelope curve spectrum are calculated.

During the creation of a spectrum and an envelope curve spectrum a time-related vibration signal has to undergo a Fourier transformation. The units of the abscissa of the spectrum and envelope curve spectrum is in Hz. During the order analysis the time related signal is converted into a revolution-related vibration signal by using the drive channel. This has to undergo a Fourier transformation. Therefore the unit of the order spectrum and envelope curve order spectrum is the "order".

With order is meant the multiple of the reference frequency. This is normally the rotary frequency of the highest-speed shaft.

Envelope curve spectra, order spectra and envelope order spectra are available from all measuring points for the analysis.

### 3 Calculating the kinematics

It is essential to know the mesh and passing conditions of the drive for the analysis. As basis data are needed:

- the speed (unless it was not collected and the drive is absolutely speed-constant during the measurement),
- all number of teeth on gear,
- all types of bearing and the brand of gears, generators and/or motors,
- a drive diagram, which shows the adjustment of all drive elements (assembly drawing) as well as
- the information about foreign exciters (engines, pumps, aerators and so on).

With this data all kinematic frequencies respectively orders are calculated and summarized in a kinematic table. This includes:

- all frequencies of drive,
- all frequencies of gear mesh,
- the roll over frequencies on gear wheels by planetary stage as well as
- for all bearings:
  - the roll-over-frequency of one point of the external ring,
  - the roll-over-frequency of one point of the internal ring,
  - the roll-over frequency of one point of the rolling elements and
  - the cage-rotation-frequency.

### 4 Analysis

All calculated spectra, envelope curve spectra, order spectra and envelope curve order spectra are analysed for typical frequency examples of irregularities on the basis of kinematics.

## 5 The creation of a machine diagnosis report

At last all located appearances are illustrated comprehensibly in a machine diagnosis report.

The chapter "Diagnosis results" contains a summary of the located irregularities in a tabular form. It is subdivided into these different categories:

- located irregularities
- trend
- recommendation
- conditional failure probability in a year, abbreviation  $P_{\tau < 1a}$

"located irregularity" shows the mechanic causes, which can be read from the respective signal.

"trend" shows the comparison to the reference measurement.

"recommendation" describes further necessary arrangements in case of assuming confinements of availability and therefore a need for action is seen.

"conditional failure probability in a year ( $P_{\tau < 1a}$ )" is a subjective, an sole experience based test for the quantification of irregularities. Stated is the estimated probability, which is based on the vibration diagnosis estimated irregularity, which causes a breakdown in less than 12 months. For the probability of breakdown four steps are indicated:

(no statement)	no irregularity diagnosable
< 5 %	minimal irregularity detectable, generally no action needed
20 %	one of five of these irregularities cause a breakdown within a year
50 %	one of two of these irregularities cause a breakdown within a year

In the chapter "Spectra" all spectra are shown, which are necessary for the understanding of interpretation of the relevant diagnosis.

In the chapter "Kinematics" is found the table of kinematics.

**On the demonstration of all spectra is the abstract of formal dispended. We are pleased to send you optionally mappings of all calculated spectra, envelope curve spectra, order spectra and envelope curve order spectra or as well all data on a CD-ROM.**

## 6 Abbreviations / Explanations

2x BSF .....	pass frequency of a rolling element irregularity on both raceways
BPFI .....	ball pass frequency of an irregularity on inner race
BPFO .....	ball pass frequency of an irregularity on outer race
BSF .....	ball spin frequency
Bearing seat problems.....	indications of micro movements in the bearing seat (See as well hitting parts or fit problems)
Cage .....	cage rotary frequency
Envelope curve order spectrum.....	envelope curve spectrum of an order related signal
Envelope curve spectrum .....	spectrum of the envelope curve of a signal, here are shock-pulse appearances verifiable
Fit problems .....	advice that a rolling bearing has micro movements in a seat (See also hitting parts bearing seat problems)
GfM No.....	GfM report number
Hitting parts.....	indications that parts of the revolving shaft are hitting one time per rotation (See as well fit problems or bearing seat-problems)
Local deviation of flank shapes.....	advice for irregularities of one or several flank of tooth of a gear
Rolling elements.....	number of rolling elements
Order spectrum .....	spectrum of an order-related signal
$P_{\tau < 1a}$ .....	failure probability for one year
PF annulus.....	pass frequency from a point of the annulus
PF planet.....	pass frequency of a point of the planet
PF sun .....	pass frequency of a point at the sun
Reference report no.....	reference report number
Rel. rotary frequency of planet.....	spin frequency related to the planet carrier
Revolving deviation of flank shapes.....	advice for irregularities of all flanks of a gear
Rot. freq. ....	rotary frequency
Rot. freq. planet .....	rotary frequency planet carrier
Rot. freq. sun .....	rotary frequency sun
Spectrum.....	spectrum of a signal here are sinusoidal appearances detectable

## 7 Interpreting spectra, envelope curve spectra, order spectra and envelope curve order spectra

The physical measured variable found is assigned at the ordinate in the spectra and envelope curve spectrum, mostly acceleration  $a$  in  $m/s^2$ , and at the abscissa assigned the variable frequency. For the interpretation relevant spectral lines, as far as possible, the respective frequency as explanation are written in our graphics.

Example: "12.5 Hz - rotary frequency" or "187.6 Hz - tooth mesh"

The physical measured variable is also assigned at the ordinate in the order spectra and envelope curve order spectra. The abscissa is indicated with the physical quantity "order". The order is "1" and not written down. The order is a nominated frequency through the frequency reference. Which frequency was taken as reference frequency can be extracted from the kinematic table. The commentaries at the spectral line have to be named correctly rotary **order** instead of rotary **frequency**. Since it is difficult to understand for our customers, who are not familiar with the order analysis, we continue to use the normal definition of rotary **frequency** in the order spectra and envelope curve spectra. For this small incorrectness we ask for your understanding.

GfM Gesellschaft für Maschinendiagnose mbH  
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