Condition Monitoring + Process Analysis

in one System/机械振动检测与过程数据分析一体化

Agenda

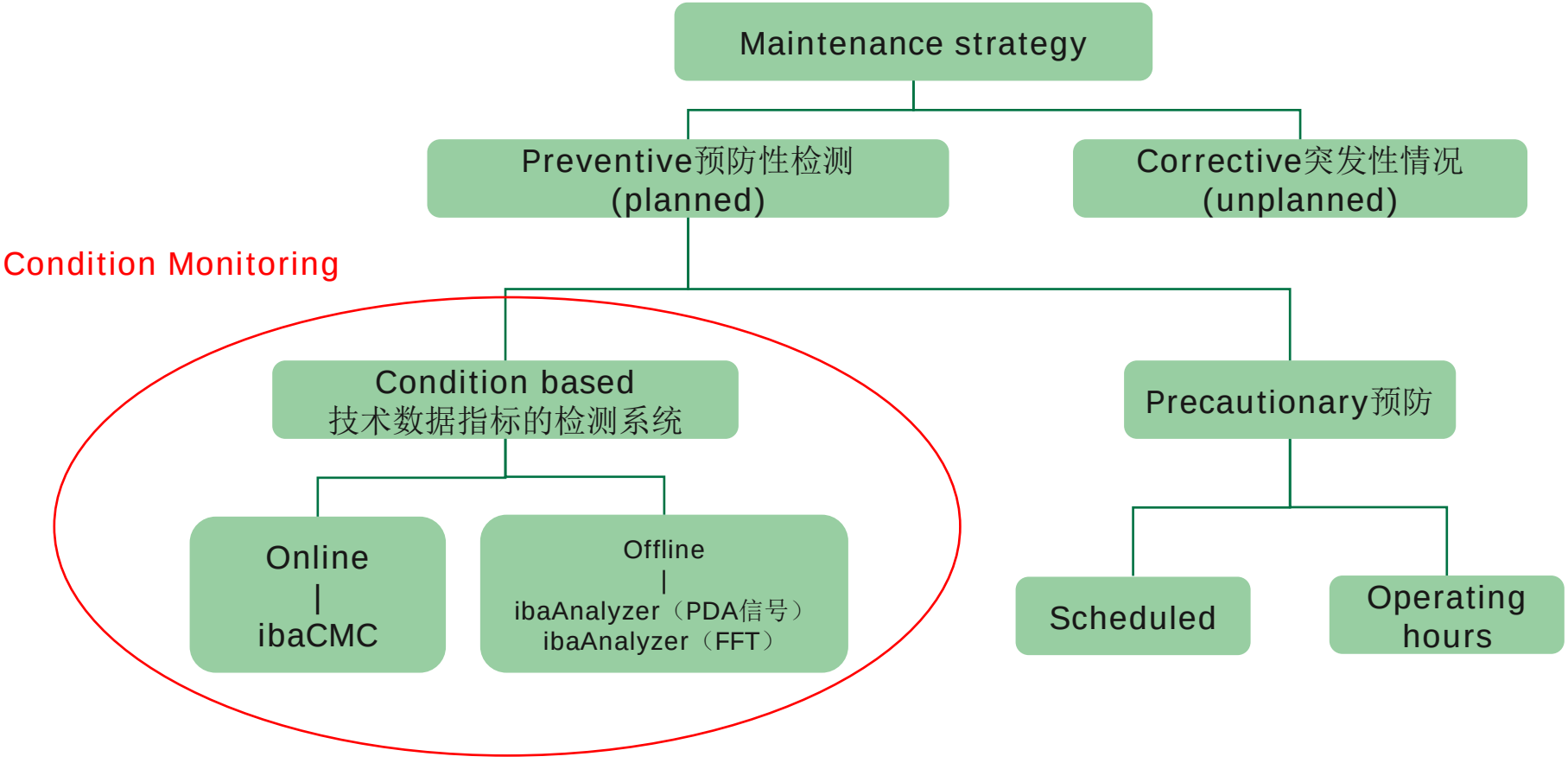
- Definitions /定义
- Introduction/介绍
- Weaknesses of todays CMS/当今CMS（condition monitoring system系统的弱点)
- The iba solution for Condition Monitoring/iba振动检测方案
- The ibaInSpectra System/ibaInSpectra系统
  - ibaInSpectra Analysis Center/-ibaCMS, **C**ondition **M**onitoring **C**enter
  - ibaInSpectra Library/ ibaInSpectra库
- Summary/总结

Definitions - Condition Monitoring

- **Machine Monitoring**/机械振动检测（现场设备）
  - Monitoring of machines for a condition based maintenance/机械振动检测为依据的维护工作
  - Detection of wear on mechanical components/检测机械部件磨损
- **Process Monitoring**（产品质量）
  - Monitoring of process-parameters for optimization of efficiency and quality
    用于生产效率和质量优化的过程参数的监控
- Examples for recording of physical values in CMS:CMS

  其它可以记录到ibaPDA的相关变量/参数
  - Lubricant examination 润滑检查
  - Infrared thermography 红外热成像
  - Sound emission 声学信号
  - Sonography 超声波
  - Motor Current Analysis 马达电流分析
  - Vibration monitoring 振动检测

Maintenance strategies 维护策略



Maintenance strategies/维护策略

- Corrective maintenance (repairing after breakdown)/补救性维护（停机后维修）
  - \+ Minimal costs for spare parts because only broken components are replaced
    成本最小，因为只有损坏的部件才被更换
  - − Downtimes not plannable
    计划外停机
  - − Risk of secondary damages (e.g. fire due to overheated bearing)
    二次损失的危险（由于轴承过热引发的火灾等）
- Preventive maintenance (by schedule or operating hours)/预测性维护（按日程或者工作时间排班）
  - − Increased costs for spare parts because components are replaced early
    因为提前更换部件，成本会上升
  - \+ Downtimes plannable
    停机时间可掌握
  - \+ Reduced risk of secondary damages
    减少二次损失的可能性
- Condition based maintenance/机械振动检测为基础的维护
  - \+ Low costs for spare parts because only components with advanced wear are replaced
    只有过度磨损的部件才会被更换，成本会降低
  - \+ Downtimes plannable
    停机时间可掌握
  - \+ Reduced risk of secondary damages
    减少二次损伤的几率
  - − Investment and operating costs for CM-System
    系统投资成本

Introduction 机械振动检测的目的

CMS use vibration monitoring to detect wear on mechanical components at an early stage. They are the base for a condition based maintenance strategy.CMS
使用振动检测来检测早期机械部件磨损。以机械振动检测为基础的维护策略。

Using mechanical components in an optimal way over their lifetime, reduces costs for spare parts and unplanned downtimes.
延长使用寿命，减少备件计划外的停机时间

The measurement of vibration as one of the main tools has a long pre-warning time for the detection of wear damages, but is also very sensitive to environmental influences.
对于磨损检测应该有比较长的预警时间，对环境因素比较敏感

In complex production plants the changing operation conditions have a serious influence on the vibration monitoring and the calculated levels of damage are very unsteady.
工厂操作和生产的变化也会对机械振动检测有很大的影响，损坏计算结果很不稳定

This causes false alarms. As a result the alarm-thresholds are raised, which leads to shorter pre-warning times and the benefit of the whole CMS is nullified.
误报会让警报水平升高，预报警时间会缩短，CMS的效果会被抵消掉

Only if all relevant operation-parameters are taken into consideration CMS can work reliable under these conditions.
只有所有相关的操作参数都被记录在内，CMS才能在此种情况下提供可靠参考

Weaknesses of todays CMS 其它系统的缺点

Todays CMS are mostly self-sufficient solutions with very limited access to relevant operation-parameters.
如今CMS系统更多是一种自我封闭的系统，对于相关的生产操作参数关联甚少

The efforts for implementing these CMS especially into older automation-systems rises the costs and makes the investment uneconomic.
较早的自动化系统如果整合了上述类似CMS系统的话会增加系统成本，投资不合理化

An integration of the CMS into the automation landscape would solve this problem.
以整体为概念，把CMS系统整合到自动化系统中会比较有效果

However in factories with a heterogeneous automation landscape this is surely short-sighted.
在一个工厂里如果有多种检测平台的存在是比较短视的

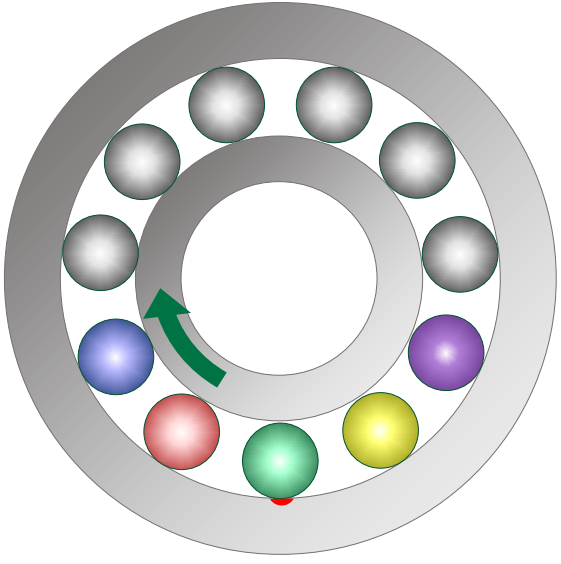
The operator would have to handle a different CMS on each plant and a comparison between the plants is also not possible.
不能同时比较并且处理多个CMS系统的数据

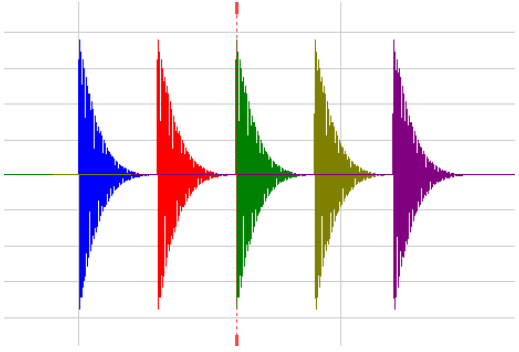
Additionally a CMS analyses frequencies up to 8 kHz with a resolution of 0,05 Hz. Therefore each sensor has to collect and process around 500.000 data points. Common automation systems are normally not suitable for this processing- and memory-intensive tasks.
另外，如果CMS系统以0.05Hz采集最高到8kHz的信号，每个传感器必须收集并且处理500000个采样点。普通的自动化系统基本上不适合处理这种过程和内存密集型任务。
sin(2*PI()*8000***T()) 8000Hz**

The iba solution for Condition Monitoring iba解决方案

- Open interfaces for SPS and HMI (Connectivity)/二级以及HMI系统开放接口
- Consistent CM-solution for factories with heterogeneous automation landscapes./对于多种类型检测类型的一体化振动检测方案
- Seamless integration of CM-functionalities into the total-plant-monitoring.
  和整体生产线监控方案的无缝集成 (PDA, ibaLogic)
- Parallel monitoring of wear and process-induced vibrations (e.g. chatter in a cold rolling process) with one system.
  同一系统中，同时检测零部件磨损振动和生产过程谐波振动（比如冷轧轧机谐波振动）
- Covering the complete CM-landscape涵盖完整的CM方案
  - Real-time system as guard for humans, machines and products
    保护人、机器和产品的实时系统
  - Online Systems for condition based maintenances
    在线振动检测维护系统
  - Monitoring for simple components (fan, pump etc.)
    简单的单体设备也可以检测（风机、泵等）
  - Complex monitoring solutions
    (planetary gear, acoustic test bench etc.)
    复杂系统检测（行星齿轮、声学测试平台等等）

Detection of roller bearing damages





Typical outer race damage (red marker).
具有代表性的外圈损伤（红点）

If a rolling element rolls over the fault on the surface, an impulse occurs which stimulates a vibration. This vibration is transmitted to the bearing housing and can be measured by mounting an accelerometer on the housing.
如果一个滚动体压过损伤表面，脉冲会随即产生并且产生振动。这个振动会冲抵到轴承体并且可以用安装在表面的加速度传感器检测到。

If the rolling elements in the picture pass the damaged position clockwise, the vibration signal displayed below the picture is generated.
如果图中转动体顺时针转动经过损伤部位，那么会产生下图形状的曲线。

The distance between the impulses is related to the ball pass frequency of the rolling elements on the outer race. Which is depending on the revolution and the diameter of the bearing.
两个脉冲之间的间隔取决于两个转动体经过外圈的频率。也就是取决于转速和轴承直径。

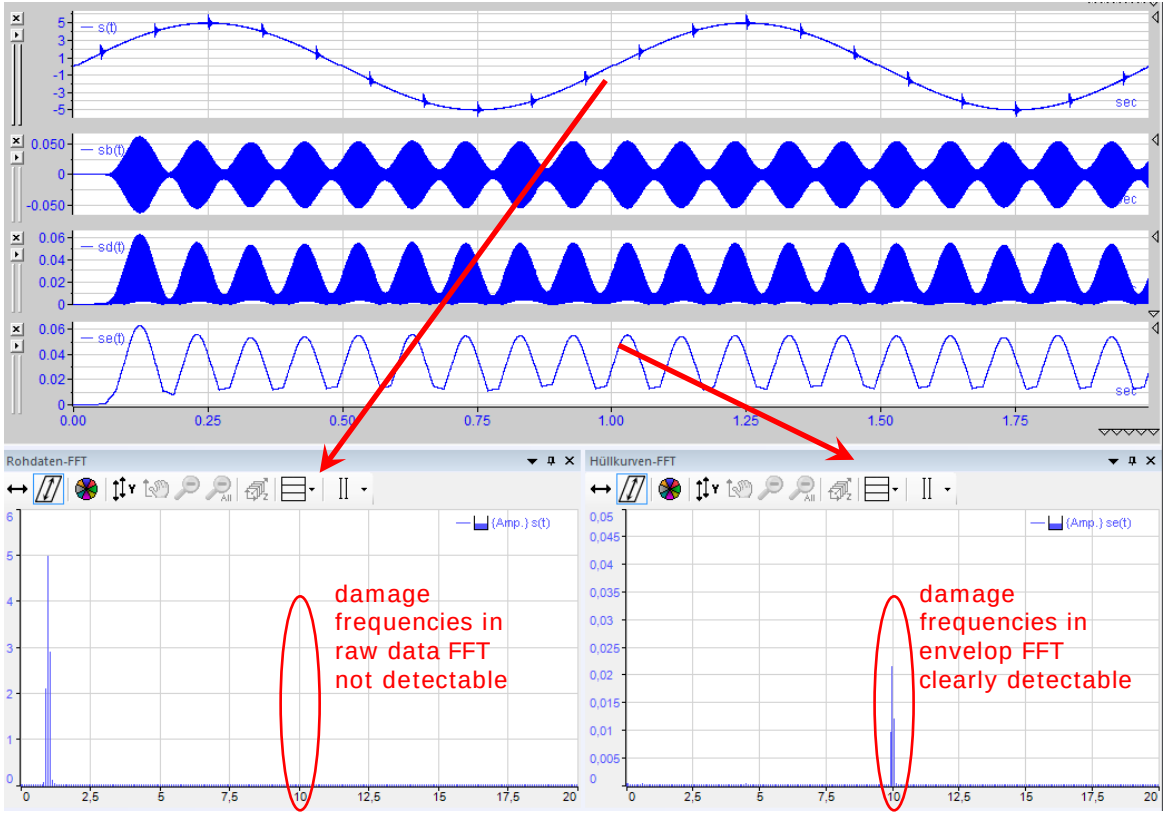
The ibaInSpectra System 数据记录与离线振动分析

The **ibaInSpectra Library**, vibration monitoring in real-time.

- free configurable spectrum analysis
  可设置的自由频谱分析
- real-time alarms (<200 ms)
  实时报警（<200ms)
- snap shot function
  (coupling with CMC)
  截屏功能
- analysis profiles
  分析模型
- extensive possibilities for visualization
  可视化延伸功能开发
- in-depth analysis
  深层分析
- application range:
  - chatter monitoring
    共振检测
  - monitoring of process vibrations
    生产振动
  - test facility monitoring
    测试设备检测
  - etc.

Detection of roller bearing damages

The small amplitudes in the damage frequency have to be extracted out of the signal through demodulation.故障频率中相对较小的波峰 必须通过检波从故障曲线中提取出来：



signal acceleration sensor
n = 1 Hz; BPFO = 10 Hz

band-pass natural frequency

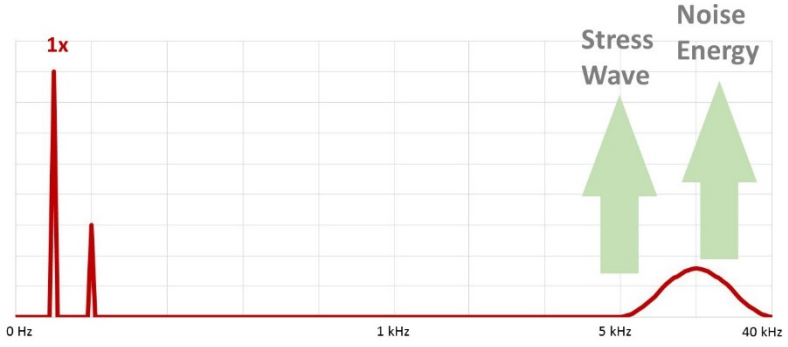
absolute value calculation

envelope

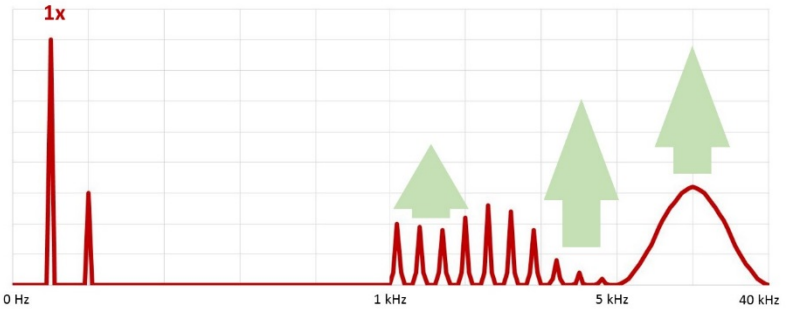
5

Detection of roller bearing damages

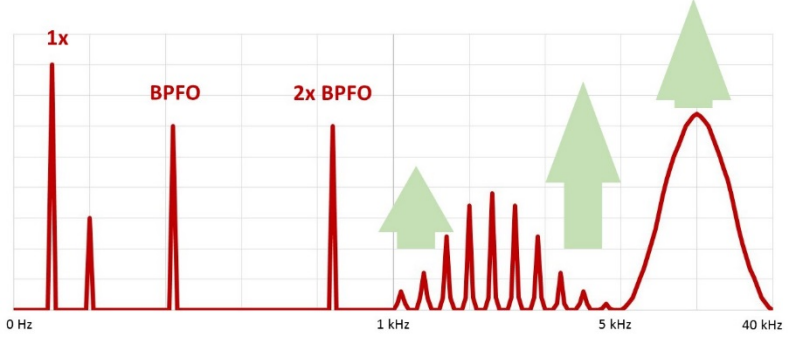
Stage One:



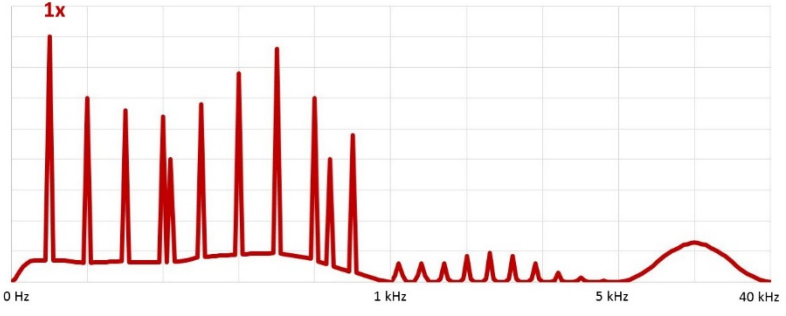
Stage Two:



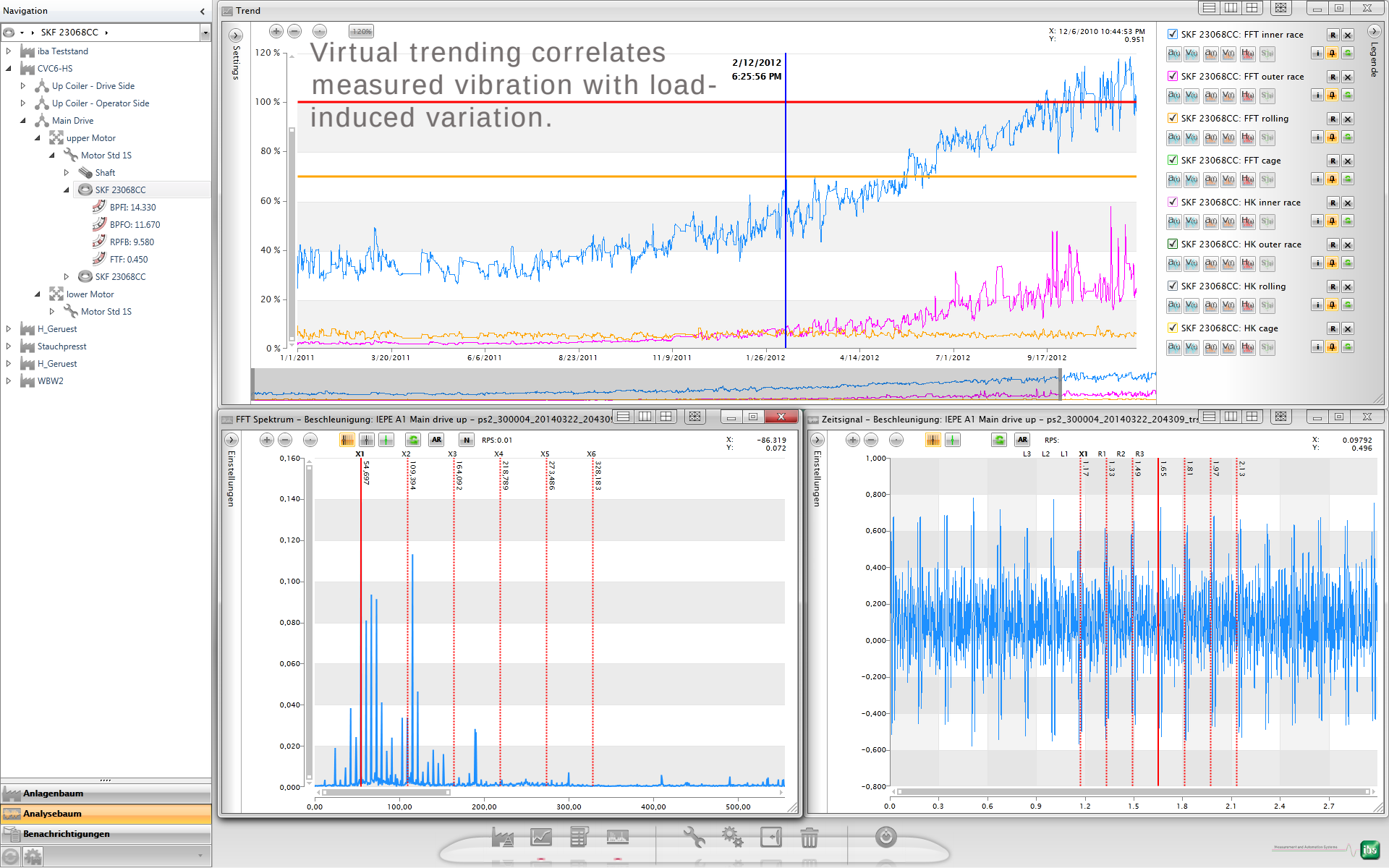
Stage Three:



Stage Four:




Navigation
SKF 23068CC
iba Teststand
CVC6-HS
Up Coiler - Drive Side
Up Coiler - Operator Side
Main Drive
upper Motor
Motor Std 1S
Shaft
SKF 23068CC
BPFI: 14.330
BPFO: 11.670
RPFB: 9.580
FTF: 0.450
SKF 23068CC
lower Motor
Motor Std 1S
H_Geruest
Stauchpresst
H_Geruest
WBW2
Anlagenbaum
Analysebaum
Benachrichtigungen
Trend
Raw trending without consideration of process-parameters (ex. load)
2/12/2012
7:50:51 AM
SKF 23068CC: FFT inner race
SKF 23068CC: FFT outer race
SKF 23068CC: FFT rolling
SKF 23068CC: FFT cage
SKF 23068CC: HK inner race
SKF 23068CC: HK outer race
SKF 23068CC: HK rolling
SKF 23068CC: HK cage
FFT Spektrum – Beschleunigung: IEPE A1 Main drive up – ps2_300004_20140322_204309
Zeitsignal – Beschleunigung: IEPE A1 Main drive up – ps2_300004_20140322_204309_trs


Navigation
SKF 23068CC
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Up Coiler - Drive Side
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Anlagenbaum
Analysebaum
Benachrichtigungen
Trend
Virtual trending correlates measured vibration with load-induced variation.
2/12/2012
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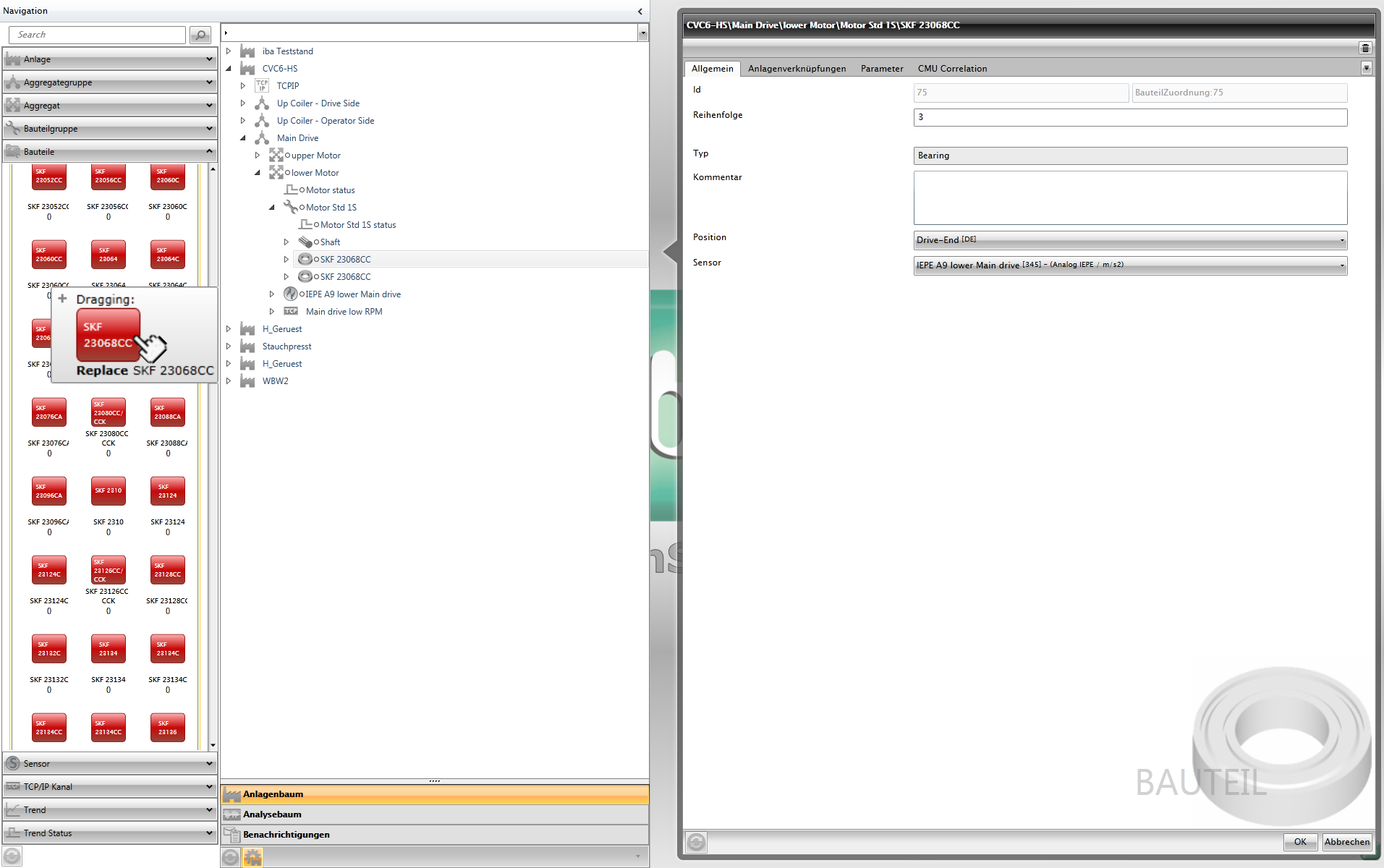
SKF 23068CC: FFT inner race
SKF 23068CC: FFT outer race
SKF 23068CC: FFT rolling
SKF 23068CC: FFT cage
SKF 23068CC: HK inner race
SKF 23068CC: HK outer race
SKF 23068CC: HK rolling
SKF 23068CC: HK cage
FFT Spektrum – Beschleunigung: IEPE A1 Main drive up – ps2_300004_20140322_204309
Zeitsignal – Beschleunigung: IEPE A1 Main drive up – ps2_300004_20140322_204309_tr1


Navigation
Search
Anlage
Aggregategruppe
Aggregat
Bauteilgruppe
Bauteile
SKF 23052CC
SKF 23056CC
SKF 23060C
SKF 23060CC
SKF 23064
SKF 23064C
SKF 23076CA
SKF 23080CC/CCK
SKF 23088CA
SKF 23096CA
SKF 2310
SKF 23124
SKF 23124C
SKF 23126CC/CCK
SKF 23128CC
SKF 23132C
SKF 23134
SKF 23134C
SKF 23134CC
SKF 23136
Sensor
TCP/IP Kanal
Trend
Trend Status
Dragging:
SKF 23068CC
Replace SKF 23068CC
iba Teststand
CVC6-HS
TCPIP
Up Coiler - Drive Side
Up Coiler - Operator Side
Main Drive
upper Motor
lower Motor
Motor status
Motor Std 1S
Motor Std 1S status
Shaft
SKF 23068CC
SKF 23068CC
IEPE A9 lower Main drive
Main drive low RPM
H_Geruest
Stauchpresst
H_Geruest
WBW2
Anlagenbaum
Analysebaum
Benachrichtigungen
CVC6-HS\Main Drive\lower Motor\Motor Std 1S\SKF 23068CC
Allgemein
Anlagenverknüpfungen
Parameter
CMU Correlation
Id
75
BauteilZuordnung:75
Reihenfolge
3
Typ
Bearing
Kommentar
Position
Drive-End [DE]
Sensor
IEPE A9 lower Main drive [345] - (Analog IEPE / m/s2)
BAUTEIL
OK
Abbrechen

The ibaInSpectra System

The **C**ondition **M**onitoring **U**nit is the heart of the system

- collects time-synchronous, raw data from sensors directly at up to 40 kHz
  收集传感器的时间同步、原始数据信号，最高达40kHz
- exchanges data with the automation environment
  与自动化环境交换数据
- performs bulk of the signal analysis
  可以处理大量信号分析
- records calculated results and raw data
  记录计算结果和原始数据
- produces alarms, e.g. using digital outputs (stand-alone operation)
  产生报警信号（例如使用数字输出）

ibaCMU-C

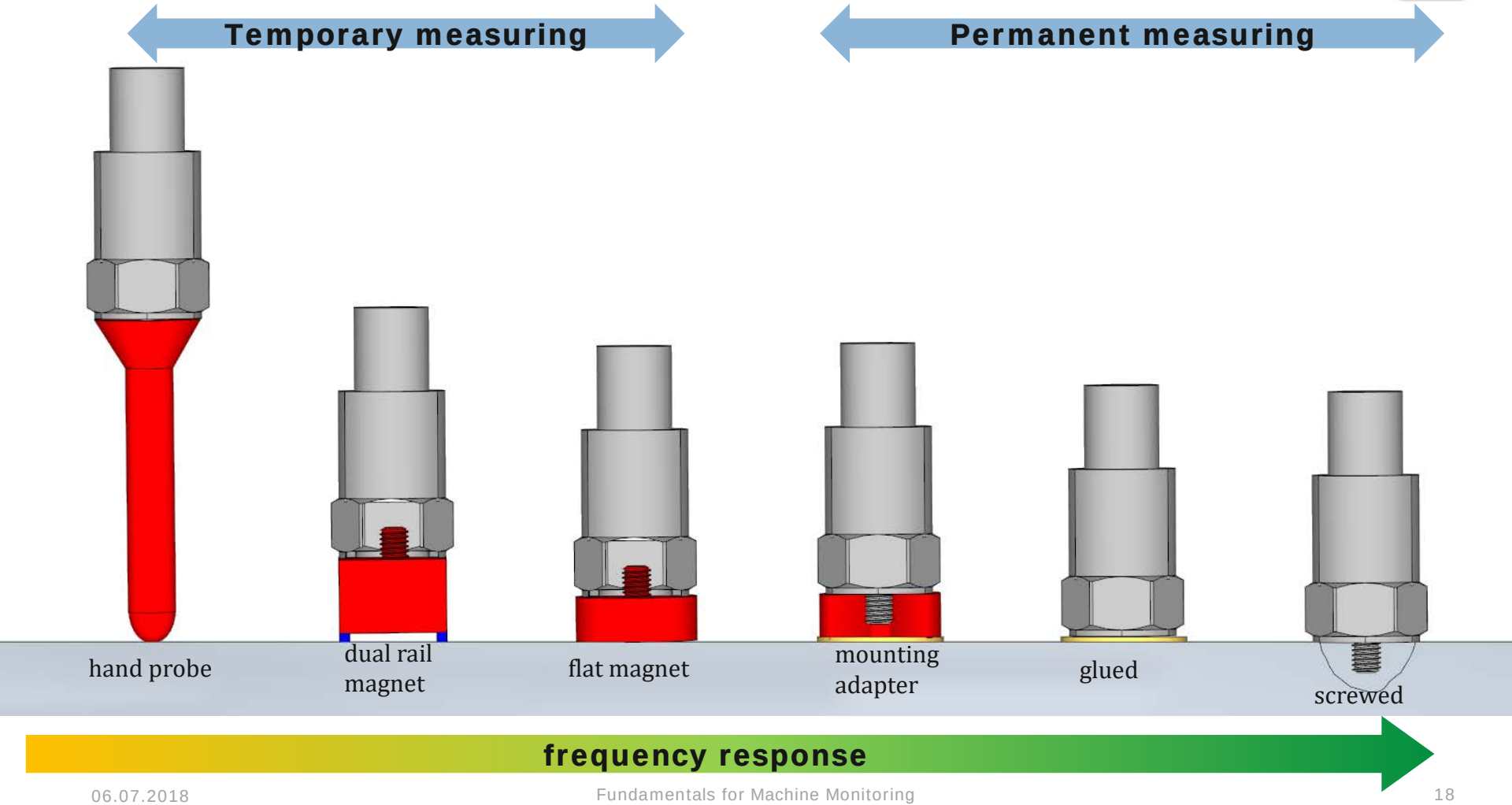
- Great for single component monitoring
- vibration monitor
- characteristics value formation

紧凑型数据采集模块

ibaCMU-S with modules

- Great for monitoring of machine groups
- complex spectrum analysis
- special applications

Sensor system – mounting technique

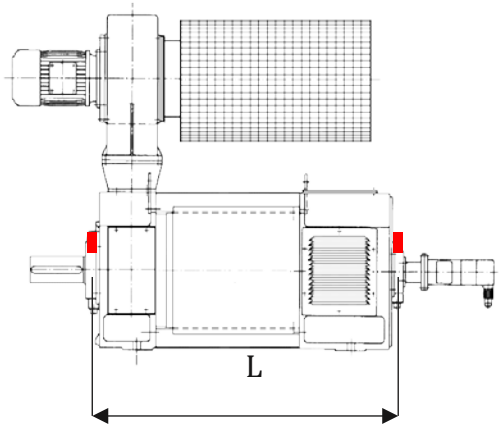


Sensor positioning 传感器位置

The choice of the right sensor location is critical for an effective condition monitoring.

Too many sensors make the system more expensive and don't have any additional benefit. Using not enough sensors would downgrade the monitoring results.

sensor positioning motor



sensor position

Rule of thumb:

- L < 1,25m:
  One sensor on the main bearing is sufficient
- L > 1,25m:
  Two sensors are required

The ibaInSpectra System

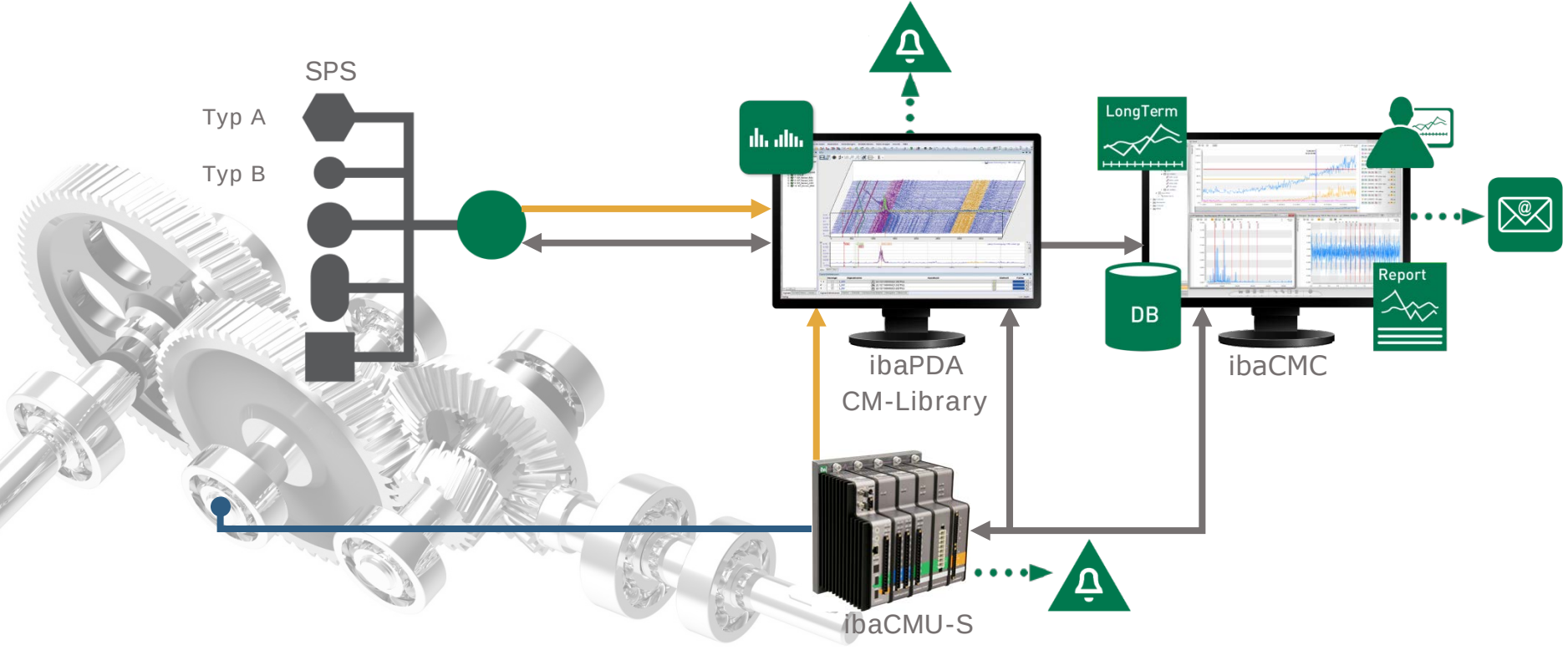
The ibaCMC iba **C**ondition **M**onitoring **C**enter(ibaInSpectra Analysis Center), control center for global factory CM

- powerful data management and reporting system
  强大的数据管理和报告系统
- web based user interface
  web界面
- convenient configuration interface
  便捷的设置界面
- component database
  零部件数据库
- long-term trending
  长期趋势
- virtual trending
  (correlation with process data)
  虚拟趋势
- Alarming/报警
- reporting /报告
- in-depth analysis/深层分析

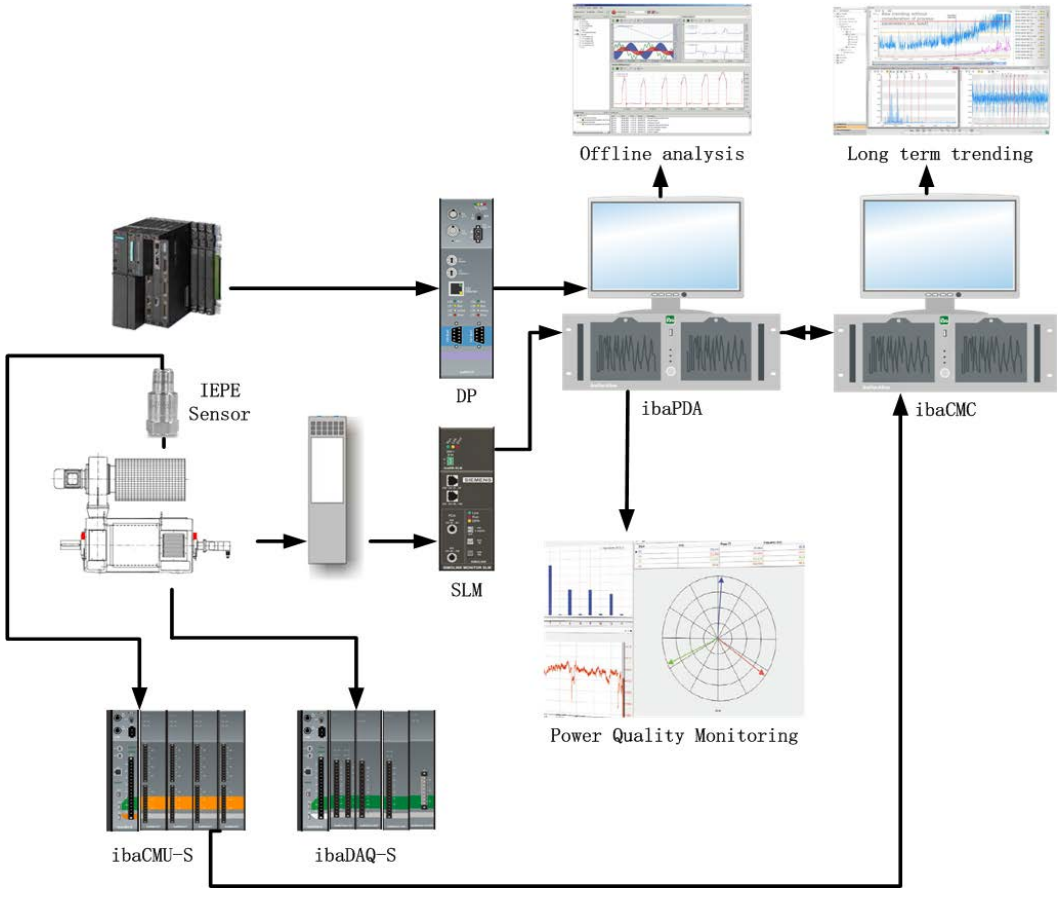
ibaCMC, iba Condition Monitoring Center

ibaCMC, 工厂级机械振动检测平台, monitoring in the context of a complex plant.

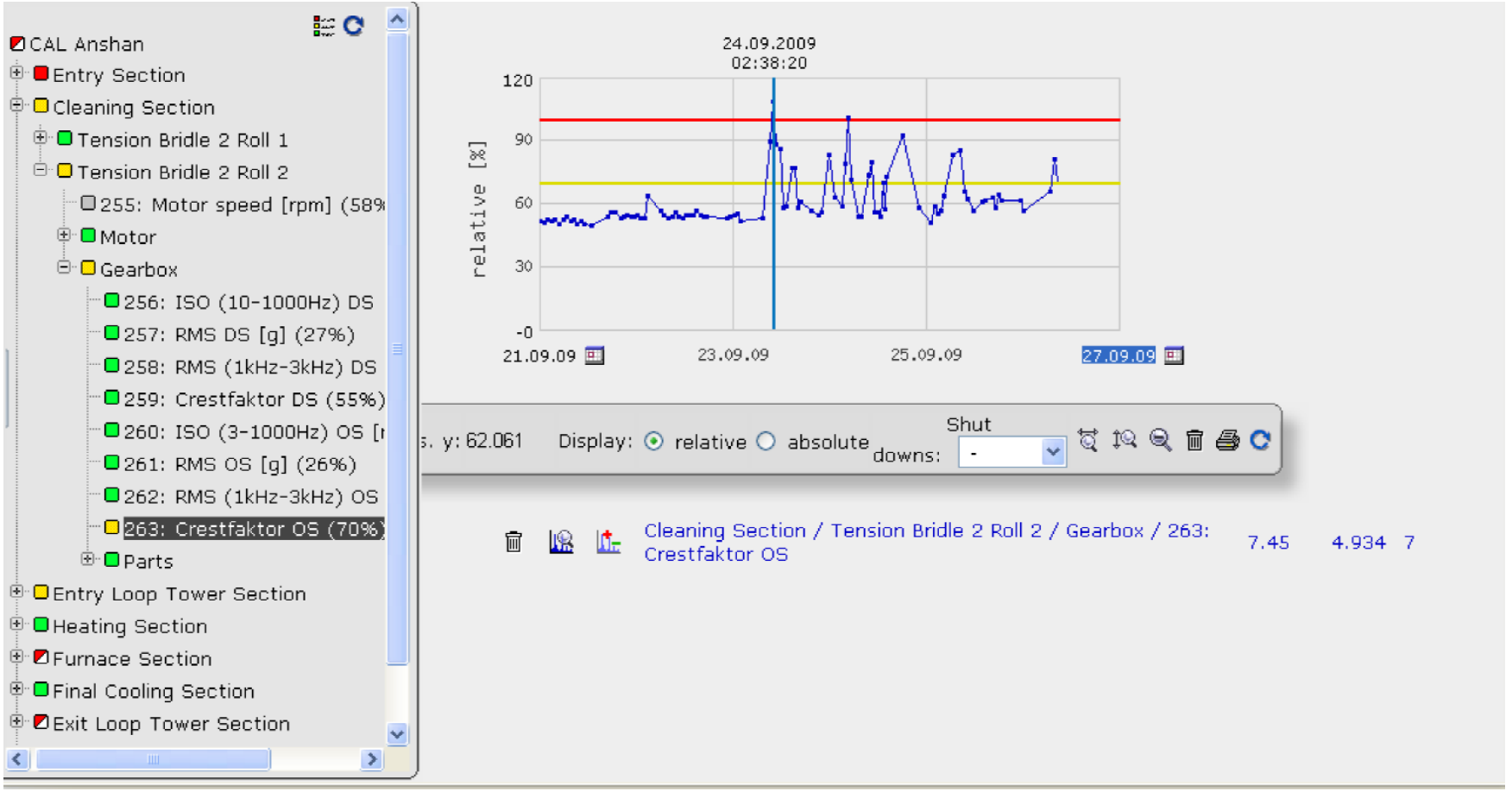
- central recording of all relevant machine-, process-, material- and quality-data
- monitoring across all production areas



ibaCMC 系统实例


Offline analysis
Long term trending
DP
IEPE
Sensor
ibaPDA
ibaCMC
SLM
Power Quality Monitoring
ibaCMU-S
ibaDAQ-S

Examples


CAL Anshan
Entry Section
Cleaning Section
Tension Bridle 2 Roll 1
Tension Bridle 2 Roll 2
255: Motor speed [rpm] (58%
Motor
Gearbox
256: ISO (10-1000Hz) DS
257: RMS DS [g] (27%)
258: RMS (1kHz-3kHz) DS
259: Crestfaktor DS (55%)
260: ISO (3-1000Hz) OS [
261: RMS OS [g] (26%)
262: RMS (1kHz-3kHz) OS
263: Crestfaktor OS (70%)
Parts
Entry Loop Tower Section
Heating Section
Furnace Section
Final Cooling Section
Exit Loop Tower Section
24.09.2009
02:38:20
120
90
60
30
-0
relative [%]
21.09.09
23.09.09
25.09.09
27.09.09
s. y: 62.061
Display:
relative
absolute
Shut
downs:
-
Cleaning Section / Tension Bridle 2 Roll 2 / Gearbox / 263:
Crestfaktor OS
7.45
4.934
7

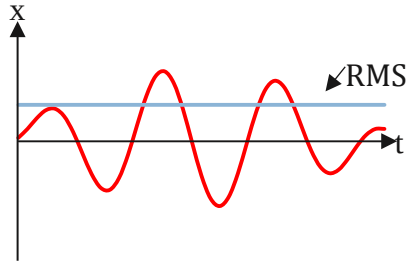
Examples-Calculation

- **Crest factor (peak factor)** $k_s = \frac{|x|_{max}}{x_{RMS}} = \frac{Peak}{RMS}$
  - Caused by a small disruption in the roller bearing surface, a short-term impulse (peak) occurs every time a rolling element runs over it. 轴承表面伤害的短期脉冲表现
  - Due to the short impulse, the RMS value remain relatively steady. However, the crest factor will increase.
  - If the disruption enlarges the crest factor keeps rising.
  - If the damage extends over the entire surface the crest factor drops again because the RMS-value rises. **Therefore, the crest factor is a good indicator for roller bearing damages in an early stage.**

- **RMS (Root Mean Square)** 均方根 / 有效功率

  RMS is a representation of the energy content within the vibration. For machines without considerable process vibrations, the RMS-value in long-term trending can indicate changes in machine condition. This requires RMS-values to be measured under comparable operating conditions. Bearing damages only lead to higher RMS-values if there is advanced damage.

$$x_{RMS} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} {x_i}^2}$$



Examples-demages

Summary

The ibaInSpectra products allow for the first time a factory-wide and cross-plant diagnosis of all production processes and plant conditions, even in heterogeneous automation landscapes.

一体化过程数据解决方案，包括PDA数据和机械振动检测数据

The central storage and analysis of all material-, process-, quality-, and condition-information has a serious additional benefit.
存储的分析范围包括：材料、过程数据、质量和振动检测信号

For Example:

- Obvious reduction of fault alarms with a maximum early warning time by coupling vibration- and process-data (virtual trending). 预警，提早排检
- Accurate detection of wear intensive operating points. 准确检测磨损
- Detection and avoidance of quality affecting vibration conditions and vibration caused process disturbances. 减少由于机械振动引起的产品质量问题

Thank you for your attention

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