Brüel & Kjær Vibro

Compass 6000

Uptime & Performance

Setting New Directions

When serving large industries, like power, petrochemical, oil & gas, process and maritime, our focus turns towards safety, uptime and performance. The results are reliability in production and maximum availability of machinery critical to the process.

Knowing the actual condition of the machinery allows for planning maintenance activities ahead of time, making sure that machines are opened only when necessary.

The Compass 6000 safety and condition monitoring system is specifically designed and dedicated for protection, fast and reliable detection and diagnosis of developing faults in your machines.

The Compass 6000 is a powerful package built on experience and knowledge about machinery and their potential failure modes that focuses on dedicated monitoring strategies for your particular application and machine operation.

Daily situation ...

Keeping machinery operating at "24/7" can be quite a challenge. Downtime can be avoided, however, if the necessary information is available. This allows fast, accurate decision-making for re-starting machines or opening them for inspection and repair.

An unscheduled repair due to equipment malfunction is one of the largest unnecessary expenditures when considering inefficient maintenance practices. Some disadvantages connected with time-based machinery maintenance are:

- Short overhaul intervals are necessary to deal with risk of premature faults causing a shutdown
- For rough-running machinery, there is often insufficient information for deciding when to reduce load or speed, or shut it down
- Sometimes machines are stopped and completely inspected without knowing the source of the fault, which may remain after reassembly
- Lack of information for solving recurring faults (root-cause analysis)
- No information is available on how efficiently the machine is operating

...and the consequences

In today's business with stringent requirements for availability and efficient throughput, any unnecessary downtime can result in seriously cut profits; lost production, increased repair and maintenance cost, and penalties for incomplete deliveries.

Low machine performance and lack of efficiency can become critical parameters when considering the overall turnover. Loss in production can be the direct effect of improper maintenance. This can undermine the machine's health and can, in serious cases, cause expensive consequential repercussions.

Being unable to operate machines efficiently, running only at part load or just standing idle for a single day can lead to irrecoverable production.

Time-based maintenance for critical machines often results in machines in perfect condition being stripped down for service. As a result of this there is a risk that faults can be unintentionally introduced in the machine during re-assembly.

Machinery uptime can be enhanced when the overhaul interval is based on actual condition and the repair duration is shortened because the area of concern is known in advance.

Profit and Productivity

Maintenance profit centre

An effective machine condition monitoring system can actually turn your maintenance centre into a reliability-driven maintenance profit centre. By changing from a preventive to predictive maintenance strategy, the potential for savings by increasing the reliability of making decisions and reducing planned and unplanned machine downtime can be very high.

Support making decisions

Fast operational and maintenance decisions have to be based on useable information. A flashing alarm light from the safety system tells you your machine has a developing fault, but there is not enough information telling you what kind of fault it is. When should the speed or load be reduced? When should maintenance be scheduled? External consultants can offer their advice in this situation, but the time for making a diagnosis may be too long. The fastest and best information is actually provided by the machine condition monitoring system itself.

Fast payback

The savings from avoiding a single failure in many cases justify the initial investment and installation of the monitoring system. There are also considerable savings by avoiding false alarms that cause unplanned maintenance and downtime. A number of dedicated monitoring functions are available to help reduce the planned machinedowntime, thus improving the return on investment (ROI):

- Extending the time between overhauls
- Maintenance can be cost-effectively planned in advance
- Time for repair is reduced because maintenance is focused
- Letting machines in good condition continue working (“If it isn’t broken - don’t fix it”)

Applying performance monitoring can generate additional savings:

- A 1% drop in efficiency due to fouling, erosion and leaking seals, can be translated into significant payback
- Flow disturbances such as surge, choking, rotating stall, pressure pulsations and recirculation not only reduce efficiency, but can also overload machine components
- Monitoring the efficiency of a gas turbine can be used for optimising on-line washing effectiveness, thus giving maximum efficiency and production
- Reducing the interval and duration of off-line washing provides machine uptime

Compass 6000¸ is an intelligently automated system that has many functions that were traditionally done by specialists:

- Adapted monitoring strategy allows alarming in different operational modes (e.g. run-up, running, coast-down)
- Spectrum and measurements are monitored to alarm limits
- Automatic machine advisory and diagnosis software can automatically recognise the symptoms of developing faults

Compass 6000 - Balanced Solutions

VC-6000™ and Compass 6000 have a number of unique features that provide balanced solutions to suit very diverse problems and applications.

Application-specific hardware designed and developed from years of experience results in an application-specific, modular construction with

- virtual 'plug 'n play' implementation,
- extremely fast system response speed,
- minimal setup requirement,
- low MTTR and a high MTBF

to ultimately reduce the amount, and therefore the cost, of required technical support. Reliability supplied at no extra cost to you.

A dual-power supply module for simultaneously connecting AC and DC supplies functions as effectively as a redundant power module, providing an automatic backup in case of failure of one supply type.

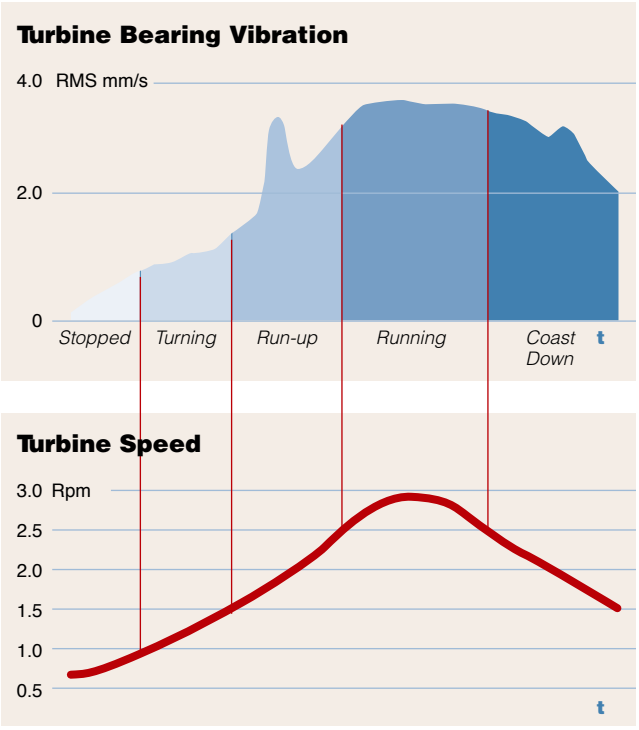
Application-specific software modules that have been designed specifically for

- fault detection using the CPB spectrum and trending,
- diagnosis using all the most powerful signal analysis tools,
- performance monitoring for optimisation of machine efficiency and
- advisory for fast signal interpretation

which can all be combined into a tailor-made solution that needs minimal configuration, cutting down on the cost of preparation before implementation and getting a running start on system return of investment (ROI).

Adaptive monitoring strategy (AMS) is used in the Compass 6000 to gain maximum sensitivity to small changes, without generating false alarms. This technique is used in predictive monitoring to automatically adapt the reference and alarm levels to any given machine condition for reproducible results.

A set of *Machine states* is defined in a monitoring system using *speed, relay, binary inputs* and any other single values as defining inputs (see Table 1 for an example with RPM and logic values). As measurements are made and monitored, Compass 6000 automatically recognises a change in a machine's operating regime. The measurements are then automatically compared to the specific alarm limits for that particular machine state, and stored in the database for the same machine state.



Constant Percentage Bandwidth (CPB)
The CPB measurement gives a constant *relative* bandwidth on a *logarithmic* scale, i.e. the bandwidth is a percentage of the centre frequency. This type of measurement allows a wide frequency range to be plotted, with higher resolution at the low frequencies and coarser resolution at the high frequencies. This allows a wide range of machine faults to be detected.

Communication modules with OPC, RS-232 and 485, single Modbus and dual-Modbus RTU, LAN (TCP/IP) interfaces provide all the commonly-used interfaces for data import and export, time synchronisation, parameter setup and firmware downloads you could want.

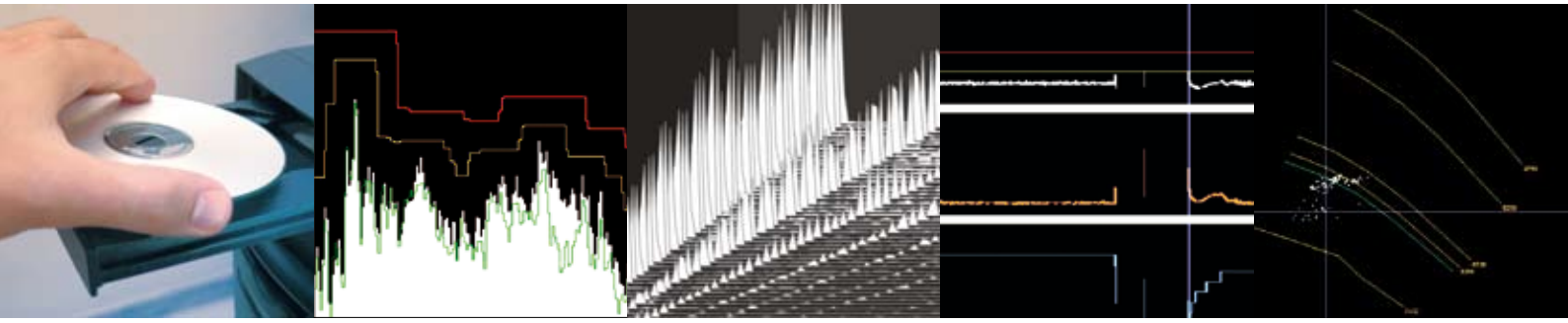
Familiar user-interface software supported by an operating platform that has an international reputation for security and rugged reliability considerably reduces the long-term costs for system management, maintenance and administration.

Operator-friendly displays and database management methods with a 30-year data storage capability, automatic event signalling on machine mimic diagrams, rapid measurement-point fault location and powerful in-depth signal analysis tools all contribute toward reduced techno-stress on the part of the operator and lower end-user day-to-day operating costs in terms of man-hours.

Critical and auxiliary machines that are efficiently monitored on line for safety, fault detection, diagnosis and performance with VC-6000™ and Compass 6000 can

- be operated at maximum safety and efficiency for the optimum service life
- consistently produce a high-quality product
- provide maximum ROI in the shortest possible time and
- be operated, maintained and managed at the lowest practical cost

Application-ready Products



Both the VC-6000™ monitoring hardware and the Compass 6000 software have been designed to a unique, modular concept that sets the system apart from other systems. The ready-to-use modules and software are factory set for specific machine applications, thus saving you time in finding a monitoring strategy and setting up the system.

Monitoring Modules

There are modules that will fit your specific machines. There are a number of configurations with different input channels, output channels and relays to choose from.

Trending and Detection Software

Basic condition monitoring of non-critical machines could not be more effective. All single-value data can be monitored to machine states, including user-defined, calculated measurements. The CPB measurement is also included because of its early fault detection capability.

Diagnostic Software

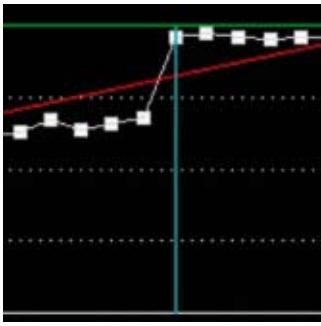
Advanced condition monitoring and diagnosis can be done on specific machines such as compressors, gas turbines, steam turbines, motors, generators and pumps.

Performance Monitoring Software

Thermodynamic formula calculations are done on a number of specific machines for detecting fouling, erosion, leaks in components, flow disturbances, and for monitoring emissions and determining combustion effectiveness.

Advisory Software

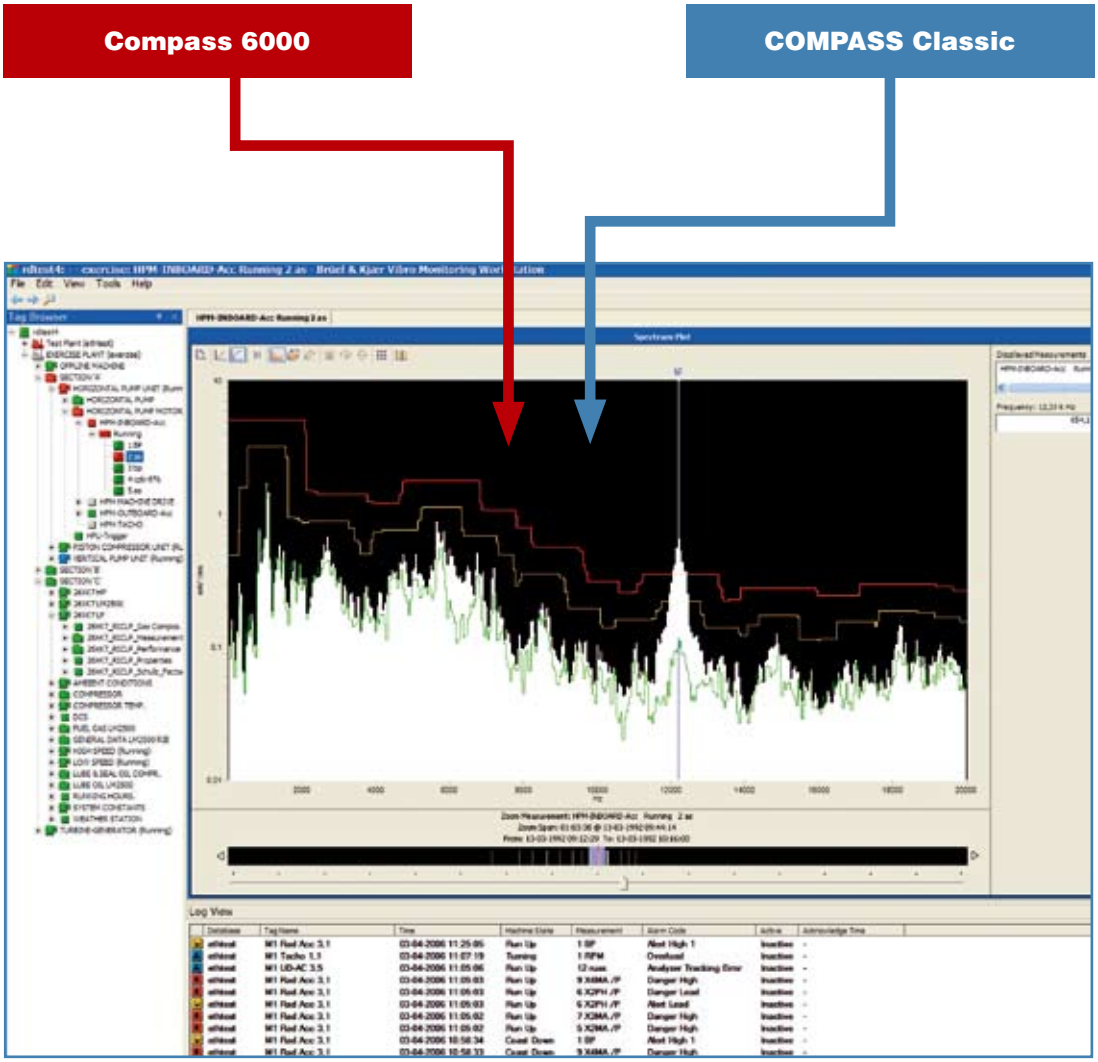
ADVISOR™ is a data reduction tool that scans large amounts of data and focuses your attention on only those machines with problems. It identifies changes in all kinds of Compass 6000 measurements and makes quantitative diagnoses. A complete set of tools is available to verify and confirm the diagnoses results.



Forward Compatibility for COMPASS Classic

Compass 6000 contains the new generation of VC-6000™ rack-based hardware. The DSP processing technology of the Compass 6000 is faster and more compact, and includes ready-to-use hardware and software configurations for specific machines. The Windows-based Compass 6000 user interface is more flexible and versatile.

Much of the functionality that made the earlier versions of COMPASS renowned are incorporated in the Compass 6000 software, such as the powerful database, the adaptive monitoring strategy, alarm limits for spectra, the CPB measurement, etc. These unique functions have proven to be efficient and powerful tools over time and are just as valid today as they were when first introduced. Earlier versions of COMPASS are still being used in many parts of the world for some of the most demanding applications. The new Compass 6000 systems can be easily added to existing systems.



Project Delivery and System Testing

Project management is required where turnkey solutions are delivered. Today's projects grow in size and complexity requiring effective project management.

Monitoring system projects are implemented with many of the world's leading oil & gas, petrochemical and power companies, and typically include the following requirements:

- Project management
- Documentation
- Reporting
- Training
- Testing

Project management includes coordination with project activities and all the relevant contacts, including end-users, contractors, OEMs, DCS systems and other suppliers.

Brüel & Kjær Vibro is committed to ensure that system deliveries are implemented on schedule and on budget.

Standard documentation

- Suppliers master document register
- Functional design specifications
- Product specifications (power consumption, data sheets, etc.)
- Certificates (conformance, Eex, etc.) and packing list
- VC-6000™ standard product specific manuals

Drawings

- System overview
- Dimensions and monitor allocation, giving tag-number relationship with rack
- Detailed interconnections for system I/O (field inputs, digital inputs, relay outputs, power and ground, serial and LAN communications, etc.)
- Typical loops showing all signal paths and the entire measurement system

Front-end

- Front-end drawings showing the measurement chain (sensors, junction boxes, racks), including mounting drawings)
- Mechanical installation and testing of sensors, and guidelines on how to install and test the sensors' installation
- Electrical testing of sensors, and guidelines on how to install and test the sensors' installation
- Product specifications, a collection of the project-specific equipment data sheets

Database and set-up

Implementation of Brüel & Kjær Vibro monitoring strategies:

- VC-6000™ SM-610 modules
- On-site database trimming - basic measurement, reference and alarm set-up (service product)

Cabinet and wiring

- 1, 2 or 3 monitors per cabinet

Test Activities

- 100% Pre FAT
- FAT
- Site integration test (SIT)
- Commissioning
- Site acceptance test (SAT)

Customer Support Services

A service partnership provides you access to responsive, experienced professional service engineers for system optimisation and implementation, training, diagnostics and performance. A number of individual services can be customised to your specific needs to ensure maximised production and minimised maintenance costs.

Each customer has unique requirements, so a “one size fits all” product/service concept may not apply for plant-wide monitoring applications. Our extensive, fine-tuned, “full circle” service and support packages match the specific requirements of a wide range of industries, machines and specific applications.

Long-term Service Agreements (LTSA)

Many applications are more cost-effectively serviced by long-term comprehensive agreements. Part of our group is dedicated to these and experience shows there is increasing interest in these services. We provide an individualised service and are flexible enough to adapt the agreement to changing business requirements.

Helpdesk

Our Helpdesk Service provides fast and efficient technical and engineering support during normal working hours, via telephone, e-mail, or fax. We provide fast, intelligent answers for your service problems and questions and your satisfaction is our priority.

Software upgrade service

Our focus is on delivering major upgrades and maintenance releases of our software products to give you full value for your investment.

On-site training

We work with you to plan and execute on-site customised training that meets your specific requirements. This reduces the time your employees are away and cuts expenses. You select the training modules you need from a range of programmes and dates.

Application services

Our cost-effective, time-efficient, standard and customised monitoring solutions are fine-tuned to meet your specific application requirements. We work with industry specialists and machine manufacturers to deliver optimum monitoring solutions and constantly keep track of developments in international standards to update our monitoring strategies.

Because vibration monitoring cannot be used for diagnosing all faults, we include process and performance parameters in our integrated monitoring strategy. These parameters allow faults such as seal leaks, dirty blades and impellers, malfunctioning combustion burners, faulty guide vanes, etc. to be detected.
Performance parameters are also useful for correlating with vibration for reliably diagnosing compressor surge, rotating stall, turbulence, damaged blades, etc. You get fast information for making reliable operational and maintenance decisions.

Further services include:

- System optimisation service
- Start-up and system setup service
- Consulting and engineering services
- Monitoring system maintenance services

Modular Hardware

A wide range of standard monitoring modules are available to meet your specific requirements.

Transmitter modules

Input: Displacement, velocity, acceleration and process sensors
Output: DC (4-20 mA/0-10 V)

Safety monitoring modules

Input: Displacement, velocity, acceleration and process sensors
Output: Relays

Condition monitoring modules

Input: Displacement, velocity, acceleration and process sensors
Binary input (e.g. trip multiplier/ trip override)
Output: DC (4-20 mA/0-10 V)
Relays

Application modules

Some standard monitoring modules and examples for specific machines:

- Electrical motors
- Gas turbines
- Steam turbines
- Helical gears
- Planetary gears
- Pumps
- Centrifugal compressors
- Reciprocating compressors
- Fans and blowers
- Generic sleeve bearing machinery
- Generic rolling-element bearing machinery
- Other machines

Compressor train

Electrical motor-driven compressor train requires three modules in one rack.

Electrical motor

Input: Radial vibration (X-Y), speed (tacho/reference) and local trip multiplier
Output: Relays

Helical gear

Input: Seismic vibration, radial vibration (X-Y) and local trip multiplier
Output: Relays

Centrifugal compressor

Input: Casing vibration, radial vibration (X-Y), axial position, speed (tacho/reference) and local trip multiplier
Output: Relays

Power generation steam turbine

Requires 5 - 6 modules, in two racks

Steam turbine section

Input: Radial vibration (X-Y), casing vibration (H-V) and local trip multiplier
Output: DC and relays

Steam turbine miscellaneous

Input: Displacement (relative and absolute expansion, rotor eccentricity) and speed (tacho/reference)
Output: DC and relays

Generator and exciter

Input: radial vibration (X-Y), axial position, speed (tacho/reference) and local trip multiplier
Output: Relays

Overspeed control

Requires three modules in one rack and dual power supply in a second rack (API 670 compliant solution)

Overspeed module

Input: Speed (tacho) sensor and binary input
Output: DC (4-20 mA/0-10 V)
Relays

Modular Software

Both critical and auxiliary machines can be monitored by Compass 6000. The VC-6000™ monitoring modules and the various condition monitoring and diagnosis software modules provide machine-specific monitoring solutions for all monitoring needs.

Safety

For some machines the requirement is pure safety, where the machines are brought to a stand-still in case of excessive vibration.

Early fault detection and trending

Other machines require only basic condition monitoring, where primary measurements are used together with CPB spectra with alarm limits.

Diagnostics

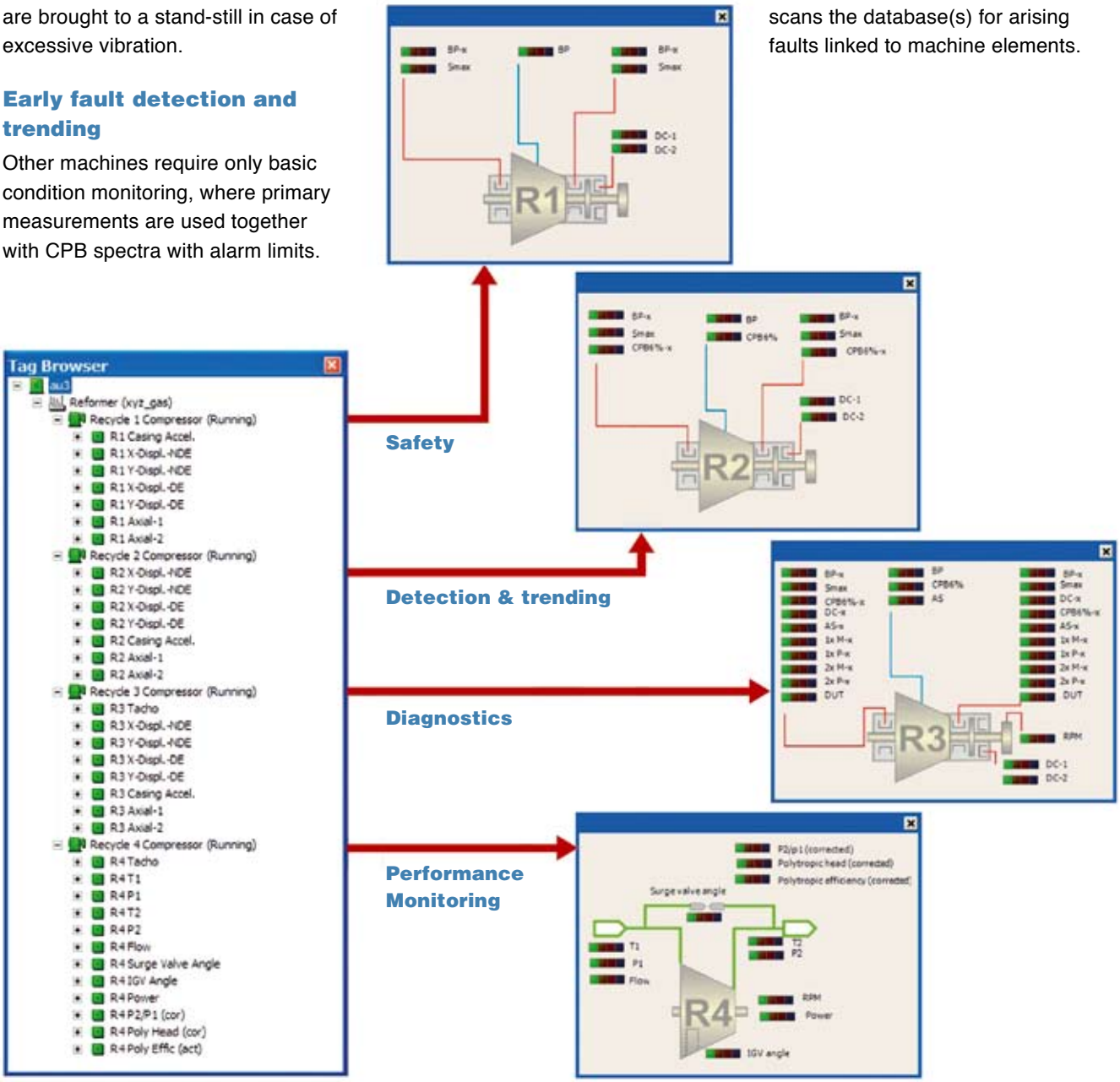
Critical machines require diagnostic monitoring in addition to basic trending and early fault detection. It is important to correlate data, make dedicated spectral analysis, and use plots dedicated for that purpose.

Performance monitoring

Machines handling process liquids and gases require monitoring of the performance in terms of efficiency, head vs. speed and flow, etc.

ADVISOR™

For installations where high availability and reliability are required, Compass 6000 advisory software is recommended. The advisory tool scans the database(s) for arising faults linked to machine elements.



Compass 6000 Monitoring System

Compass 6000 is a modular safety and condition monitoring system that can be used for monitoring from a single machine to plant-wide installations with hundreds of machines. Compass 6000 offers both an integrated and distributed information management solution for exchanging data between systems and users.

Front-end and monitoring hardware

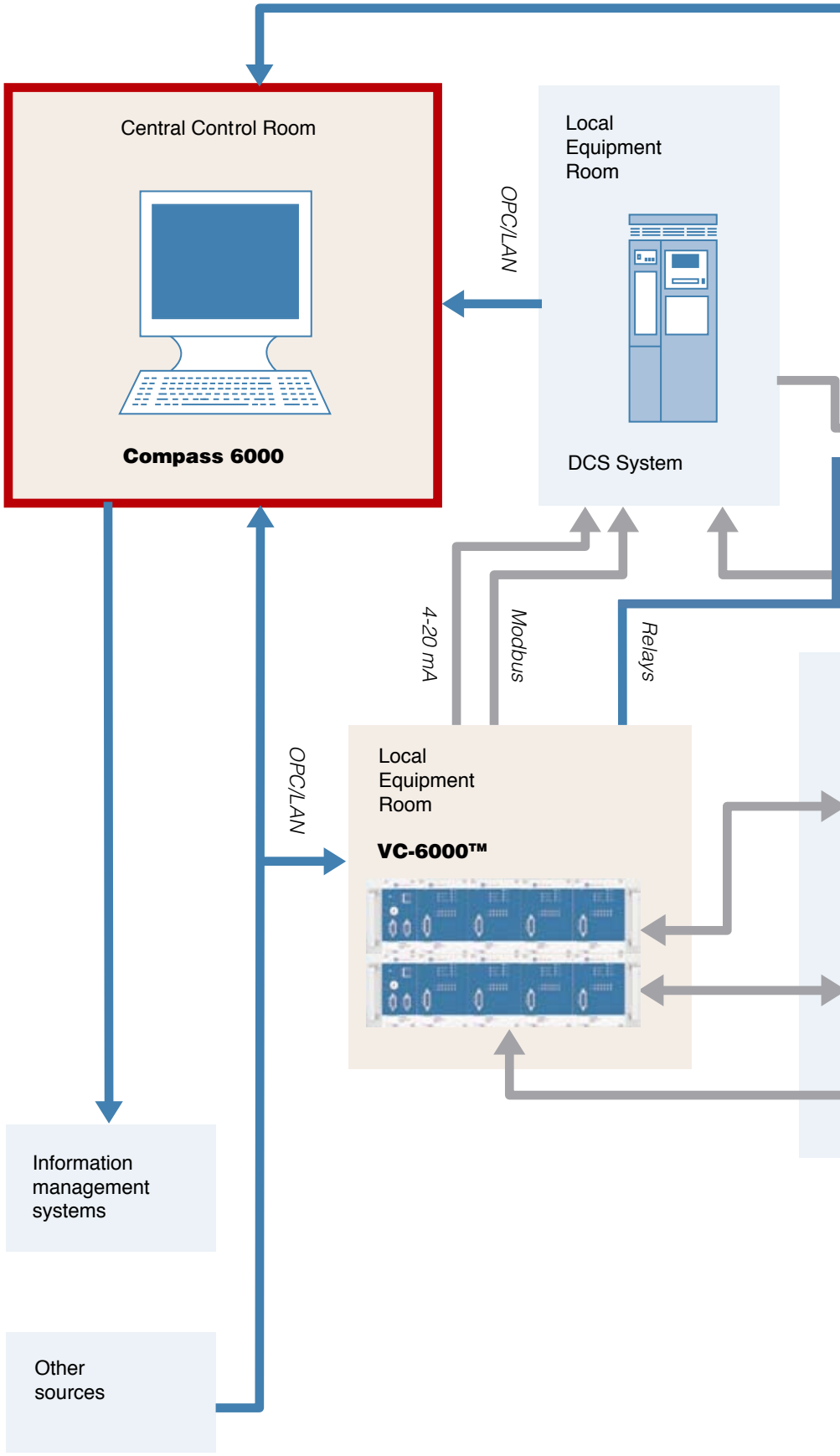
There are many configuration possibilities available with sensors, cabling, signal amplifiers and barriers. The VC-6000™ monitoring hardware offers application-specific modules for safety and condition monitoring. Performance monitoring requires no installation of additional sensors, as process data are imported from a DCS.

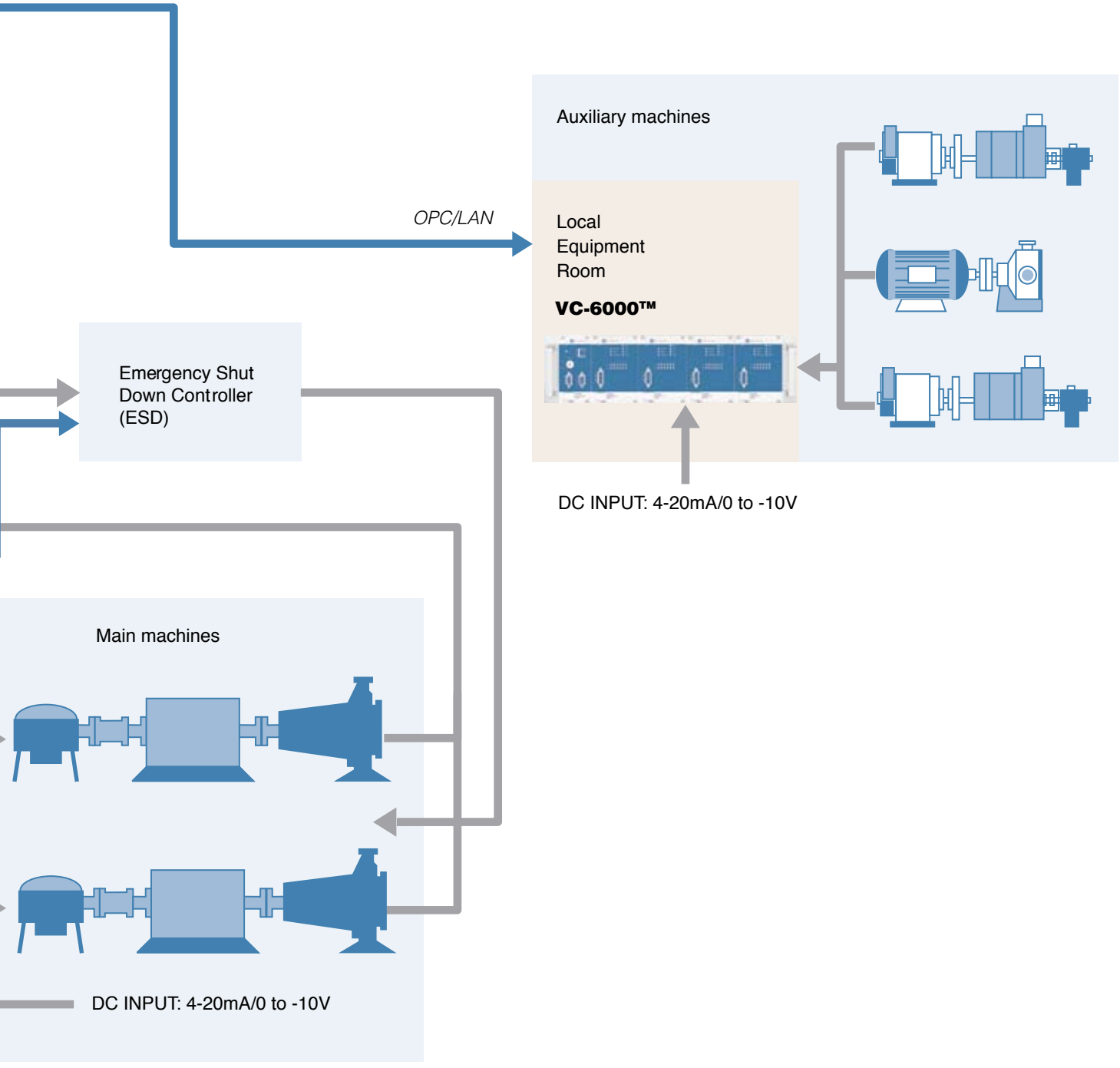
System interconnectivity

Compass 6000 condition and performance monitoring capability can easily be added to an existing safety system. The OPC interface allows data to be exchanged with other systems such as the DCS and information management systems. A dual modbus connection can be used for sending critical information such as alarms, relay positions and overall vibration values to the DCS.

Remote access

Compass 6000 is web-enabled. Data and monitoring setups can be accessed and changed from anywhere using a web browser. Security is ensured since customised information can be accessed by users with user-specific privileges. Even data from other systems can be remotely and automatically imported to Compass 6000.




Auxiliary machines
OPC/LAN
Local
Equipment
Room
VC-6000™
Emergency Shut
Down Controller
(ESD)
DC INPUT: 4-20mA/0 to -10V
Main machines
DC INPUT: 4-20mA/0 to -10V

Brüel & Kjær Vibro A/S 2006 • Graphic Design: Gitte Blå • Photo: Brüel & Kjær Vibro and SCANPIX • BBR0023-EN -14

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