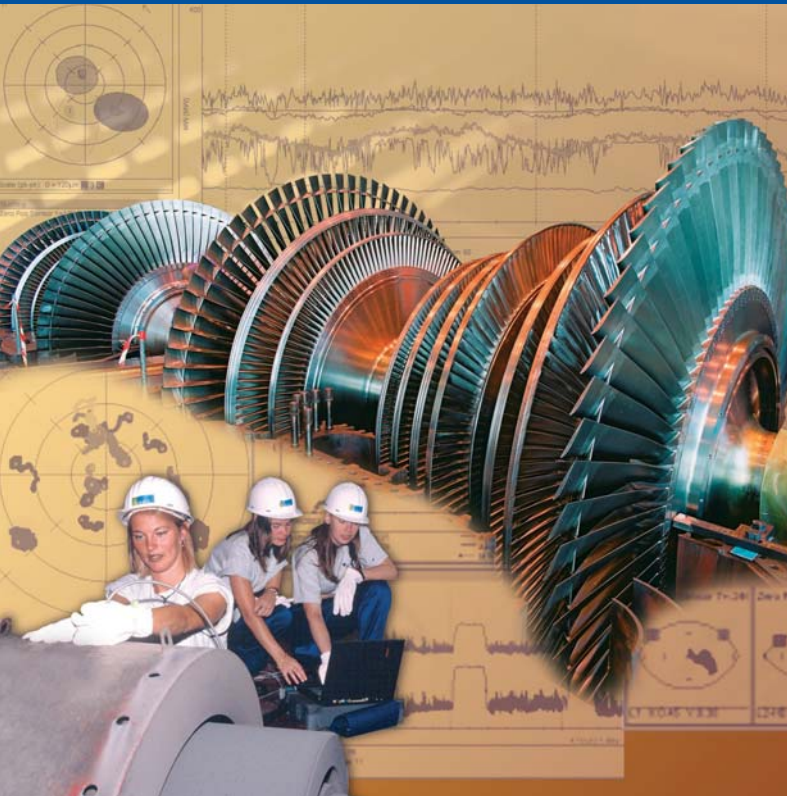


Efficient vibration monitoring  
creates substantial savings  
over your turbogroup's life cycle



# LVMS

A Laborelec product



**LABORELEC**

The technical Competence Centre  
in energy processes and energy use.  
**From R&D to operational assistance.**

## Monitor the heartbeat of your machine ...

What precisely happened with your turbogroup just before, during, and after the alarm sounded or the machine tripped? LVMS will tell you. LVMS is the most comprehensive system for industrial vibration monitoring. It is well-suited for all types of power plants. It continuously measures your machine's vibrations for a precise analysis of its true condition. It is arguably the project manager's most valuable tool for any greenfield project and for operational or maintenance managers throughout the total life cycle of their turbogroups.

### By and for power industry

Laborelec electricity generation experts have been building up their experience with power plants since 1962. They specifically developed LVMS for the power industry, based on that experience. LVMS is entirely independent from machine manufacturers. It is no surprise that the system is already in use in dozens of power plants all over the world. The system has been updated frequently, always based on the insights provided by numerous analyses campaigns on all kinds of turbogroups.



*Thanks to its accuracy, LVMS gives you the best possible insight into the mechanical aspects of your turbogroup throughout its complete life cycle.*



## ... and achieve substantial cost savings throughout its total life cycle

The consistent implementation of condition-based maintenance strategies requires knowledge about the actual condition of your machines. Thanks to its thoroughness and elaborate analysis capabilities, LVMS provides this insight much more accurately than the usual vendor-dependant vibration monitoring systems. This leads to considerable cost savings on top of the traditional merits of vibration monitoring.

- **In a greenfield project - Reduce start-up costs**  
Detect faults right from the start, and bring your new electricity generation units onto the net without any surprises, at the same time increasing the accountability of your contractors. **p. 4 and 5**
- **During normal operations - Increase the availability and reliability of your generation unit**  
An intelligent alarm system allows you to detect any deviations before they develop into severe damage. This increases the reliability of your installation, saves you time and reduces the costs that come with unplanned outages. **p. 6 and 7**
- **Preparing for and finishing off overhauls - Improve maintenance planning**  
Identify the machine elements that need special attention, and take them into account for the precise planning of your next scheduled overhaul. And then reduce start-up time and cost after the overhaul. **p. 8 and 9**

## LVMS investment made to measure

**p. 10 and 11**

Laborelec has a tailor-made LVMS offering, just right for your power generation unit.

- **Most profitable investment scheme**  
You can rent, lease, or buy an LVMS installation. Together with your team, we calculate which investment scheme is the most profitable in your particular circumstances.
- **All or only the necessary functions**  
LVMS comes stand alone, or with remote monitoring. You can purchase the complete hardware package or couple LVMS to existing vibration instrumentation. You have all the most effective options available to cover your exact needs.
- **A range of services**  
Laborelec offers a full range of services with LVMS, from a permanently available helpdesk and an upgrade contract, to incident analyses and training. We help you maximize your return on the investment in LVMS.

# Seamless commissioning and start-up



*How well can you evaluate your turbogroup's commissioning? Have you truly detected all errors in the machine before the warranty period expires? LVMS reduces the level of uncertainty regarding the mechanical behaviour of turbogroups; always a major concern for greenfield project leaders. It helps detect any deviations from normal behaviour. By focussing everyone's attention on the right issues at the right time, LVMS helps allocate budget and time resources to actions that keep the project on schedule.*

## LVMS follows vibration evolution from the first firing

### Puts the Project Leader in stronger position vis-à-vis the manufacturer

'Our new power plant was exhibiting abnormally high vibration levels for a new group. The relative vibrations exceeded the recommended ISO standard value for a new machine. Laborelec's analysis of the LVMS vibration data concluded that the machine was sensitive to imbalance changes. They also saw that the generator bearing supports moved over time. After several attempts by the manufacturer to solve the problem, the successful Laborelec proposal was to realign the machine and to rebalance it. Thanks to LVMS, Laborelec not only identified the problem as being abnormal for a new machine, they also helped us definitively solve it.'



*Renaud Desclee -  
Assistent greenfield  
project leader in  
Vilvoorde power plant  
Owner: Electrabel -  
Total capacity steam  
and gas: 400 MW*

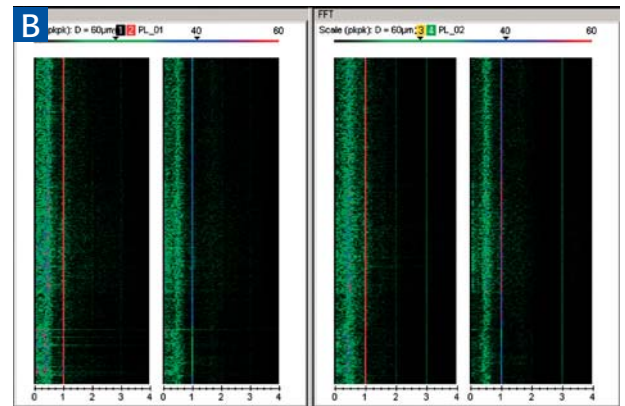
### Why choose LVMS ?

- **A reference fingerprint from day one increases accuracy of all future diagnoses**  
LVMS records the original vibration signature of your machine. This will be your reference for all future analyses. It enables you to diagnose changing vibration behaviour much more effectively throughout the life cycle of the turbogroup.
- **Precise analyses smoothes the start-up of your new installation**  
With LVMS, you can diagnose the exact cause of an alarm. This allows you to take appropriate corrective measures before suspicious behaviour can cause irreparable damage to your new turbogroup. Less hassle, less time lost, and less costs.
- **Accurate measurements increase the accountability of greenfield subcontractors**  
LVMS and the Laborelec vibration experts are contractor independent. The software helps identify the true cause of the fault based on objective measurement results. An open discussion with the manufacturer on the evolution of vibration behaviour increases confidence in machine reliability at commissioning.



The Baymina power station is equipped with two gas turbines and one steam turbine. Total power output is 770 MW. (Tractebel (Groupe SUEZ), Turkey)

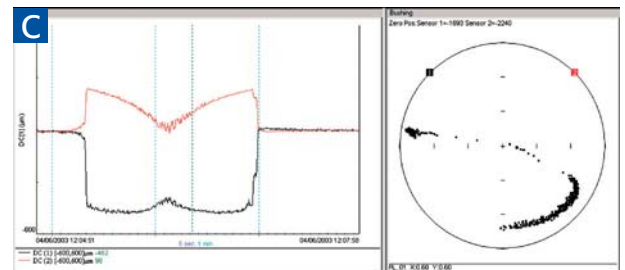
### Fast Fourier Transform plot and bushing diagram



FFT plot as a function of time. The amplitude of the peak at each frequency is indicated using a colour scheme.

The results of the Fast Fourier Transform can be represented in different diagrams, indicating the frequency components as multiples of the unit's rotation speed. Positive and negative frequency components can be shown, as desired by the user.

Diagram B shows the frequency components of the relative shaft vibrations at both ends of a high pressure steam turbine. Besides the predominant first harmonic vibration, the coloured dots in the subharmonic region indicate significant vibration peaks near the resonance frequency of the high pressure rotor. Further analysis showed that these vibrations typically occur with certain valve positions of the steam turbine.



Evolution of the position of the shaft in one bearing when a valve is closed and opened.

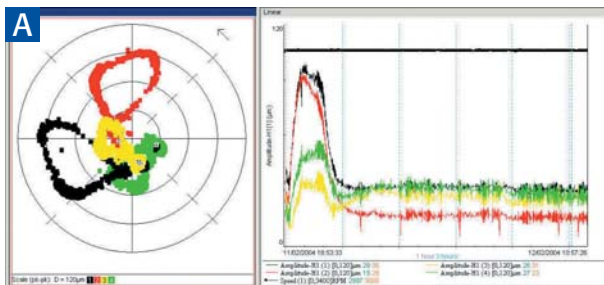
The bushing diagram C is an important tool for the analysis of such phenomena. This diagram shows the variation of the intermediate shaft position in a measurement plane, compared to the available clearances in that plane.

Analyses showed that the shaft lacked support stiffness in one bearing. Replacing the bearing solved the problem.

LVMS followed up the commissioning of the plant, allowing accurate diagnose of vibration behaviour in the start-up phase. This saved significant time and money.

### Some examples:

#### Polar diagram of four vibration sensors



The diagram A is a vector representation of the measurement results of four relative shaft vibration sensors. The sensors are installed at the turbine and compressor bearing of a large industrial gas turbine unit.

The plots show the evolution of the shaft vibrations after a significant load change. The vibrations vary considerably in amplitude and phase. The combination of polar diagram and time plot enables an easy analysis of the occurring time constants of the variations. Analysis suggested that this phenomenon was due to a problem with rotor expansion, possibly combined with a rub incident. Further follow-up is necessary.

# Smooth operation without unplanned shutdown

*An important task in day-to-day power plant operations is ensuring a high availability while safeguarding machine dynamics. LVMS helps you detect any important changes in vibration behaviour before they cause a machine safety mechanism to trip or result in damage. With LVMS, false alarms are history. Your analysis effort is always effective and you can often keep your turbogroup running safely with only minor adaptations. You can then properly prepare for a permanent solution of the issue at the next planned stop. This LVMS early warning system and swift analysis saves you a considerable amount of money.*



## Remote monitoring:

### Fast access to accurate analyses

'Two minutes. That is how long it took Laborelec experts to get started with the analysis of a vibration problem in our power plant. They logged onto our network remotely and accessed data that our LVMS system had stored. Thanks to Laborelec's wealth of experience, they quickly discovered that the subharmonic vibration that tripped our unit was caused by insufficient clearance at an oil seal on the turning gear installation. Luckily, we found out in time, avoiding days of inspection and high costs for the unplanned shutdown. Thanks to Laborelec, we could restart the unit after only a small intervention, and with the full confidence that the problem was solved.'



*Johan Derks - General Manager  
Gelderland power plant,  
the Netherlands  
Owner: Electrabel -  
Capacity: 620 MW*

## Why choose LVMS ?

### ■ Investigating genuine alarms reduces stress and saves unneeded expenses

LVMS has an intelligent alarm system that prevents a warning being given when it is not strictly necessary; for instance, when a sensor is defective. This also keeps operators sharp: they know that every LVMS alarm requires swift action.

### ■ Early corrective measures prevent expensive future damage

Genuine alarm signals are given before suspicious vibration behaviour can cause any serious damage. Moreover, the system is self-learning, reducing the operator intervention needed in configuring alarms, while ensuring close monitoring of the vibration behaviour.

### ■ Quickly identifying the real cause of vibrations keeps the machine up and running

In many cases, you can adjust the machine operation to avoid harmful vibrations, keeping the machine fully operational until the next planned stop. In other words, LVMS helps you avoid unplanned stops and related penalties.

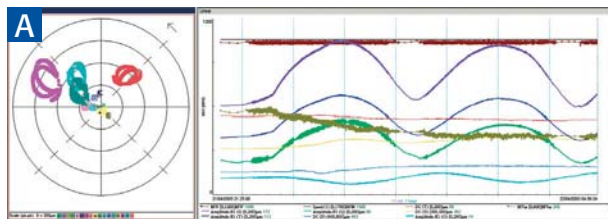


The steam turbine of the 1100 MW capacity nuclear production unit of Doel 4 (Electrabel, Belgium)

Early and correct alarms allow the identification of changes before they become expensive problems.

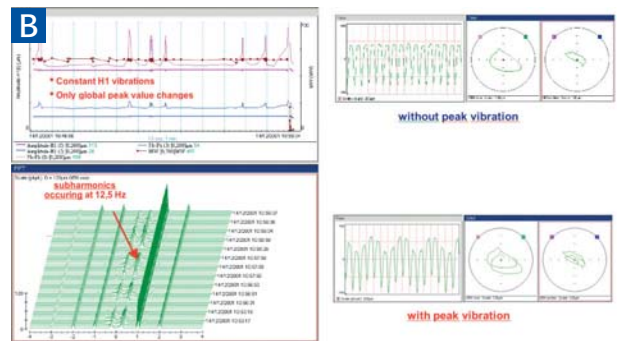
**Some examples:**

**Typical polar diagram and amplitude diagram showing a rubbing phenomenon**



The polar diagram A shows a continuous significant variation in both phase and amplitude of the first harmonic of the vibration signal. The amplitude diagram confirms the conclusion of slow, periodic change in vibrations, with a time constant of 3 to 4 hours. This is a typical diagram resulting from a rubbing phenomenon. Laborelec located the rubbing in the hydrogen seal of the generator. No particular actions were necessary. The phenomenon was kept under control by changing the sealing oil parameters, and disappeared after the next planned stop.

**Raw signal diagram and Fast Fourier Transform plot**



The raw signal diagram B shows the basic vibration signature of a turbogroup. The signal obviously varies, with two frequencies. The Fast Fourier Transform (FFT) plot clearly shows subharmonic vibrations at 12.5 Hz. Analyzing the LVMS data, Laborelec discovered that this phenomenon was caused by a partial rub condition, exciting the first critical speed of the generator. Laborelec experts identified the problem as too small a clearance in an oil seal near the generator. The problem was solved by increasing the clearance.

**The time bar**

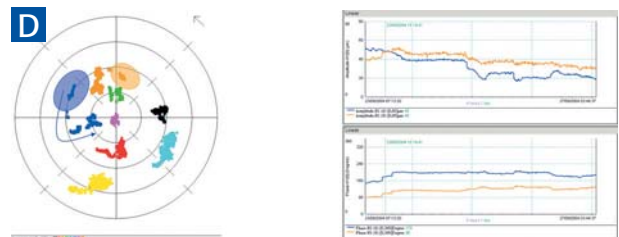


The time bar C is a unique user-friendly tool in LVMS to enable easy selection of data. Analyses are performed faster, thanks to the data filters that are operated through this tool and that direct the operator to the relevant data.

**A linear and a polar diagram**

Any unplanned change in amplitude or phase of a vibration signal is a phenomenon that should be investigated. That is why the LVMS alarm can be triggered if the vibration amplitude is increasing as well as if it is decreasing.

The density of measurement data that are recorded automatically increases before and during an alarm phase. This provides vital information for later analyses.



The polar diagram D shows the confidence zone and the first jump of some vibration vectors, leading to the first alarms long before the evolution is noticed in amplitude trends.

# Well prepared and completed overhaul

**Minimum downtime during an overhaul is only possible when you prepare for every minute detail. LVMS helps you with that. By performing a thorough analysis of all vibration signals beforehand, you know exactly where special attention needs to be paid, and what part of the machine will most likely need to be inspected. And after the overhaul, LVMS is also the ideal tool to verify that every part of your installation is back to optimal operational specs. You can confidently start-up your machine safely and in the shortest possible time frame.**

## Temporary LVMS installation

### Smoothly back on the net after overhaul

'We called upon Laborelec and their LVMS to perform a temporary measurement campaign in our combined heat and power generation unit. In the weeks preceding the overhaul, they recorded the vibration signature of our machine. After the overhaul, LVMS assisted us in verifying that our machine was reassembled correctly, and that it was operating within satisfactory vibration limits. Laborelec's expertise helped us minimize the necessary balancing actions. This project made us realize how much added value LVMS offers us. That is why we decided to permanently equip our turbogroups with an LVMS. Since the installation, we have performed three major overhauls on the gas turbines we operate. In two cases we had to make balancing adjustments after the overhaul. Thanks to



*Kees van den Berk is Operations Manager at the Moerdijk power plant from Essent Capacity: 339 MW*



LVMS, these balancing actions were realized within the shortest possible time.'

## Why choose LVMS ?

### ■ Detailed analyses help focus on the essentials during overhaul

With LVMS, you can determine beforehand what elements of the machine train need attention during shutdown. This not only allows you to plan the necessary maintenance work, it also avoids unnecessary efforts spent on machine elements that are operating correctly.

### ■ Balancing is easier and less time consuming

With LVMS equipment already in place, you need only minimum effort to balance your turbogroup after a major overhaul. Fine tuning is possible during the next planned shutdown, based on the data available from the on-line monitoring during the last operation period.

### ■ Comparing vibrations before and after a shut down speeds up fault detection

Comparing the LVMS data after an overhaul with the signature from the period prior to the overhaul allows a complete analysis of the post-overhaul behaviour. This will provide you with essential information to evaluate the impact of executed maintenance actions, or improve troubleshooting of newly occurring problems.



The 40 MW combined heat and power unit at the Esso site in Antwerp (Electrabel, Belgium).

A temporary LVMS measurement campaign helps in defining the most appropriate alignment after the overhaul. Comparing the post-overhaul LVMS data with that taken prior to the overhaul confirms that the vibration level has been reduced to a satisfactory level.

**Some examples:**

**Reducing balancing time to a minimum**

With a turbogroup that is equipped with LVMS, the expert user has on-line access to all relevant data that are necessary for determining the balancing actions.



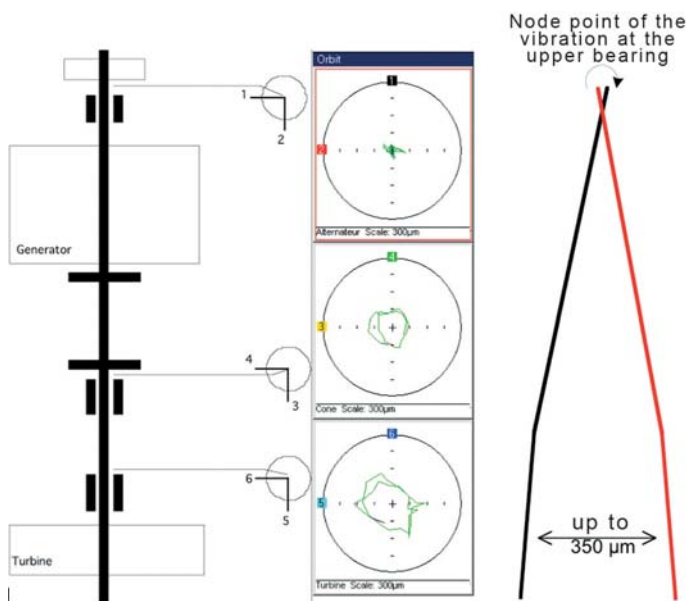
Placing a 170 gr weight at the compressor inlet during a balancing campaign of a gas turbine.

**Evaluation of your overhaul**

During the overhaul of a hydraulic turbogroup, an alignment problem was identified at the coupling between turbine and generator. To avoid an unplanned outage, the machine was started anyway, after minor balancing efforts at the generator side. LVMS was installed to monitor the vibration level, resulting in an advice to rebalance the turbine as well. These measures will allow the machine to continue producing safely until the next planned shutdown.



Storage reservoirs of a hydraulic power plant



Engine room of a hydraulic power plant

# LVMS made to measure

***LVMS can be adapted to the specific needs of any power plant and set of measurement equipment. It can be as limited or as comprehensive as you choose. Laborelec can propose an adapted financial formula that fits your budget and investment policies.***



*Laborelec installed a temporary LVMS system at the Al Taweelah (United Arab Emirates) facility to monitor and then analyse the data to advise them on the best solution for vibration problems at their steam turbine.*



*The Rodenhuize power plant has had a very cost effective LVMS assistance contract with Laborelec since 1985.*

## Temporary LVMS installation

You can choose a temporary LVMS installation. This limited formula connects LVMS to your existing vibration monitoring system to acquire measurement data. This formula can be particularly useful in the analysis of acute incidents or during overhauls. You can decide whether you want Laborelec to analyse the measurement results or do it yourself.

## All-in formula

Most operators want their turbogroup to be permanently monitored, with every alarm signal analysed. That is why they call upon Laborelec. We give purchase advice on the most appropriate instrumentation for vibration monitoring. We can also execute a mutual assistance agreement. This means your LVMS equipment remains up to date and completely reliable as your needs evolve.

## Balanced investment

Laborelec offers you the best available expertise in a complete package. Monitoring and analysing the mechanical condition of your turbogroup is one of the aspects of that service. LVMS is the best tool for that type of monitoring and analysis available on the market. Laborelec, together with your specialists, evaluates your needs and offers you the most appropriate and cost-effective LVMS formula.

- You can **rent** the LVMS equipment for temporary measurement campaigns.
- We offer several financing formulas for **buying and leasing** if you want to permanently equip your turbogroup with an LVMS installation.

## Flexible configuration

- **Remote monitoring:** to save time and cost, you can have Laborelec experts log onto your system at any time you wish, using a modem or available network connection. The confidentiality of your data is, of course, ensured at all times.
- **Universally compatible:** connect LVMS to the existing vibration signal acquisition system on your turbogroup, regardless of the manufacturer. Or Laborelec can deliver LVMS and advise on the purchase of the necessary instrumentation to integrate it into your power plant.

## A full range of services

- **Incident analysis:** analyzing an occasional vibration incident is not a sinecure. You may want to take advantage of Laborelec's years of expertise to do the job for you. This results in a comprehensive, independent investigation and report of the incident, with advice on the most appropriate corrective measures.
- **Follow-up before and after overhaul:** an overhaul must be well planned down to the last detail. Laborelec helps you prepare the overhaul by analyzing LVMS measurements and indicating exactly those parts that need special attention. After the overhaul, our experts verify the vibration signature to check that the turbogroup runs smoothly.
- **Permanent helpdesk:** you can negotiate a custom helpdesk agreement with Laborelec, categorizing possible incidents and agreeing on the required response time for each category. Our helpdesk can be on standby every hour of the day, every day of the year.
- **Assistance agreement:** besides all services for maintaining the correct functions of hardware and software, this can also include an annual report about the vibration behaviour of your machine. You'll receive that report several weeks before the next overhaul, so that you can meticulously plan the interventions that will be necessary according to the report.
- **Training:** Laborelec provides thorough training sessions in the use of LVMS and the correct interpretation of data. We also train your operators and maintenance officers when you buy the software. And when new operators or maintenance staff start working at your site, we can provide training for them as well.



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**Five reasons for you to choose Laborelec:**

- you have one-stop shopping for your energy needs;
- you get access to more than 40 years of experience;
- you get rapid service with reliable solutions;
- you increase the profitability of your installations;
- you benefit from independent and confidential advice.