

DOSSIER ON NATURAL GAS TECHNOLOGIES



Expertise in all aspects of gas technologies

Laborelec is continuously expanding its expertise in various domains of power plant infrastructure, including natural gas technologies. This edition of Laborelec News will concentrate on the latter, demonstrating our expertise in, among other things, chemistry, vibrations, and materials used in natural gas power plants. We also show how our specialists collaborate across domain boundaries to enhance overall power plant performance.

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Detection of combustion chamber defect in Saint-Ghislain

Leaking casing replaced, similar casings examined

Laborelec discovered poor welding quality at different points in the combustion chamber casings of the Saint-Ghislain Combined Cycle Gas Turbine (CCGT) power plant. The casings will be replaced with new ones that will be inspected and approved in our laboratory before final acceptance. As a result of this incident, we will also develop a quality assurance plan as an advice for the casing manufacturer.

The investigation was initiated after the operator experienced an unexpected temperature increase in the anti-noise casing. The unit was shut down and a visual inspection carried out. This revealed a leak in the weld of a forward casing of the combustion chamber. Laborelec conducted a non-destructive examination on several other installed casings, using its ultrasonic Phased Array tool. We found a similar weakness in one of these casings.

Welded joints were weak and unstable

Destructive analysis of the leaky casing revealed that poor welding had caused the problem. We examined four welds (two interior and two exterior) and found that all of them were of bad quality. The outside welds were especially problematic, since examination of the crack through the weld showed very limited oxidation, indicating that the failure was both rapid and recent.

Eighteen spare casings were available at the Eems Power Plant in the Netherlands. We had three of them sent to our laboratory for non-destructive testing. This inspection, using the same Phased Array tool, revealed similar welding quality problems.

Follow up the manufacturing process of new casings

Based on the risks and economic consequences, we proposed a non-destructive examination of all available spare parts and the selection of the best of them in case an emergency replacement is needed on site. We recommended negotiating with the manufacturer for the replacement of the sub-standard casings. We also recommended ordering new casings and the development of a quality assurance plan for a thorough follow-up of the manufacturing process of these casings.

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Multidisciplinary research traces the origin of filter degradation

Gas turbine and generator air filters in SUEZ Combined Cycle Gas Turbine (CCGT) power plants in Italy and Oman showed unexpected signs of degradation and even failure. Laborelec traced the origin of this degradation thanks to a comprehensive multidisciplinary research effort.

Both air filters were examined in our laboratory in three steps. We first measured the pressure drop over the filter and compared this with data sheets from the manufacturer and reference measures on clean filters. We then analyzed samples from the filtered substances to determine the possible origin. Finally, we carried out destructive analyses to obtain a complete profile of the filters.

The history of the Oman filter was unknown, but the visual analysis clearly showed a complete penetration of the filter material. This was due to a prolonged exposure to desert sand, so the filter was not replaced on timely basis.

This could not be the case in Italy however, since these filters were only two months old. The filter was intact but covered with a layer of dust that contained elevated concentrations of salt and sulphur. We discovered that this probably came from the construction of a new asphalt road nearby, a non persistent problem.

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The visual analysis of the Oman filter clearly showed a complete penetration of the filter material.

Comprehensive study of CCGT power plants inlet air systems

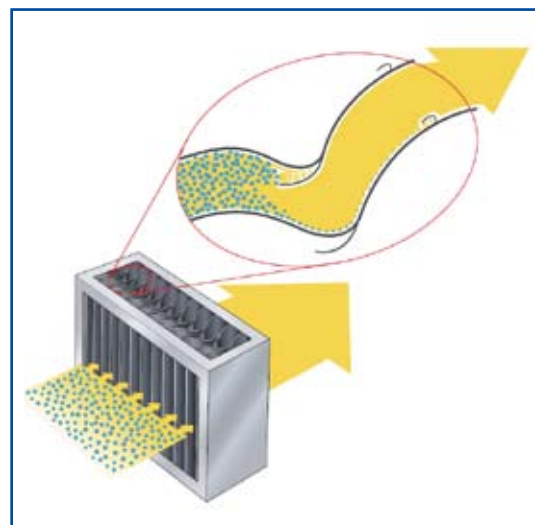
Clear recommendations on filter quality and housings

Considering the importance of an effective air-conditioning system on the performance of gas turbines, Laborelec conducted a comprehensive study of the installed systems in the eight Belux Combined Cycle Gas Turbine (CCGT) plants. We subsequently provided clear recommendations regarding filter quality, appropriate filter housing design, and the use of droplet catchers.

A CCGT power installation typically draws up to 600 kg of air per second through the compressor into the combustion chamber and the turbine. Along with that air, dust is also drawn in that can cause erosion and/or corrosion of the turbine components as well as obstruction of cooling holes. Air filters are installed at the inlet to help avoid such problems. We examined the available systems in each of the eight CCGT power stations in Belgium and Luxemburg and focused particularly on the types of filters used, the design of their housing, and the availability and design of a droplet catcher. We also recorded the replacement frequency of various filters.

Standardize the filter housing design

Based on the survey, we made several clear recommendations, the first of which was regarding filter quality. Using the highest quality filters (and thus the most expensive) is only justified in base-load power stations where there is no time for off-line washing of the compressor to get rid of accumulated dust. In stations where the production is regularly stopped, a more moderate and less expensive filter quality can be used. We also observed a trend towards three-stage instead of two-stage filters, especially in base-load power stations. This requires an appropriate filter housing design with at least two filter frames, each capable of holding two filters. We recommend standardizing the filter housing design on all gas turbines.



To avoid pressure drops due to fog agglomerating on the filters, a carefully designed droplet catcher should be placed at the filter inlet.

Carefully dimension the droplet catcher

In the Belux climate, filter performance can suffer from fog and rain. Water drops can settle on the filter surface causing large pressure drops. To avoid this, a droplet catcher should be placed at the inlet. Some of the stations examined did not have one; in some others, it was not appropriately dimensioned. We recommend that the droplet catcher always be carefully designed based on geometry and operational parameters of the particular gas turbine.

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Diagnostic Centre detects faults at an earlier stage

New monitoring tool spots anomalies in gas turbine behaviour

Early fault detection in gas turbine units helps prevent costly unplanned outages of power generators. The Generation Diagnostic Centre now uses SmartSignal as a tool to detect subtle anomalies even before they become apparent in the performance of the unit or in other traditional monitoring systems. This early detection enables preparations for detailed analyses and eventually appropriate preventive action.

Laborelec uses a series of dedicated measuring systems such as LVMS for vibrations and the combustion dynamic monitoring system programmed in Labview. These systems developed by Laborelec enable detailed analyses of the gas turbine behaviour in specific respects, but they are not always suitable to signal possible faults at a very early stage.

Smarter than the detection of peak values

We selected the SmartSignal predictive monitoring tool, which is designed for just that purpose. It was originally developed for the Aircraft Industry to monitor the behaviour of jet engine turbines and was first used in the electricity industry to monitor the U.S. Comanche Peak and Palo Verde nuclear units.

The system collects real-time measurement data from various sources and compares it to statistical models based on historical data. Whenever significant differences arise between measured values and expected values, the system generates warnings. This kind of statistical analysis is much smarter than the detection of peak values.

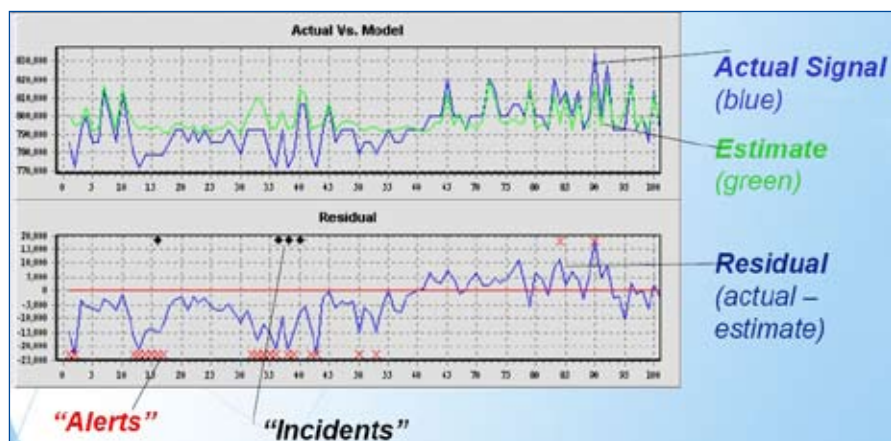
Schedule measures to prevent unplanned outages

The system monitors all types of relevant variables. These include such things as temperatures, pressures, valve positions, flows, vibrations, combustion dynamics, etcetera — approximately 800 variables in total, depending on the type of plant. Models are built based on historical data collected in systems like PI, typically over 1 year.

Based on SmartSignal warnings, the Diagnostic Centre advises whether additional analyses should be executed using LVMS, the combustion dynamic monitoring system, PI, or other appropriate tools. In some cases, we advise visual inspections at the next production halt. This procedure enabled Laborelec to recently detect two problems in the Eems Power Plant at an early stage, allowing for appropriate preventive action.

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The system generates warnings whenever significant statistical differences arise between measured and expected values. This enables earlier detection of problems than total reliance upon the traditional peak analysis method.

Gas turbine training session for SUEZ Energy Generation North-America

In February 2008, Laborelec conducted a training session on gas turbine materials at the Hopewell Power Plant in the U.S. This training was aimed at improving the general knowledge of plant personnel regarding how to deal with component failures, what material characteristics they have to pay particular attention to when buying components, and what the hot gas path of a power plant looks like.

Laborelec has been providing training on gas turbine materials over the last decade for non-engineering power plant personnel such as maintenance workers. The training sessions take a total of two and a half days and provide the participants with such information as the different types of gas turbine materials, the characteristics of super alloys and high temperature coatings, and how the lifetime of gas turbine components are assessed.

During the sessions, our experts supplement theory with interesting practical case studies, typically focusing on root cause analyses of component breakdowns. Those cases are illustrated with damaged parts brought along by the instructors.

Over the years, the training course has been given at numerous European power plants within the SUEZ Group, and adapted as needed to new trends, findings, cases, and local standards. In February 2008, SUEZ Energy Generation North-America (SEGNA) invited Laborelec experts to give their first gas turbine training session on American soil. Fifteen staff members of various SEGNA power plants in the U.S. attended the training sessions. 'Thanks to this training session,' one of the attendants stated in the evaluation form, 'I now know what I have to pay attention to when buying and testing new components for our turbine.'

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Helping pinpoint the cause of vibrations in a Baymina gas turbine

After only a few months of operation, both bearings of one of the gas turbines of the Baymina Power Plant in Ankara, Turkey showed significant vibrations. Close collaboration between the power plant operator and Laborelec helped reveal the true cause of the problem.

After installing the Laborelec Vibration Monitoring System, our experts were able to point out some probable causes for the high vibration levels. Among other things the vibrations could be related to a problem with the expansion of the gas turbine or a rub in one of the bearings. During an inspection of the gas turbine bearing, the Original Equipment Manufacturer (OEM) discovered and removed deposits inside the bearing's seals. However, this did not stop the vibrations.

The power plant operator indicated that there was a correlation between the vibrations and the temperature in the seals at the turbine's exhaust. Subsequently, the exhaust frame and bearing fans were supplied with additional cooling. As a result, vibrations decreased significantly.

When examining the OEM's inspection report, Laborelec's experts noticed the deposit inside the seals was in fact coke. Overheating can transform the oil into coke. When the coke is in contact with the rotor, this will create a rub that could lead to excessive vibrations.

Re-inspection of the bearing showed that coke had again formed. The re-inspection also revealed a gap between the upper and lower half of the exhaust frame casing, causing cooling air to escape. These findings could explain the high temperature in the bearing area, the formation of coke, and the vibrations.

Since the gap in the exhaust frame has been stopped, the vibrations no longer occur.

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Stress relaxation tests determine creep behaviour

Cutting test times from months to days

Laborelec is among the first in Europe to determine a material's creep behaviour in only a few days time, by using stress relaxation tests. Our research has confirmed that the new method is a valid alternative for conventional creep tests, but the results are generated many times faster and without sacrificing valuable samples.

One of the crucial aspects during lifetime assessment of gas turbines is establishing the remaining creep strength of the blades. To determine this, samples are taken from the root of the blade to serve as a reference sample and from that part of the blade which is exposed to the highest temperatures.

Results in only a few days time

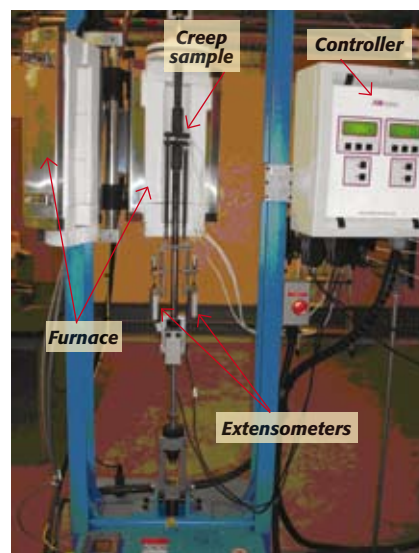
During conventional creep tests, the samples are exposed to a constant temperature and stress until rupture. This may take from weeks to several months. Laborelec experts can now employ a method to drastically reduce the testing time and without sacrificing the original samples. During stress relaxation tests, testing equipment applies a constant strain at constant temperature. As soon as the sample is strained e.g. 0.5%, the total strain is kept constant and stress is allowed to gradually relax. Monitoring this rate of stress relaxation enables our experts to mathematically calculate the material's creep rate. The entire test only takes a few days.

Repetitive testing on original sample

Unlike conventional creep tests, stress relaxation tests are practically non-destructive. Since the sample deforms only slightly (approximately 0.5%) the original sample can be tested repeatedly. Such repetitive testing can be used to confirm the reliability of the initial test results.

Classical creep strength tests remain useful

Laborelec experts have discovered that the results of stress relaxation tests are consistent with the results of the conventional creep tests. This however, does not mean that classical creep tests will no longer be used. Stress



Laborelec has invested in new stress relaxation testing equipment

relaxation tests only reveal information on the current creep state of the material, whereas the conventional creep tests reveal information on various degradation mechanisms in the material's micro-structure.

Laborelec will continue using both stress relaxation tests and conventional creep tests, during lifetime assessments as well as for research related to high temperature behaviour of materials and welds.

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