The Momina Klisura hydroelectric power station is the lowest in elevation of four hydropower stations on the Belmeken-Sestrimo-Chaira cascade on the Maritza river. It is heavily influenced by the perennial climatic changes of the region, so during periods of low rainfall, machine availability is critical. Downtime due to machine faults is unacceptable, making reliable monitoring vitally important.

**Challenge**
To install an integrated monitoring system that includes diverse techniques, and monitors these parameters for different operational conditions.

**Solution**
A comprehensive vibration and process parameter monitoring system was installed on two generating units at the hydropower station.

**Results**
Initial results have been positive, with the monitoring system also being used to help optimise safe operating loads for the hydro generating units.

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**Case study:** Brüel & Kjær Vibro | Integrated monitoring at HPP Momina Klisura
Background

The Momina Klisura hydroelectric power station in Bulgaria is the furthest down in elevation of a total of four hydropower stations on the Belmeken-Sestrimo-Chaira cascade on the Maritza river.

The two 60MW Francis turbines operate under a 251m head at 300rpm. The penstock takes in 54.4 m³/s flow from a canal exiting the upstream Sestrimo hydropower station and discharges it into the River.

Momina Klisura produced 174 GWh in 2006. Natsionalna Elektricheska Kompania EAD (NEK EAD) owns Momina Klisura, together with 30 other hydropower stations, with a total installed capacity of 2563MW.

The Momina Klisura power generation, as with the other Bulgarian hydropower stations, is heavily influenced by the perennial climatic changes.

Therefore, during periods of low rainfall, machine availability is critical. Downtime due to machine faults simply cannot be tolerated during these demanding periods. In addition to this, the varying reservoir levels plus the irregular hours spent on stabilising the grid results in varying loads on the generating units, thus making it difficult to effectively implement a time-based maintenance strategy.

Machine maintenance cannot be accurately predicted under these conditions, as the components wear at different rates. As a peaking station, the machines are more stressed compared to baseload applications and thus more prone to premature failure.

This is compounded by the fact that the machines have reached the end of their life cycle expectancy – Momina Klisura was commissioned in 1972.

The severe operating conditions and ageing equipment resulted in high operation and maintenance costs, low availability due to high failure rate, and low overall efficiency.

A major refurbishment was carried out to increase availability, reliability and efficiency, while at the same time ensuring conformity to the Union for the Coordination of the Production and Transport of Electric Power (UCPTE).

The rehabilitation work encompassed upgrading the turbine, generator, auxiliaries and the distributed control system (DCS).

As a consequence of the demanding operating conditions at Momina Klisura, a condition-based maintenance strategy was adopted to replace the primarily time-based one. Therefore, installation of an advanced machine condition monitoring system was also an important part of the rehabilitation project.

A comprehensive on-line vibration and process parameter monitoring system was installed in 2006. This was an important step in moving towards a condition-based maintenance strategy from the interval-based maintenance strategy.

Selection of a condition monitoring system was based on a monitoring strategy, which draws from the operational and maintenance experience mentioned above.
The basic overall requirements for the condition monitoring system were already determined by the power station operation and maintenance staff prior to the rehabilitation.

The primary objective of the rehabilitation and implementation of a condition monitoring system was to improve machine uptime, reliability and efficiency, and reduce maintenance costs.

Because of the demanding operational conditions at the plant and the maintenance experience acquired, it was decided that the primary machine components for monitoring would be the generator, turbine and shaft and bearings.

The objectives for monitoring these components were focused on:

- Detecting and diagnosing faults at an early stage of development so maintenance can be planned ahead of time.
- Optimising part load operation to avoid cavitation

The monitoring system selected to accomplish these objectives is described in the sections that follow.

After being selected, the monitoring system supplier conducted an on-site survey early in the year in the machine hall to facilitate installing the system.

This is not always necessary for off-the-shelf portable monitoring systems, but it is imperative for plant-wide permanently installed systems like the one selected for this application.

Some of the site survey activities included:

- Determining the type of sensors needed to fulfil the requirements of the monitoring strategy, and determine their ideal location for optimal signal response. This also included determining how the machine monitoring surface should be prepared, and making specialised brackets to support the sensors.
- Positioning the sensor conditioning units, signal wiring, junction boxes, and monitoring cabinet racks and properly grounding and wiring these.
- Setting up the monitoring system network and any other system communications.
- Determining how process data and digital signals are to be imported into the monitoring system from the distributed control system (DCS).
- Evaluating the ideal locations for the monitoring system servers, remote terminals and other computer peripherals such as printers.
- Collecting machine data to help with setting up the database.

“The primary objective of the condition monitoring system was to improve machine uptime, reliability and efficiency, and reduce maintenance costs.”
The solution

A number of measurements are done on the vibration and process signals coming from the sensors.

The generating units at Momina Klisura are frequently started up and shut down for peaking (often at part load), or used in a synchronised compensation operation to stabilise the grid. This places special demands on effective monitoring, since the vibration signature for the same measurement is different for the different machine states.

The monitoring system utilises an adaptive monitoring strategy so a measurement is monitored to alarm limits specific for each respective machine state. “Tighter” alarm limits give earlier fault detection with less risk for false alarms. The measurements are saved in the database separate from the same measurement in other machine states, so it is easier to identify trends.

The monitoring system is installed as a plant-wide system that includes sensors, data acquisition and conditioning units, a monitoring system server with a database, and remote access to operators and the distributed control system.

Training is very important for plantwide monitoring systems, because of the wide range of measurement techniques used, and the comprehensive nature of the technology.

The monitoring system operators and administration manager, as well as some of the control room operators, were trained in running the system for one week. Momina Klisura has a support agreement with the local agent for the monitoring system.

Only a conditioned-based maintenance strategy can be used on a multi-role hydropower application such as Momina Klisura.

The multiple starts and stops put extra loading on the machine components and the varying duty cycles make machine component wear unpredictable.

This kind of application requires an advanced machine condition monitoring system that is capable of detecting and diagnosing faults at an early stage of development using a number of vibration and process inputs from many machine components.

The wide range of measurement parameters then have to be monitored to individual alarm limits and stored in the database with respect to a specific machine operating condition.

The results

Because of the risk of cavitation occurring at part load at Momina Klisura, the monitoring system is also used for optimising the loads which can be safely operated by the hydro generating units.

An advanced condition monitoring system is critical for peaking applications, since downtime cannot be tolerated.

Because of the risk of cavitation occurring at part load at Momina Klisura, the monitoring system is also used for optimising the loads which can be safely operated by the hydro generating units.

An advanced condition monitoring system is critical for peaking applications, since downtime cannot be tolerated. In fact, any downtime at the baseload thermal power stations has to be compensated for at Momina Klisura.

The complete process of installing, fine-tuning and commissioning of the system was successful, but was not without mishaps. Some sensors were incorrectly installed or wired, and some of the measurements were incorrectly set up, but these were quickly identified during the commissioning.

Proper project management is vital when installing a plant-wide comprehensive monitoring system.