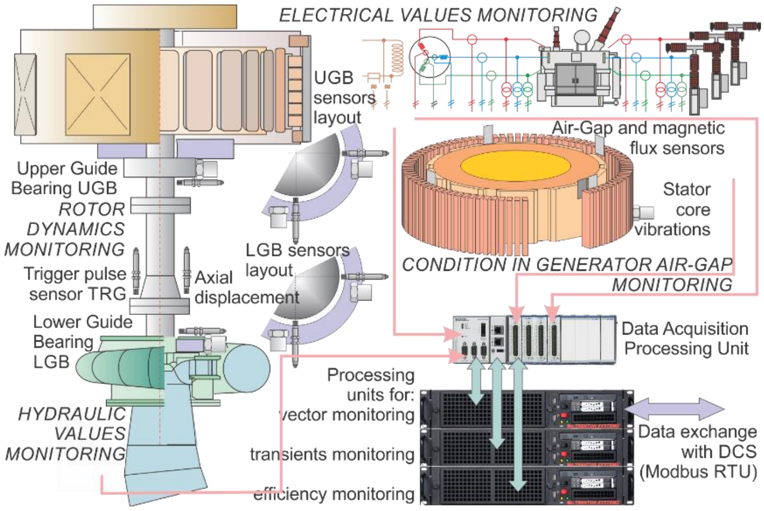
CASE STUDY – 04

Hydrogenerator Rough Load Zone (RLZ) mapping

Machine data:
Umbrella type hydro unit with 2 guide bearings (Generator guide bearing, Turbine guide bearing); Rated power: 30MW; Stator Bore Diameter: 5,65 m; Francis Turbine; Rated Speed: 187,5 RPM; Installed flow: Qi = 120 m3/s (2x60); Design head: Ht = 47 m; Maximum head: Hmax=56.5 m;

CoDiS Condition Monitoring System is installed on two identical units and consists of:

- 4 Relative shaft vibration
- 4 Absolute bearing vibration
- Axial displacement (two probes)
- 1 Magnetic Flux probe
- 4 Air Gap probes @ 90°
- Phase reference (and RPM measurement)
- Turbine cover vibrations
- Pressure under turbine
- Process quantities
- Electrical quantities
- Hydraulic quantities
- Efficiency measurement
- Cavitation monitoring



Problem: High dynamic instability in the Rough Load Zone (RLZ)

This case study describes application of already installed CoDiS on line monitoring system in the identification and analysis of the Rough Load Zone (RLZ) appearance on umbrella type hydro generator.

RLZ operation is often observed on hydro units with Francis-type turbines. It causes several irregularities (increased relative shaft and absolute bearing bracket vibrations, axial displacement oscillations, power swing etc.) which can be dangerous for the safe plant operation.

The analysis procedures installed in existing monitoring system were applied, as well as new procedures developed with the main objective to reliably detect RLZ operation. Based on the results of these analyses, procedures for unambiguous detection of RLZ operation were determined, and embedded into the existing system.

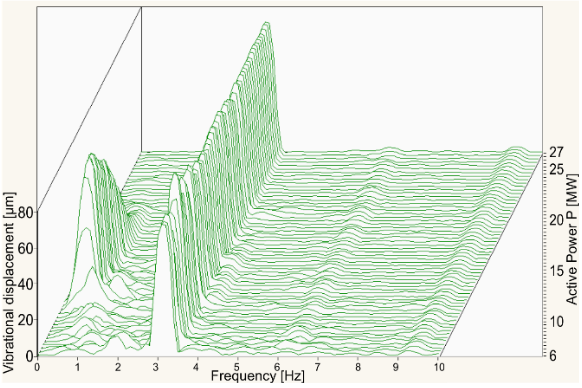
Data analysis and problem identification

On both hydro-units the effects of RLZ operation were noticed in Low load/High head operation modes. According to the plant's crew perception, over time, intensity of these phenomena increased. Consequently, decision was made to investigate RLZ appearance and its consequences.

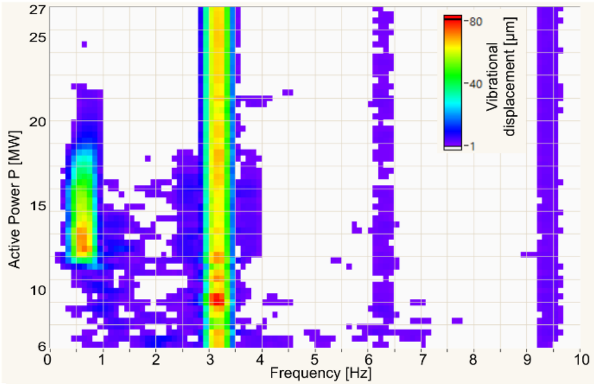
CoDiS system is suited for real time analysis and trending of all important signal components including the components required for RLZ detection such as Low frequency band < 1Hz, calculation of Smax (maximum shaft displacement in the measurement plane) coefficient - ratio between regular Smax and non-averaged one measured on long period (10 s – for low freq. component detection). CoDiS system characteristics made possible not only RLZ measurement & analysis, but the whole operation was performed using remote access, without requiring VESKI expert's presence.

Having the signals and RLZ detected in real time it is possible to change the alarming levels accordingly to avoid false tripping of the machine while passing through RLZ. Some additional alarming quantities were introduced (e.g. Smax coefficient – ratio between 10 s Smax maximum and Smax averaged per turn, normally 1 to 1.1 whereas in RLZ it can increase up to 2.2), as reliable measured/calculated indicators of RLZ presence.

Since the RLZ changes with operating conditions (net head and active power) long term history mapping was applied to the data recorded by additional RLZ monitoring module in order to obtain dynamic scale of RLZ which is now used to operate machine and plant more safely and efficiently.



Relative shaft vibrations Waterfall diagram – Vibrations vs. Active Power



Relative shaft vibrations Intensity diagram – Vibrations vs. Active Power

RLZ is detected on power span from 10-20 MW in the frequency range below 1 Hz, as shown on figures above. The span of RLZ appearance varies with net head.

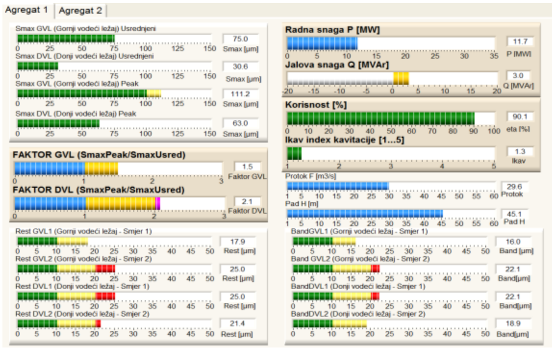
Conclusion

Both of these units have quite extensive dynamic stability problems while operating in RLZ. Since RLZ operation extended from 10-20 MW plant management wanted to correlate the RLZ with operating conditions to be aware of machine capabilities at all times. Therefore RLZ mapping was performed correlating the power and net head data recorded during longer period of operation using CoDiS-RLZ database history trends.

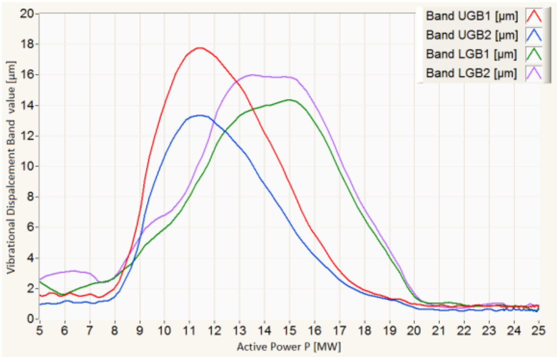
RLZ on line detection and alarming is set on two signal components:

1. Overall amplitude in specific frequency band calculation
   Overall amplitude in the frequency band 0,6 - 0,8 Hz is calculated. Alarm limits are set referring to these values, determined after testing. These values may vary, depending on hydraulic conditions (high head, low head, net head, flow). The specific frequency in which the effects are most detectable may change with condition changes, and they can be completely different for units of different design.
2. Calculation of Smax coefficient out of measured/averaged Smax maximal value ratio, measured on both bearings. It is a relative indicator, requiring simple control of possible condition changes.

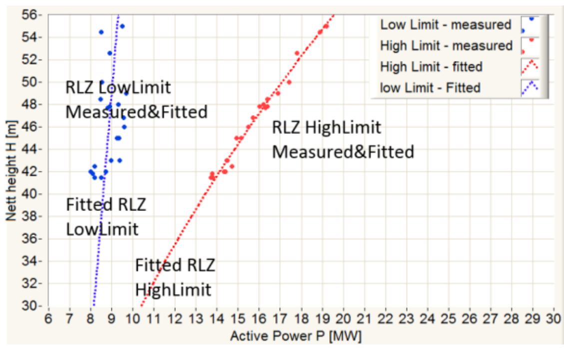
When RLZ operation is detected CoDiS-RLZ automatically alerts the operator that unit is operating in undesired conditions.



CoDiS-RLZ permanent monitoring module Main Panel



Low frequency band-pass value vs active power



RLZ appearance mapping – based on CoDiS RLZ recorded data