





Challenges during the Control System retrofit in a 900 MW HPP with Double Pelton Turbine that operates as a Synchronous Condenser

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Contextualization

SUMMARY

- Henry Borden HPP
- Double Pelton Turbine
- Synchronous Condenser operation mode
- Modernization
 - Governor
 - Automation and Subsystems
- Comissioning Results
- Conclusions



CONTEXTUALIZATION

Henry Borden HPP - External Powerhouse





External View

Internal View

Penstocks

CONTEXTUALIZATION

Henry Borden HPP - Underground Powerhouse



Generators



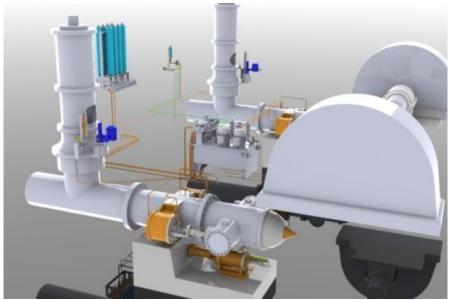
Butterfly Valves

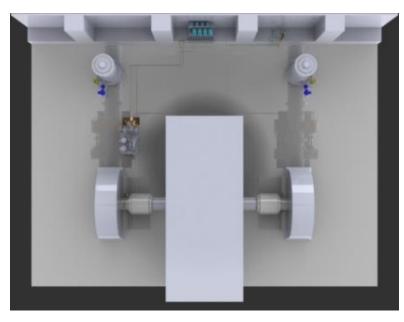


CONTEXTUALIZATION

Double Pelton Turbine







Pelton turbine

Isometric Drawings – Perspective and Upper views

REIVAX ONLINE **CAPABILITY CURVE NO FAILURES** LOCAL CH1 **ACTIVE** Control mode **AUTO** 1,10 0,90 Channel selection Simulation Step-5,00 % -Limiters **Capability curve** Protection-... **NO LIMITER ACTIVE** NO PROTECTION ACTIVE Machine data Pulse 5,00 s **Save** V/Hz UEL SCL MEL Protection settings... Operating point Active power 0,8021 pu Power factor 0,9968 Frequency 1,0000 pu Reactive power 0,0647 pu Stator current 0,8047 pu 1,000 pu Field current 1,267 pu Terminal voltage 1,0000 pu 1,267 Control Back Voltage Regulator

CONTEXTUALIZATION

Synchronous Condenser operation mode



MODERNIZATION

Governor – Hydraulic Systems





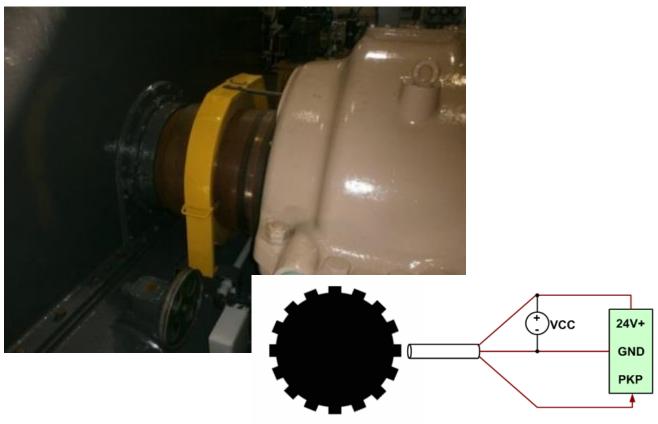
Original Systems

New Systems





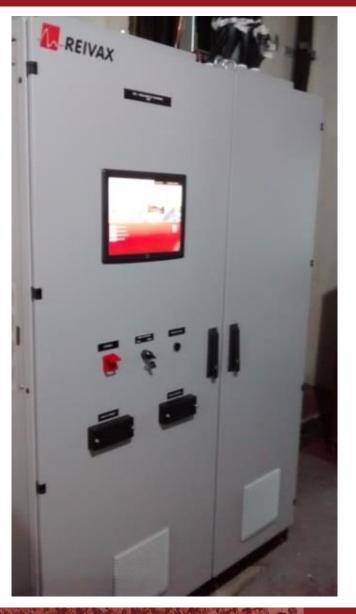
MODERNIZATION Governor – Sensors



Original Systems

New Systems







MODERNIZATION Governor – Digital Control

New Governor –
Control Cabinet
External View and
Internal View





MODERNIZATION Automation System

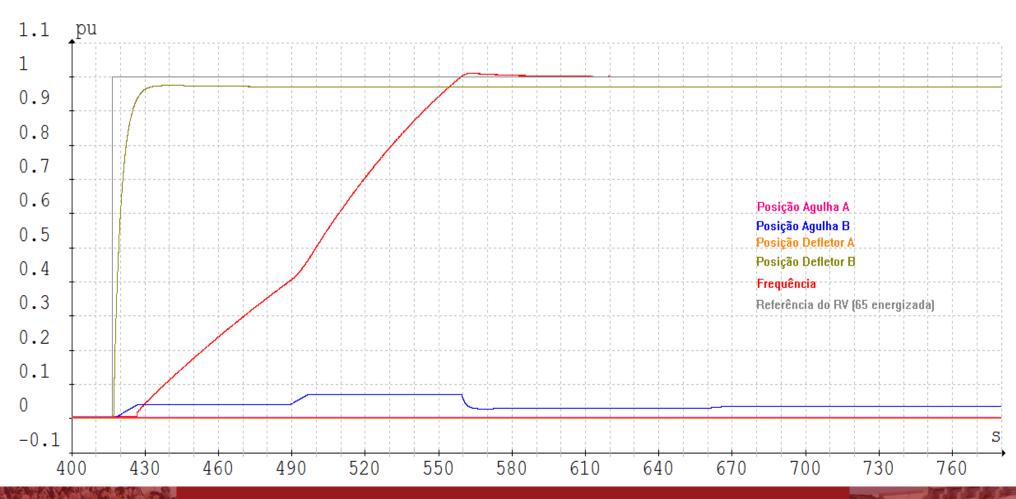


Operation Room
Control panels
Governor Remote
HMI



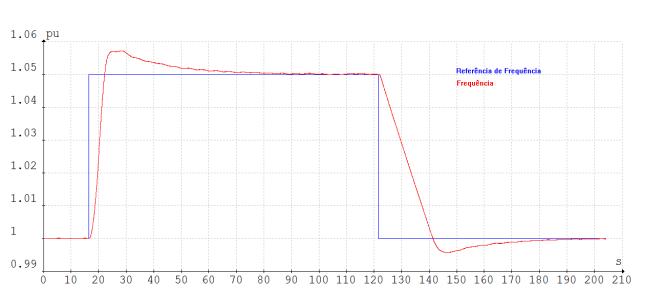
COMISSIONING

Automatic Start



COMISSIONING

Tuning the Control Loops





Frecuency step response

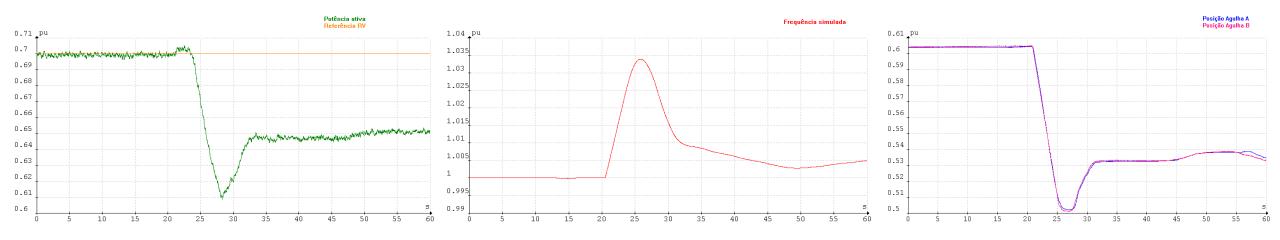
Active power step response



COMISSIONING

Tuning the Control Loops – Isolated testing

IEC60308 / IEEE1207



Reference and Active Power

Simulated frequency

Nozzles



CONCLUSIONS

- Maintenance: New diagnostic and testing tools
- Operation: New way visibility of all process + centralized commands
- Versatility: Synchronous condenser mode
- Better performance: Isolated Simulation
- Reliability Increased







Thank you!

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