HYDRO-QUÉBEC ADOPTION AND DEPLOYMENT OF THE INTEGRATED ZETEC TECHNOLOGY PLATFORM

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ABSTRACT

Steam Generator inspection systems can be integrated using individual technologies from multiple sources or from a single developer.

Faced with a significant reduction of the inspection window in 2008, Hydro Quebec required a doubling of its inspection equipment fleet.

This paper describes the evaluation of new technologies that led to the decision by Hydro Quebec to set aside their traditional multiple source inspection system in favour of a fully integrated single source inspection system. The paper also describes the qualification and first deployment results as well as performance improvement metrics.

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1.0 Introduction

Hydro-Québec is a state corporation that provides electricity to the province of Quebec, Canada and the north-eastern parts of the United States. Hydro-Québec supplies electricity to over 3.5 million Québec customers. Hydro-Québec Gentilly-2 nuclear generating station has been in commercial operation since September 1983 and supplies more than 675 MWe (~3%) to Hydro-Québec's grid. Gentilly-2 is a CANDU 6 reactor type. The plant is made up of 380 pressure tubes used to cool the fuel coupled to 4 steam generators (SG) each containing 3550 Incoloy 800 tubes.

Gentilly 2 refurbishment is scheduled in spring 2011 for an 18 month shutdown.

Steam Generator inspection at Gentilly are managed and realised in house by the Reactor Inspection team. This small crew is composed of NDT and mechanical engineers, two NDT technicians and an instrumentation technician. They are responsible for writing procedures and techniques, maintaining the equipment and training acquisition and analysis work force.

1.1 Context and problem area

Since the beginning Hydro-Québec inspection department has the mandate to carry out periodic inspections. They have developed, adapted and optimized equipment to realise their mandate. Outage schedules were always planned taking into account only one inspection system. At every inspection a huge system is deployed to assure the quality of the inspection meets code requirements. The Hydro Quebec system uses components sourced from both internally and externally.

Gentilly-2 steam generators are in very good condition for their age and are likely to be left in service through refurbishment. More than the periodic inspection has been performed and the only typical defects is fretting at the scallop bars and loose part damage at tube sheet. After refurbishment the periodic inspection program will continue.

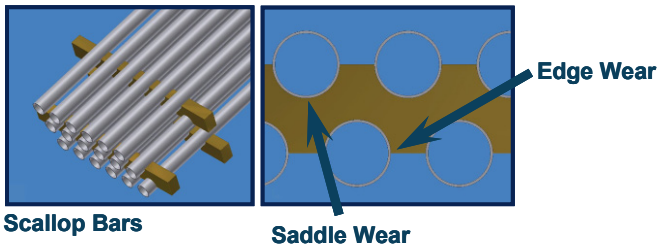


Figure 1 - Fretting

1.2 Background

The traditional SG inspection system is composed of 2 manipulators, a 1980's Intercontrol finger-walker and a Hydro-Québec manipulator developed by IREQ (Hydro-Québec Research Institute) over the past years. The eddy current equipment from RD

tech is used for all exchangers, TC7700 (bobbin and X-Probe®), T6700 (BoP) and TC5700 (Remote field) compose the fleet. Two software are used, Multiview® for acquisition and Eddyview® for analysis. Over the years Hydro-Québec has developed its own data management system and uses Carto® as data base. The probe pusher has been developed by RD Tech and uses an air assist system to allow full length inspection (air to air) from hot leg reducing intervention to radiation area.

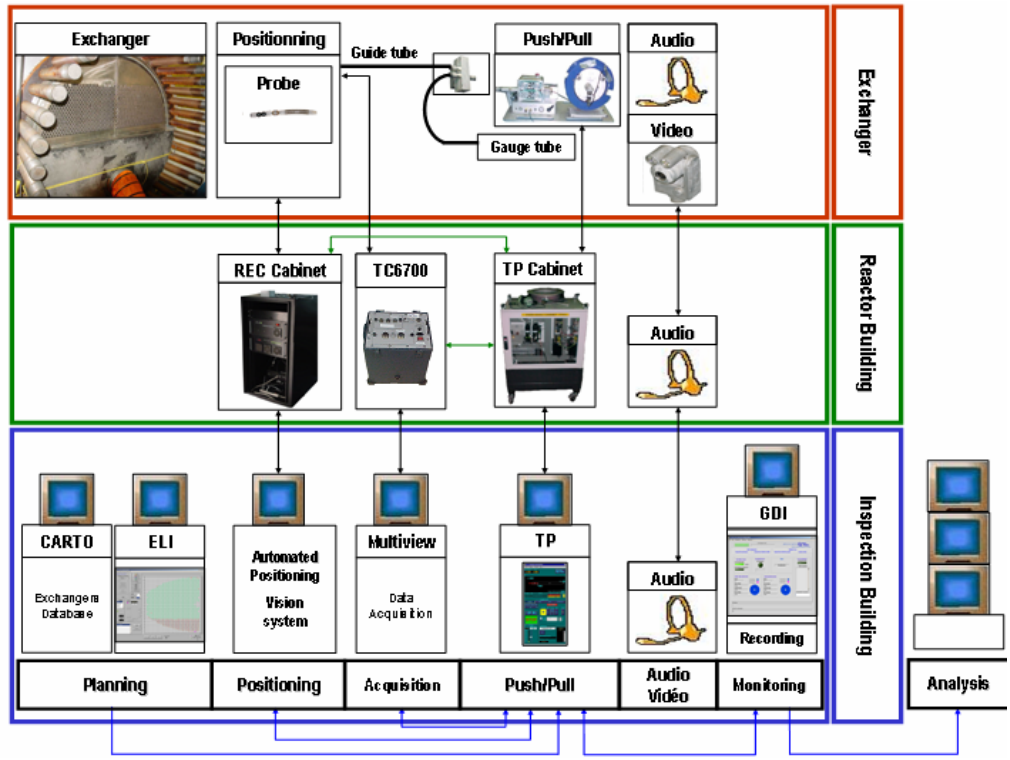


Figure 2 - Traditional SG Inspection system

2.0 2008 Steam Generator Inspection

2.1 Mandate

Faced with a significant reduction in inspection window for 4 SG, management asked to find a solution to fit the inspection in their schedule. Hydro-Quebec was not equipped to realise the inspection of 2 steam generators in parallel. Performing parallel inspection needs at least 2 operational systems, with one complete operational backup or in spare parts. The inspection team had to propose an economic solution in a context where refurbishment had not been approved yet.

2.2 Scenarios and solution

We had to choose between 3 scenarios:

1. Double our existing customized equipment
2. Use our old one with a new one
3. Vendor supplied integrated system

Research started 12 months before the outage. The first and second scenarios were utopian. For the first one, cards for the eddy current equipments were discontinued. Regarding the second scenario, it is useless to say that this situation would have been risky and a source of total confusion. In both cases backup equipment could not be completed.

A summary of advantages and challenges for the first two scenarios is shown in the following table:

Existing Customized Equipment / Old System with New System

Advantages	Challenges
• The Hydro-Québec inspection team was very familiar with this system. • The probe pushing system has air assist integrated to allow full length inspection from one side. • No issue on compatibility of the data.	• This solution results on a customized amalgamated system with multiple computers and multiple suppliers for eddy current acquisition systems, pusher, manipulators, software and data management. • Lack of availability of additional equipment and spare parts due to discontinued equipment. • The old system is hardware synchronised which result in additional seconds per tube. • This system is “Unique” and Hydro-Quebec people are the only ones trained to efficiently operate it. • The support for hardware and software is available only internally, no OEM (Original Equipment Manufacturer) support is available anymore. • A small pool of trained people for acquisition and analysis are available. Training from scratch has to be done every outage. • Manipulators are tube sheet mounted involving additional operations to cover 100% of the tube sheet. • Since it is a customised setup, only on site analysis is possible. • Sources of total confusion even with all of these challenges resolved.

The third scenario came after discussion with suppliers. In the spring of 2007 a benchmark visit at Millstone Power Station in Connecticut during an Areva inspection was organized to see the Unix Zetec system in action. Many positive features of the operating system were observed concerning security, reliability, as well as user friendly and fail safe operations. The MIZ-80iD setup and the operational efficiency were observed.

Shortly after this visit, the decision was made to go with the full Zetec solution. In the following table are advantages and challenges related to this solution:

Two Zetec Integrated Systems (Eddynet®Suite, MIZ-80iD, SM-23G)

Advantages	Challenges
• A fully integrated equipment with software synchronisation. This allows increasing efficiency to about 5s/tube. • Access to an external support for both hardware and software. • It is the industry standard equipment and software. This solution opens availability to trained workers. • This setup benefits from International feedback, and it is a state of the art equipment. • A man way installation allowed Hydro-Québec to reduce dose associated to SG inspection. • It opens access to external supplier to have remote analysis reducing on site personnel.	• Conversion of the historical data to be compatible with EddyNet®. • Acquisition and installation of a UNIX Operating system on the actual Windows network. • Integration of air assist probe pushing system which is not available “off the shelf”. • Many Software changes are necessary to meet these challenges.

2.3 Challenges

This major investment project began with the long process of approval in a context of end of life station as the refurbishment had not been approved yet. Five months of presentations, discussions and arguments ensued during which almost nothing cold proceed. The project really started 7 months prior the inspection.

The project started with training people on Zetec system to bring Hydro-Québec personnel to a sufficient level of competence to work on procedures, documentation, system qualification and take part in the challenges of both software and hardware.

Figure 3 - Sealing device

Among these challenges was the air assist option which needed a specific sealing adaptation device at the tube sheet to allow testing the tubes full length from one leg. Fortunately, the MIZ80iD has integrated capability to control a third party equipment. Regardless, some firmware modification was needed to perform the auto acquisition routine to automatically engaged and disengaged Air Assist, without software or personnel interaction.

Software adaptation had been done to meet Hydro-Québec needs. First to support compatibility of historical data (Multiview®), a full software equivalency had to be verified including process channel mixing, amplitude, phase measurement and setup. To support our unique numbering system (Row 1 farthest from divider plate, Column/row or X/Y as opposed to row/column, Unique tube skewing pattern) two options were available, the first one was the backup solution to the second one. The first solution was to change Hydro-Québec steam generator tubes coordinates with all the impact on the historical documentation and reports. The second one which appears feasible along the project was to test the full Zetec system with our tube sheet numbering.

Data equivalency was also an issue. Acquisition and analysis techniques had to be converted and tested to be equivalent to our historical data. The opportunity was also taken to modify the acquisition techniques to use the MIZ-80iD internal electronic bobbin in lieu of the built-in reference coil of the bobbin probes

Zetec and Hydro-Quebec worked very closely to overcome all these challenges.

3.0 Zetec integrated System

The two new integrated systems were built, assembled and tested in a very short period of time and made this major project a success. The following paragraphs describe the key elements of this success story.

3.1 MIZ-80iD

First of all the MIZ-80iD is a fully integrated eddy current acquisition system, an advanced eddy current tester consisting of next generation demodulation techniques. This instrument uses the exclusive MIZ-iD technology allowing for automatic probe configuration and validation. It has an advanced auto acquisition sequencing consisting of real time landmark detection. With its options, the MIZ-80iD has integrated Hydro-Québec's Air Assist system allowing for automatic control of air actuation. Through this

equipment, we benefit from worldwide feedback adoption since it is currently used in 12 countries.

Figure 4 - MIZ-80iD

3.2 SM-23G complete with Machine Vision

The SM-23G is a small manipulator designed to perform efficiently in CANDU steam generators. Remotely controlled from an EddyNet workstation, it is a modular design including four modules connected by auto-locking hot shoes. Man way mounted, with no cable inside the steam generator. The robot runs in auto mode with the integrated Machine Vision with no exclusion zone. During the project, a sealing device had been implemented for the tube sheet to allow air assist capability.

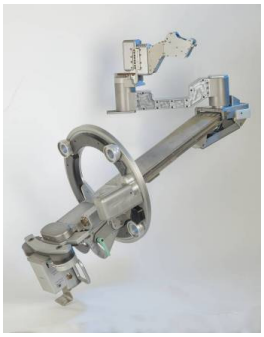
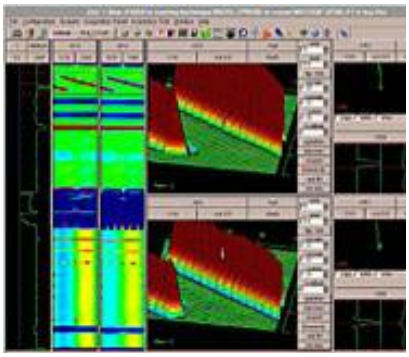


Figure 5 - SM-23G

3.3 EddynetSuite 3.1



Eddynet suite is the nerve center of the system. It is an integrated software platform, an industry standard user interface with seamless interaction concerning Acquisition, Analysis, Data Management, and System Administration. Eddy suite has extensive site configuration allowing users to configure an entire eddy current inspection which is downloaded by operators in a client/server approach. It has advanced validation controls and lock-outs to prevent human error thus improving the quality of the inspection.

3.4 Bobbin and X-Probe

Figure 7 - X-Probe

During the inspection, both Bobbin and X-Probe were deployed. All probes utilized MIZ-iD technology which allowed the system to automatically recognize the probe avoiding risk of configuration and acquisition errors. The use of X-Probe for characterizing and mapping fretting wears resulted in a high speed inspection thus reducing inspection time.

3.5 On-Site Original Equipment Manufacturer (OEM) Support

The last but not least element of success was the on-site OEM support. Jointly with Hydro-Québec personnel, Zetec supplied on-site expert technical support in all aspects of the system to prepare and participate actively to the inspection. These experts had acted as consultants for Hydro Quebec to properly and efficiently implement the full Zetec suite of products. They were available before, after, and during the inspection for pre and post deployment efforts as well as 24/7 technical coverage.

4.0 Inspection Results

Originally planned to four (4) 50% SG inspection, it was reduced to two (two) SG inspection due to a fuelling machine incident. In summary,

Steam generator #2

1844 (50%) tubes inspected with bobbin

16 wall lost (Fretting) results are within code requirements

12 tubes inspected with X-Probe (Characterization)

Steam generator #4

1829 (50%) tubes inspected with bobbin

23 wall lost (Fretting) results, 20 are within code requirements

3 plugged

18 tubes inspected with X-Probe (Characterization)

All tubes were inspected full length from hot side. The air assist and the new low friction conduit had helped performing the inspection from the hot leg only.

This new integrated technology allowed Hydro-Québec to considerably reduced radiation dose by 50% (700 mRem) compare to 2005.

The 3673 tubes were inspected in parallel during a 48 hrs window, including installation and removal.

5.0 Conclusions

The good synergy between Zetec and Hydro-Québec contributed to resolve all issues. The project is a successful deployment of the Integrated Zetec Technology Platform at Gentilly 2. Two steam generators inspection had been done full length from the hot leg, within schedule, reducing radiation doses by 50%.

6.0 Acknowledgements

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Areva: Bill Cecil – Kevin Gavin – Bobby Knox – Kerry Richardson

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