Replacement of Turbine Controls, Supervisory and Overspeed Protection for Point Lepreau

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Abstract:

As part of the ongoing Point Lepreau Nuclear Power Station refurbishment program, the replacement of turbine controls, turbine supervisory and overspeed protection equipment is being designed and coordinated by AECL. This paper describes the scope of replacement and critical areas that were considered during the process of preliminary design through to final installation of the equipment. The interface of a modern distributed control system (DCS) with the existing station digital control computers (DCCs) and complexities of integrating with other refurbishment work associated with the turbine/generator are discussed. With an operating station, the need to minimize peripheral changes is also considered.

Introduction

In July 2005, NB Power was granted approval from its Board of Directors and the Province of New Brunswick to refurbish the Point Lepreau Generating Station (PLGS). New Brunswick Power will continue with detailed engineering and procurement activities in advance of an eighteen-month shutdown that begins in April 2008. AECL is a contractor for the replacement/refurbishment of the Electro-Hydraulic Governor (EHG), Turbine Supervisory Equipment (TSE) and overspeed protection equipment. This refurbishment is necessary to ensure an additional thirty years of reliable operation.

Why replacement?

The 25 years old analogue electro-hydraulic governor, over speed protection, and turbine supervisory systems were considered as state of the art when the station was first commissioned and placed into service in 1983. With the advent of digital technology the original installation has become obsolete and is experiencing problems as described below, resulting in the need for replacement. The equipment has progressively developed several significant operating and maintenance problems due to aging, as identified by the condition assessment carried out in 2001. These include unavailability of spares, spurious alarms due to faults related to dry joints on printed circuit boards, speed/load control problems due to faulty set point modules and component obsolescence. The condition assessment also identified plant trips attributable to the EHG and increased on-line maintenance due to aging equipment. The plant increased training, overhauls of critical components and monitoring in an effort to improve reliability to an acceptable level until such time as the EGH could be replaced. Some specific operational and maintenance difficulties, described below, have been identified:

Turbine Supervisory System

- Extensive maintenance work has been performed on the chart recorders leading to a point where the recorders are now been switched on only during the process of plant start-up, shutdown and during transients. The recorders are also obsolete.
- The bearing vibration, differential expansion and eccentricity sensors and transmitters have been repaired and rebuilt on different occasions, due to limited availability of spares. They also needed frequent zero adjustment. The present configuration of vibration instrumentation limits the ability of maintenance staff to perform periodic planned vibration analysis, requiring supplementary instrumentation to do this task.
- The main power supply units have been repaired or replaced, however, obsolescence is affecting continued operation.

Overspeed Protection

- Turbine Trip solenoid valves have recent history of problems, where replacement and additional testing of solenoid trip valve ‘B’ was required due to a Fire Resistant Fluid (FRF) leak into the coil.
- Trip test/reset Solenoids: routine tests have been performed on these solenoid valves where the need for defective valves replacements was identified.
- Difficulty with adjustment of the over speed bolts requiring additional set up time. For example, during past outages, with the exception of 2006, up to three calibration adjustments were made before the unit tripped at the required overspeed set point. This method of overspeed protection is not 100% repeatable and stresses the rotor during the overspeed. The need for accurate overspeed detection and trip is absolutely crucial as failure would be catastrophic. Oil injection tests were performed monthly to test the freedom of the over-speed bolts. This will no longer be required when replaced with a digital system.

Turbine Electro-Hydraulic Governor

- The EHG has been well maintained under the current maintenance program where, in general, the faults are automatically detected and alarmed. However, unplanned maintenance has been increasing due to on load valve testing (OVLT) push button failures, frequent adjustments of variable components to achieve specified test point values, loose PCB sockets and back plane wiring failures (wire wrap see Figure 1). The governor also experienced problems related to stability due to superimposed signal noise causing secondary wear of main steam valve spindles and bushings.

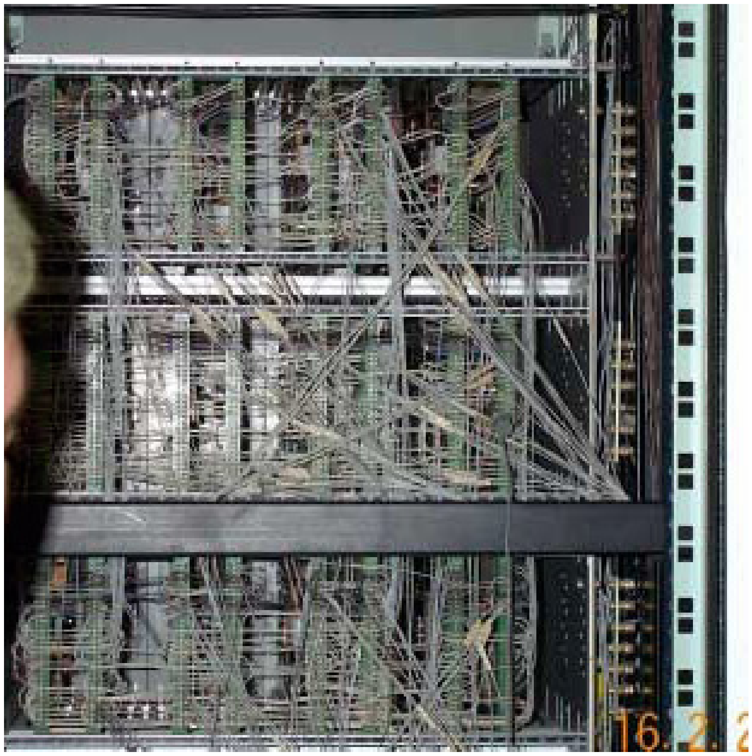

Figure 1 View of the back plane of the governor system showing the use of Wire Wrap

Operating History

The original controls were one of six such systems made by Reyrolle Parson Automation, a joint venture between Reyethon and Rolls Royce (then owned by C.A. Parsons). Parsons was purchased by Rolls Royce (UK). Siemens KWU group in Germany purchased the Parsons assets with the exception of the Controls group. The Control group was renamed Data Systems & Solutions.

Table 1 and 2 shows the history of the number of work orders and the respective annual time spent by the station operating and maintenance staff on the turbine control system and instrumentation. Due to the developments in technology many of the system components are now considered obsolete. Siemens have tried to approach sub-suppliers or create spares through reverse engineering, but were unable to maintain form fit and function. The uncertainty of the availability of spare parts for critical items is a serious concern for future operation of the power station.

Year	1993	1994	1995	1996	1997	1998	1999
Work orders	42	32	31	17	24	49	42
Man Hours	305	195	314	65	245	538	610

Table 1 History of work order and time spent prior to Condition Assessment

Year	2000	2001	2002	2003	2004	2005	2006
Work orders	21	18	3	61	36	38	24
Man Hours	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 2 History of work order subsequent to Condition Assessment

Based on these findings and the risk of undiagnosed faults, causing loss of power production and increased overtime, it was concluded that the turbine EHG and TSE systems (including overspeed protection) could not be adequately maintained beyond 2013.

Scope of work

Based on the condition assessment, conducted in 2001, the client elected to replace the EHG (including OLVT), TSE and over speed protection with modern state of the art control and instrumentation that will provide a 30-year life extension.

Critical areas to consider during design and implementation

Unlike a new installation, where there are no existing equipments being retained, careful consideration was given to the management of the configuration and interfaces with the existing systems and controls. The challenges lay in establishing accurate and consistent design requirements without exceeding the scope of the contract requirements. Due to the age of the existing systems and the availability of modern DCS systems, special attention was paid to minimizing changes to the interface between existing peripheral equipment not under the refurbishment scope and the new equipment. This is particularly important in the configuration of the existing station Digital Control Computers (DCC) and Main Control Room (MCR) design. The new equipment was configured to be transparent to the existing station computer program and I/0 structure.

Modern digital control systems have limitations due to sampling and processing time, along with errors through analogue/digital conversions. This could lead to short falls in the overall dynamic response of the refurbished system, compared to the performance of the existing analogue system. As such, careful consideration was given to ensure that the new DCS system does not introduce slower responses that do not comply with the existing composite system.

Due to compatibility issues and advancement in instrumentation, the field instruments have been replaced in addition to the digital control systems. Accurate interface documentation was prepared to ensure that the complete system, including existing equipment, perform equally or better than the existing system being refurbished. In addition, the design of the new governor and TSE systems ensure that the DCC modifications were minimized.

Modern control systems are provided with sophisticated human machine interface (HMI) display/control equipments that are challenging to integrate into the existing main control room (MCR) design and operating procedures. With the lack of availability of real estate on the existing MCR panel the new system was designed to emulate existing controls such that changes to the existing control panel and operating procedures were minimized.

In contrast modern EHG and TSE equipment, to be located in the control equipment room (CER), are more compact in design, where the EHG and TSE are a combined integrated package. This is quite different from the existing two stand-alone systems. While the new integrated package will simplify the physical installation in the CER, the existing cables may not be long enough and pose a challenge. The use of distributed I/O drops with suitable data link provides a solution to allow the existing cables to be retained. However, It should be noted that over-speed protection equipment remains separate due to it being a “Safety Support System”

Other activities during the refurbishment program include the replacement of all three low pressure turbines, overhaul of the high pressure turbine and rewinding of the main generator. This requires careful planning and coordination, when the field instruments (bearing vibration accelerometers, shaft speed probes and casing differential expansion transducers etc) are being installed, to minimize damage and re-work. Due to the specialized nature of the field instruments on the turbine, the responsibility of their removal and installation rested with the vendor, while the removal and installation of all the cabinets is to be conducted by AECL. The lay down areas in the turbine hall are designed for short planned outages where limited dismantling and lay out space is available for components. Due to this extensive refurbishment program the use of space in the turbine hall requires good coordination amongst all the individual tasks during the implementation phase.

Project activities

Pre-Project activities

Based on a thirty years life extension, a condition assessment was conducted by AECL in 2001, where the specific areas for refurbishment were identified. Subsequently, a preliminary design package was prepared to outline the recommended scope, budgetary cost analysis and risk assessment. NBPN used this information to prepare a request for design services followed by an approval from their board for the resulting plant configuration change for the refurbishment.

Activities during the project.

A work activity plan, for the replacement of Turbine Instrumentation And Controls, was prepared by AECL to outline all necessary activities required to fully complete the design, supply and installation work. This included inspection and familiarization of the present plant configuration and feedback from NBPN design and operations team. Based on the information gathered and the scope of refurbishment, design requirements were prepared in conjunction with New Brunswick power to meet the refurbishment program needs, while maintaining consistency with the defined scope of refurbishment.

In preparation for the procurement of equipment, a technical specification and a technical document list were prepared by AECL to initiate the tendering activity with several prospective vendors. A technical QA and commercial evaluation resulted in the selection of Siemens as the supplier. Consideration was given to the fact that Siemens is the OEM and as a result, their experience and the availability of detail documentation, while remaining within intellectual property restrictions, was favourable.

Optional items developed during the design and procurement stages

Optional items, not in the original scope of refurbishment, were identified during the process of preparing the design requirements and the technical specification. The following items were considered as enhancements, and will be considered by New Brunswick Power.

1. Option for supplementary vibration diagnostics system that would provide additional software to conduct complex vibration analysis.
2. Option for automatic loading of the turbine generator.
3. Option for triplicated linear variable differential transformers (LVDT) on the governor and intercept valves to increase reliability.
4. Replacement of the turbine trip cubicle.

Conclusions

In contrast to a new build, refurbishment work calls for additional coordination between the existing design, retained equipment, and the new state of the art design of the governor system. The new governor and supervisory systems have been designed to accept existing interface protocols to avoid costly secondary modifications. To accomplish this, accurate and consistent design documentation was prepared, while the changes to the interface between existing peripheral equipment, not under the refurbishment scope, and the new equipment was minimized. This is particularly important in the configuration of the existing station DCCs and MCR controls. The new equipment was configured such that it is transparent to the existing station computer program (DCC) and I/0 structure. It is also emphasized that the selection of vendor for this equipment was the OEM. This facilitated the need to review existing and new documentation without being subjected to intellectual property infringement.

The design of the physical arrangements of panels in the CER and the turbine hall was such that changes to existing cable configuration was minimized. Finally, the installation of this equipment during an outage that includes many other refurbishments on the turbine-generator, require careful planning in order to utilize the limited available space in the CER and turbine hall lay-down areas. These activities were closely coordinated between AECL, New Brunswick Power and Siemens.