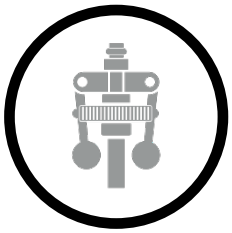
Legacy Governor Support

A Cost-Saving Study[i]



Introduction

From the earliest mechanical governors to today's microprocessor-controlled control systems, much has changed in the way hydroelectric powerplants are controlled, yet much remains the same. The primary functions of the governor remain: sensitivity to the smallest frequency excursions when islanded, and a predictable, sustained droop response when grid-connected. The question is how (and whether) to maintain the performance of legacy governors, some of which date back to the early 20th century.

This paper provides a case study of a European utility who, when faced with the prospect of an expensive governor replacement programme, came up with an innovative solution to extend the useful life of their legacy governors. The subject utility operates and maintains ten (10) low-head hydro powerplants – the oldest dating back to 1929 – with 21 generating units. Through attrition the utility had lost their hydro governor expertise.

Precious few technicians had any idea how their legacy governors worked, how to maintain and calibrate them, or what to do if the governor stopped controlling correctly. Rather than risk mis-operation or worse, suffer an unforced outage because a technician made a mistake, they chose instead to perform the minimum possible maintenance. Managers knew this was an untenable situation. Something had to be done with the governors, so they reached out to the Original Equipment Manufacturers (OEMs) for support. Each of three OEMs declined, stating that the governors the utility had in operation were obsolete (even the digital governors the utility had purchased just 15 years prior) and no spare parts were available. The utility pressed the OEMs for field service or technical assistance of any kind, but the OEMs declined again, saying they no longer had any qualified technicians who could work on these legacy governors. The OEMs urged the utility to convert to the latest microprocessor-controlled digital governors and high-pressure hydraulic equipment, which when spread across the utility's hydro fleet amounted to a £10M governor replacement programme. The utility had not planned for this, and was rather stunned, because the problem was not with the performance of their governors – which all worked well enough – but rather, with their ability to properly maintain and calibrate them periodically.

The utility researched other options and found American Governor (acquired by Emerson in 2020) in the USA, who claimed to be able to support and work on any type of governor, of any vintage, produced by any OEM. As an experiment, the utility hired the company to evaluate three different legacy OEM governor types, at three different plants; the results of which are presented in this paper. During the course of the two-week investigation, the three disparate governors were completely disassembled, cleaned and inspected, then re-assembled and calibrated. During the course of this work, our team was assisted by the utility's local maintenance crews. This proved exceptionally beneficial, as the crews were provided much-needed knowledge and training on how to disassemble, reassemble and calibrate their governors, which greatly increased their confidence.

As described in the test reports, all three governors were found to be of high quality, with little wear and no serious problems, and in good working condition, despite the lack of periodic maintenance. Some governors

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needed only simple adjustments and calibration to restore their good frequency response characteristics. For others, external repairs or refits were recommended to improve governor response. These were beyond the scope of the two-week, and the utility agreed the utility that they could do the repairs on their own, now that they well understood how the governors worked.

In summary, all three units were deemed capable of continued good service for another 10 - 25 years. There was – and is – no need to replace them, thus the utility was able to reallocate most of their £10M budget elsewhere.

Background

ESB Generation is headquartered in Dublin, Ireland, and operates and maintains a mixed fleet of hydro units, the oldest having been commissioned in the late 1930's. Their newer units have digital governors; however, the majority of the fleet are legacy units that still have their original mechanical governors. Given the retirements and workforce attrition that had occurred over the preceding 10 years, ESB management became concerned about their ability to support the legacy governors with their current staffing. They sought technical parts and service support from each of the OEMs, and were told their mechanical governors had become obsolete long ago, and no further support was available. Each OEM recommended that ESB upgrade/convert their mechanical governors to the OEM's latest digital governor system. This was no minor undertaking, since ESB owned many existing powerplants with legacy mechanical or analog governors:

Table 1: List of Hydro Powerplants – Electricity Supply Board (Ireland):

Name	River	Units	Year	Governor
Poulaphuca	Liffey	2 x 15MW	1937-49	English Electric Mechanical
Golden Falls	Liffey	2 x 4MW	1937-49	English Electric Mechanical
Leixlip	Liffey	2 x 4MW	1937-49	ASEA Analog Electric
Cliff	Erne	2 x 10MW	1955	WGC 517 Digital
Cathleen's Falls	Erne	2 x 22.5MW	1952	ASEA Analog Electric
Carrigadroid	Lee	1 x 8MW	1952-57	Voith Mechanical
Inniscarra	Lee	1 x 15, 1 x 4MW	1952-57	Voith Mechanical
Clady	Clady	1 x 4.2MW	1950	Riva Mechanical
Ardnacrusha	Shannon	4 units; 86MW	1929-34	Alstom Digital
Turlough Hill	(Pump/Gen)	4 x 73MW	1974	Voith Digital (2009)

Based on OEM-submitted proposals and the amount of engineering resources necessary to implement the digital conversions, ESB estimated the overall budget for replacing all legacy governors would be around £15M. A rather daunting sum, ESB engineers decided it prudent to look beyond the OEMs to see whether there were any other companies in the world who could support their legacy governors. ESB found us.

A conference call was conducted on June 30, 2010 to discuss the capabilities and experience of the company. They found that our company did indeed offer on-site disassembly, overhaul, reassembly, calibration, tuning and training services for all types of legacy governors, from any OEM, and had provided such services for hundreds of Woodward mechanical governors. As an example of their ability to service rare or unusual mechanical governors,

A project in the Yukon Territory (Canada) was cited where they had disassembled, cleaned, inspected, reassembled and calibrated a belt-driven Gilkes mechanical governor from the 1940s. The company noted that training of site personnel was an integral part of the work and had led to higher levels of customer confidence in their ability to support this governor going forward. As a test case, ESB hired us to inspect, evaluate and report on the condition of three different governors at three different powerhouses: a Voith mechanical governor at Carrigadrohid; a Woodward 517 Digital at Cliff; and an ASEA analog electric at Leixlip. In the fall of 2011, a US$70K contract was awarded to American Governor, with work scheduled to occur during a three-week period in October.

Test Case: Governor Inspections at Three Stations

Two veteran governor specialists, Jerry Runyan and Bill Eberman, were dispatched to perform the work in conjunction with ESB maintenance personnel. It was anticipated that the inspection and calibration process would require two days per governor to complete, and the most troublesome governors were requested to be the subject units. The following services would be performed on each governor:

- Collect or copy as much information as was available locally (drawings, manuals and operational notes)
- Strip down the governor with support from ESB maintenance personnel
- Clean all components and assess their current:
  - Identify governor parts that should be replaced on a routine basis
  - Replace bearings, bushings and seals if necessary (depending on availability from local sources)
  - Gather dimensional information that can serve as a basis for future reverse-engineering
  - Modify existing mechanical components as needed (depending on local machine shop capability)
- Reassemble the governor with support from ESB maintenance personnel
- Perform functional checks: dry stroking of the gates, dashpot adjustment, governor droop measurement
- Calibrate the unit for off-line speed control and on-line droop control
- Return unit to service

Importantly, hands-on training and instruction was provided to ESB maintenance personnel throughout the above process, to educate them on the inner workings of each governor and hence, reduce their reluctance to disassemble or re-calibrate the units. This proved to be pivotal in ESB's subsequent decision to maintain, rather than replace, their legacy hydro governors.

A management review meeting at ESB headquarters in Dublin was held at the end of the two-week inspection trip. During this meeting, the results of the work at each of the three plants was discussed, including: the viability of each legacy governor type; discussions of the availability of spare parts; and recommendations for future maintenance. It was originally thought that a long-term support plan for the entire ESB governor fleet would need to be formulated. Such a plan would include formal and informal governor training classes tailored to the individual governor type; additional service trips, and the possibility of a comprehensive reverse-engineering effort if worn parts were found and the OEM was unresponsive to ESB requests for spares or original manufacturing drawings. The author attended these meetings and had (one day prior) presented a one-day Governor 101 Training Class to ESB headquarters personnel and regional plant managers.

With the governors in such good and operable condition, ESB elected to postpone the long-term support plan effort and instead hired us in subsequent years, as needed, to perform similar inspections, overhauls and calibrations on other units in the ESB hydro fleet, as summarized below.

Subsequent Governor Inspection Trips

In the years following the first trip, additional governor inspections conducted. The results were the same: the subject unit governors were found to be quite serviceable and just needed a good cleaning and calibration. Excerpts from the associated trip reports are provided below.

Governor Inspection – Lee - 2013

Like the work done in 2011, detailed inspection, assessment, calibration and adjustment of the Voith mechanical governors was performed at Lee station. The following units were inspected:

Lee Station, located in Inniscarra, Cork:

Table 2: Lee Station Unit Description			
Unit #	**Size**	**OEM**	**Turbine Type**
Unit 1	15 MW	Voith	Kaplan
Unit 2	4 MW	Voith	Kaplan
Unit 3	8 MW	Voith	Kaplan

The work scope on the mechanical governors at Lee Station were similar to the work carried out in 2011:

- Strip down the mechanical governor
- Clean up components and condition assess
- Replace bushing and seals, if parts are locally available
- Gather dimensional information to enable future refurbishment of the mechanical governors
- Re-assemble, calibrate and re-commission the governor

Resources: 1 senior governor specialist to assist ESB staff in performing the work
Duration: 3 weeks
On-site dates: June 17 – July 5, 2013

Governor Inspection – Clady - 2014

Like the work done in 2011, a detailed inspection, assessment, calibration and adjustment of Riva mechanical governors was performed. The following stations / units were inspected:

Clady Station, located in Donegal:

Table 2: Clady Station Unit Description			
Unit #	**Size**	**OEM**	**Turbine Type**
Unit 1	4.2 MW	Riva	Francis

The work scope on the mechanical governor at Clady Station was similar to the work carried out in 2011:

- Verify poor governor operation during start-up (water on unit)
- Test and observe wicket gate operation during manual governor control (unit unwatered)
- Disassemble the mechanical governor ballhead assembly ("Tacho-accelerometric head")
- Assess condition of internal components; note any bent or damaged parts; repair if possible
- Replace O-rings, bearings, bushing and/or seals (depending on availability of parts locally)
- Re-assemble, test, and calibrate the governor
- Perform multiple starts and stops to verify performance
- Adjust off-line gains for good speed control with minimal hunting

Dates: November 3 – 7, 2014
Duration: 1 week (Monday – Friday)
Resource Requirement: 2 senior specialists to assist ESB staff in performing the work

Conclusion

Digital governor systems offer exciting new functionality, such as enhanced communication capabilities and color touchscreens that may offer on-board diagnostic and troubleshooting tools. However, the cost to convert an entire fleet of legacy governors to digital control can be daunting to European utilities who are competing in a depressed electricity market, burdened with low wholesale prices and high wind and solar feed-in tariffs. In these situations, owners of legacy governor systems will be well-served to look beyond the new digital system their OEM offers.

Legacy governors can usually provide many more years of reliable, responsive service, but they do require periodic maintenance, adjustment and overhaul. If a utility has suffered a high degree of staff turnover since the station was constructed, the internal knowledge necessary to understand how their legacy governors work, and how to properly overhaul, adjust and calibrate them and their associated governor oil pumping systems may have been lost. In this case, a third-party company may be brought in to perform the governor overhauls, providing ad hoc training to the utility's maintenance staff in the process. Formal classroom and hands-on training classes are also valuable tools to regain this lost knowledge.

References

Runyan, J. and Eberman, W., "Trip Report – ESB-Three Plants," a synopsis of three individual trip reports that were submitted to ESB International, 2012.

[i] This paper was authored by Roger Clarke-Johnson and Jerry Runyan (American Governor Company which was acquired by Emerson in 2020) and presented at HydroVision International in 2016.