

# MANUFACTURING INSPECTION GE FABRICATION FACILITY IN CLEARWATER, FLORIDA OCTOBER 12, 2017

Prepared for: Natural Resources Canada and Nalcor Energy

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## *Quality Assurance Statement*

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## 1. GENERAL

On October 12, the Independent Engineer (IE), Argirov Engineering Inc (AEI), together with Nalcor representatives, participated in a site visit at the GE plant in Clearwater, Florida.

The purpose of this plant inspection was to verify the status of GE equipment production and to review the QA/QC process relative to the manufacture of capacitor units forming part of the LCP Converter Stations AC filters with attention to the production of 1100kVAr capacitor units.

The IE was earlier informed that the 1100kVAr capacitor units made in Finland failed the 'screening tests' due to mediocre performance and refurbishment requirement of those units. Since the visit, the reconditioned 1100kVAr units from Finland have been type tested at the Clearwater plant together with the newly manufactured 1100kVAr units at this plant. Due to the excellent test results and performance the refurbished units will be used for the b-filter in Solders Pond Converter Station. Their long-term application will be further evaluated.

Main objectives of the visit were: (i) to learn about the modes of failure experienced by the 'made in Finland' capacitors, (ii) to understand the measures taken at the Clearwater plant for improving the design and manufacturing process and (iii) to assess any remaining Project risks.

### **Attendees:**

IE: Nik Argirov and Vlad Kahle

LCP: Shawn Hurley and Rosanne Williams

GE: Alan Swade, John Cousins, Dave Robertson

Consultant to GE: Dave Moorhead

## 2. AGENDA

### **Safety:**

Key points were to exercise caution when walking around the plant and not to touch the capacitor terminals as stored energy could be present.

### **LCP Update:**

Overview of the project, construction progress and schedule were presented by Shawn Hurley and Rosanne Williams.

### **Key Presentation Points by GE**

- 1100kVAr units will be available for shipment to Muskrat Falls on Nov. 14th. In total, 216 fused units will be shipped mounted on the racks.
- Units made in Finland experienced several different modes of failure during accelerated ageing tests conducted with applied voltage of 1.2 p.u. (per unit) @ 400C for 200 hours. No definite single cause of those failures was identified.

Five different issues were identified including shorted rolls and arcing along the edges, but no capacitor can rupture, or bulging was experienced. Clearwater design representative visited the factory in Finland to assist in the failed unit post-mortem investigation.

- Clearwater design team developed 600kVAr fused capacitor unit to validate the design and to test the unit according to IEC/ IEE guidelines. During factory acceptance testing (FAT) voltage of 1.4 p.u. was applied to the unit @ 300C for 600 hours. Problems experienced with made in Finland units have not been found in Clearwater and no shorts were experienced during the tests.
- In order to validate capacitor unit's ability to withstand transient voltages excursions, GE applied temporary overvoltage (TOV) of 2.25 p.u. for 15 cycles (250 milliseconds).
- GE asserts that they successfully resolved the problems found with the made in Finland capacitors and proved that the 600kVAr fused unit will successfully operate at higher voltage, i.e. at 1100kVAr.
- 1000kVAr unit was designed to fit the same envelope as the units made in Finland.

At Clearwater GE uses different insulating oil with better cold weather performance, the insulating foil assembly is somewhat different and lower mechanical pressures are applied during the bundle manufacturing and assembly of the completed units. Lower pressures facilitate more thorough penetration of the insulating oil and prevent potential capacitor degradation due to excessive mechanical stresses.

### 3. VIRTUAL TOUR

- Clearwater facility was commissioned in 2015 using up to date production line technology.
- Level of automation is high; all staff is trained and certified for their roles.
- NALCOR's capacitors are housed in 400 series stainless steel cans that are designed to expand and contract with fluctuating temperatures.
- Before oiling, the assembled cans are subjected to 'helium leak' check. The cans are then restrained and filled with oil at 8 psi pressure.

### 4. PRODUCTION LINE TOUR

- GE conducted a tour of the entire production line and explained the manufacturing, assembly and FAT processes in detail. The manufacturing process is partially automated. It is subject to continuous improvement based on the analysis of collected plant data.
- Specifically, the clean rooms, assembly shop, drying ovens, oil impregnation facilities and test bays (two of) were viewed by the group. For tour illustration see Appendix Photos 1 through to 8.

## 5. COMMENTS AND CONCLUSIONS

Clearwater manufacturing plant is clean, clutter free and it appears to be well organized and managed. GE lead designer answered all technical questions and emphasized the differences between Clearwater and Finnish plant processes. He stated that failure of the Clearwater units would be an unusual occurrence as the service life of these units is expected to be up to 30 years. Based on the above presentations, IE has no specific concerns at present.

## APPENDIX

### Photographs

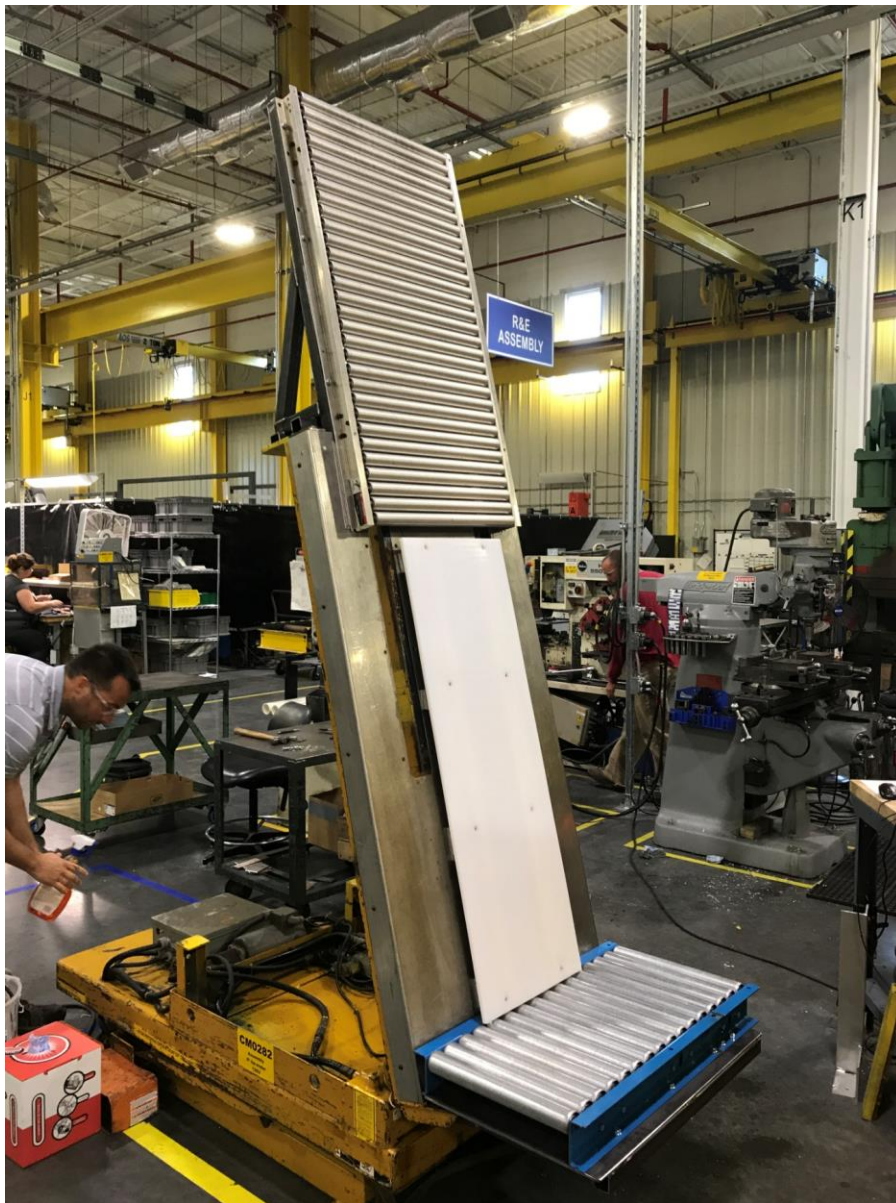


Photo 1: Assembly line.





**Photo 2:** Capacitor bundles with connector tabs ready for assembly.



**Photo 3:** Capacitor inserted into the capacitor can.



**Photo 4:** Final assembly prior to lid welding.



**Photo 5:** Drying and oil filling steps.



**Photo 6:** Drying and oil filling steps.



**Photo 7:** Electrical Test bay.



**Photo 8:** Finished product.