

MEETINGS IN ST. JOHN'S AND VISITS TO LOWER CHURCHILL PROJECT SITES, NOVEMBER 18 TO 22, 2019

Prepared for: Natural Resources Canada and Nalcor Energy
IE Point of Contact: Nik Argirov
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Quality Assurance Statement

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| Office Address | 803-633 Kinghorne Mews, Vancouver BC, V6Z 3H3 |
| Prepared by | Nik Argirov, Paul Hewitt, Vlad Kahle, Hamdy Khalil, Tim Little |
| Reviewed by | Nik Argirov |
| Approved for Issue by | Nik Argirov |

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1. GENERAL

From November 19th to 21st, 2019 the Independent Engineer (IE) team visited Muskrat Falls Generating (MFG) site including the generation, AC switchyard, and converter facilities, as well as the Soldiers Pond (SOP) site which includes the AC switchyard, converter, and synchronous condenser facilities. The team also attended project briefings and meetings at the Lower Churchill Project Delivery Office (PDO) in St. John's. Nalcor senior management representatives and technical specialists, representatives from the Government of Newfoundland & Labrador and Government of Canada also attended the presentations and site visits. The purpose of the meeting was the semi-annual update for IE and Government Representatives.

IE team: Nik Argirov (IE Team Lead)
Paul Hewitt (IE Infrastructure and Cost Subject Matter Expert [SME])
Vlad Kahle (IE Electrical SME)
Hamdy Khalil (IE Transmission SME)
Tim Little (IE Geotechnical SME)

Nalcor Meeting and Site Visit Coordinator: Rosanne Williams

Trip itinerary:

Nov. 18:

- Arrive and overnight in St John's

Nov. 19:

- Project update meetings at LCP PDO
- SOP Synchronous Condensers, Converter Station and AC Switchyard visit
- Return to and overnight in St John's

Nov. 20:

- Travel to Goose Bay
- Muskrat Falls Generation facility (predominantly the powerhouse), and the AC Switchyard (gas insulated) and Converter station visits
- Travel to St John's

Nov. 21:

- Project update meetings at LCP PDO
- Depart St. John's

Nov. 22:

- Depart for home bases

2. TECHNICAL UPDATE AT LCP PDO – NOVEMBER 19, 2019

2.1 Introductions and Safety Moment: Safety remains #1 priority. With the arrival of winter there will be added road condition hazards as well as risk of loss of footing.

2.2 Transition to Operations (TTO) Overview:

- Overall program completion increased to 84.0% from 78.6%.
- MFG emergency response risk assessment has been completed. Key concern is the remoteness of the site and timely access to medical assistance.
- Mitigation for MFG power flow without the Labrador Island Link (LIL) or Interconnection Operators' Agreement (IOA) with Hydro Quebec) is being addressed by 3- way discussions with the parties (NLSO, CF(L)Co and MF).
- Building the Production Organization (BTPO) overall progress advanced to 77.8% from 69.0% at last report.
- Maintenance contracts are in place for transmission (53 of 56 addressed) and generation (15 of 61 addressed to date).
- Ready For Integration (RFI) 90.6% complete from 87% at last report.
- Transitional studies defined LIL operational limits based on Island system conditions. Operating instructions are under development.
- Transitional studies defined 315kV lines and LIL operational limits based on Labrador system conditions. Operating instructions are under development.
- Energization studies for generation Unit #1 were completed and grid energization procedure for Unit #1 was issued for sign-off.
- Ready For Commercial Integration (RFCI) overall progress advanced to 96.8% from 96.4% at last report.
- Meetings will take place in Q4 with respect to filing options for interim and long-term agreements.
- (Ready For Operation (RFO) for Transmission overall progress advanced to 63.0% from 57.6% at last report.

2.3 High Level C1 (Generation Component) Project Overview:

- Work is continuing on MFG powerhouse with focus on Unit #1 auxiliaries.
- Turbine/ Generator (TG) work has not progressed as quickly as planned due to challenges encountered by Andritz team. Based on the current reports, the aspiration to be ready to turn on Unit #1 for Dec. 22nd is unlikely to be met. It is now hoped that Unit #1 will be ready for watering up in the New Year.
- Unit #2, Unit #3 and Unit #4 work is expected to progress at faster rate than Unit #1. A second pedestal for turbine runner assembly is being fabricated and is expected to save time.
- Balance of Plant (BoP) work is about 90% complete and progressing well.
- Spillway concrete work is complete. Plan is to de-mobilize by Christmas with the crews scheduled to return in spring 2020 for site rehabilitation and completion of outstanding punchlist items.
- Tailrace rock plug excavation is completed.

IE Comment: IE requested more details on the reasons for schedule slippage on Unit #1 experienced by Andritz. More specifically:

- Clarification on the nature of the challenges impacting delivery, commissioning, and being Ready to Turn consistent with their own schedule.
- Are those issues to be corrected on a permanent or temporary basis?
- In either case, what would be their potential impact on the long-term equipment reliability?
- If temporary, will more remedial work be expected in the future?

2.4 Spillway:

- Rollways 2, 3 and 4 have been completed thereby completing the concrete work.
- Repairs to chip out and replace defective waterstops in the secondary concrete associated with the stoplogs and roller gate guides are ongoing and expected to largely be complete by year end.
- Repairs to stoplog and roller gate guide deformation due to freezing of heating pipes are ongoing.

2.5 Powerhouse:

- There is approximately a 3-month delay in achieving the Ready to Turn status on Unit #1, relative to Andritz's recent reported delivery schedules. This has consumed schedule float in comparison to the Project baseline schedule (June 2017) and is putting at risk attaining this baseline schedule.
- Unit #4 shim required to adjust the discharge ring elevation anomaly has been installed. Change order and engineering drawings were provided by Nalcor.
- Commissioning program is in progress, as per the Completion Plan. The test sheets are signed off by Nalcor's site personnel. Engineering will also review the test documentation.

IE Comment: IE requested a copy of Andritz NCR (non-compliance report) for the Unit #4 elevation anomaly.

2.6 Completion:

- Electrical equipment commissioning expertise is available internally in Nalcor organization.
- In order to provide additional assurance, P&C testing expertise is available on site.
- Integration with Operations is ongoing. Responsibility for integration and overall training program resides with TTO (Transfer To Operations)
- Project has no responsibility for site staff training. Training packages can be/are supplied by the Contractors on optional basis.
- U1 ready-to-turn scope document will be re-issued.

IE Comment: IE requested a copy of updated U1 Ready-to-Turn scope document.

- Labrador Transmission Asset has been turned over to Operations.

2.7 C3/ C4 (Transmission Components) Update:

- GE target for integrated testing has not been completed because the hardware at GE facility was not ready.
- Interim version of the software (S/W) needed to energize the hardware was to be released on weekend 23/24 Nov. (Note: At the time of the site visit report preparation no update on design work had been received).
- 77% of the IST (integrated system tests) have been completed.
- Date for FST (factory system tests) is not yet available.
- FAT (Factory Acceptance Tests) completion is scheduled for January 19, 2020.
- GE's Internal Plan:
 - Interim S/W release: FAT (January 19) > Dynamic Commissioning (February 29) > Trial Operation (May 29).
 - Final S/W release: FAT (June 1) > Dynamic Commissioning (June 30) > Load testing at available power (July 30).

IE Comments: At this time, the optimal option is to continue with the proposed GE design process and testing timelines.

2.8 Reservoir and Dam Safety:

- Reservoir level continue to be maintained at El. 38.75 m \pm 0.25 m, using two spillway gates. It is reported that there is some minor wave splashover of the RCC dam during windy periods.
- Dam safety inspections continue to be carried out twice a week and dam safety reports are issued weekly; the IE team continues to receive copies.
- Total seepage through all dams is about 10 l/s, which is minimal. No unusual or anomalous behavior has been detected for any of the dams.
- No displacements or anomalous piezometric conditions have been detected in the North Spur. Engineering is scheduled to carry out a detailed review of performance as compared to design in mid-2020.
- Periodic inspections of the reservoir rim have not identified any significant landslides.
- Only about 4000 m³ of woody debris was collected from the reservoir after filling. The seasonal debris boom was removed for the winter and will be re-installed in the spring for debris and safety purposes.

3. SOLDIERS POND (SOP) SITE – NOVEMBER 19, 2019

3.1 Soldiers Pond Synchronous Condensers:

- SC2 bearing housing and bearing have been removed and undergoing investigation and modifications. Bearing housing tilt appears to have been addressed by stiffening brackets but the bearing is now deflecting in the housing and causing shaft binding.
- SC3 has been running but it experiences vibrations. It is not yet determined if the vibrations originate in the foundations or are mechanical vibrations of the machine itself. Vibration analysis is ongoing. Stiffeners will be added to bearing housing. *Post meeting note: Bearing housing stiffeners have been added to all 3 units.*

- Bearing tilt is as yet unresolved, bearing modifications that will allow better oil dispersion are being considered, as well as bearing housing modifications to allow better fit of the bearing in the housing.
- Converter building has been visited.

4. MUSKRAT FALLS PROJECT SITE – NOVEMBER 20, 2019

4.1 Commissioning:

- IE met briefly with site equipment commissioning specialist Don Phillips. Further discussions are planned for the next visit.
- The on-site Protection & Controls (P&C) specialist was unavailable. IE requested a meeting be scheduled for the next MFG visit.

4.2 Powerhouse:

- Unit #1 is nearing mechanical completion; overall status reported to be about 95% complete.
- Unit #2 turbine runner is installed. Generator rotor is in service bay, almost ready for pole installation.
- Unit #3 turbine runner assembly is in progress in service bay. Generator rotor frame welding is completed.
- Unit #4 stator stacking is in progress.
- Interior finishing is nearly complete.
- BoP installations are well advanced.

4.3 Converter Station and GIS:

- Converter station is not currently operational pending installation of the interim S/W.
- GIS (Gas Insulated Switchyard) is complete. One transmission line is in service and supplies power to U1 generator transformer.

5. RECAP AND UPDATE AT LCP OFFICE– NOVEMBER 21, 2019

5.1 Staff Training:

- Andritz will deliver training on the turbine/generator units.
- BoP training will be provided by SNC Lavalin, Cahill and OEMs.
- Manitoba Hydro is providing operators and training in the interim period. Plant will be operated 24/7 for period of 2 years and the plant will transit to one shift operation.

6. OPERATING DOCUMENTS

- Operational studies currently under way will result in development of Operating Instructions.
- Local Operating Instructions will be prepared by Manitoba Hydro and SNC Lavalin.
- Electrical Control Centre (ECC) is assigned responsibility for the preparation of the Human Machine Interface (HMI) mimic diagrams.
- MFG staff and vendors will prepare local HMI mimics.

6.1 Operation in 'Overload' Mode:

- Operation in monopole 'overload' mode commences with an automatic sequence that transfers load from failed monopole to the healthy one. Due to the limited loading capability of certain HVDC converter station main equipment, the power output from the healthy pole is ramped down from the maximum of 2.0 p.u. to 1.5 p.u. after 10 minutes. However, if a cable switching operation is required because the spare cable is not on the healthy pole at the start of the overload, and should the switching not occur within 5 min, the overload must be reduced to 1.0 pu within 5 min versus 10 min. This is also the case if the spare (middle) cable is not available.
- Thus, operation in the 'overload' mode at a continuous value of 1.5 pu is possible only if the healthy pole is connected to two parallel cables in ground return mode. Switching for cable paralleling takes place in the transition compounds.
- The logic for operation in the 'Overload' mode resides in the Overload function.

IE Comment: Failed monopole power may be replaced from other sources such as the Maritime Link. In that case, S/W design for operation in 'Overload' could be temporarily deferred to free up GE design resources for other tasks.

6.2 Commissioning:

- Organizational Chart LCP Muskrat Falls Generation Execution Team was provided and briefly discussed.
- HVDC Line Fault Locator testing will include staged line-to-ground fault tests on the HVDC transmission line.
- HVAC line faults on the rectifier side may cause loss of HVDC power loss; HVAC faults on the inverter side may cause commutation failure and loss of power flow.

IE Comment:

- a) *Completion Plan is in place and has been reviewed by IE. Completion team appears to have all the requisite specialties and chain of command. Respective site responsibilities, sign off process, overall responsibility for the Commissioning and Acceptance, and final approval process for the ITP's (inspection and test plans) merit clarification and further discussion.*
- b) *Nalcor may wish to verify capability of LIL converters to ride through AC faults by staged 'close-in' fault tests on the parallel HVAC lines.*

7. ACTION ITEMS AND RECOMMENDATIONS

- With respect to delays in Unit #1 commissioning, IE request more details on the issues facing the Andritz team.
- IE request a copy of Andritz NCR (non-compliance report) for the Unit #4 elevation anomaly.
- IE request a copy of updated Unit #1 Ready-To-Turn scope document.
- HVAC line faults on the rectifier side may cause loss of HVDC power loss; HVAC faults on the inverter side may cause commutation failure and loss of power flow. Nalcor may wish to verify capability of LIL converters to ride through AC faults by staged 'close-in' fault tests on the parallel HVAC lines.
- Regarding design of programming sequences for operation in 'Overload' mode, failed monopole power may be replaced from other sources such as the Maritime Link. If that is acceptable, S/W design for operation in 'Overload' may be temporarily deferred to free up design resources.
- Completion team appears to have all the requisite specialties and chain of command. Respective site responsibilities, sign off process, overall responsibility for the Commissioning and Acceptance, and final approval process for the ITP's (Inspection and Test Plans) merit clarification and further discussion.

APPENDIX 1- Site Photographs

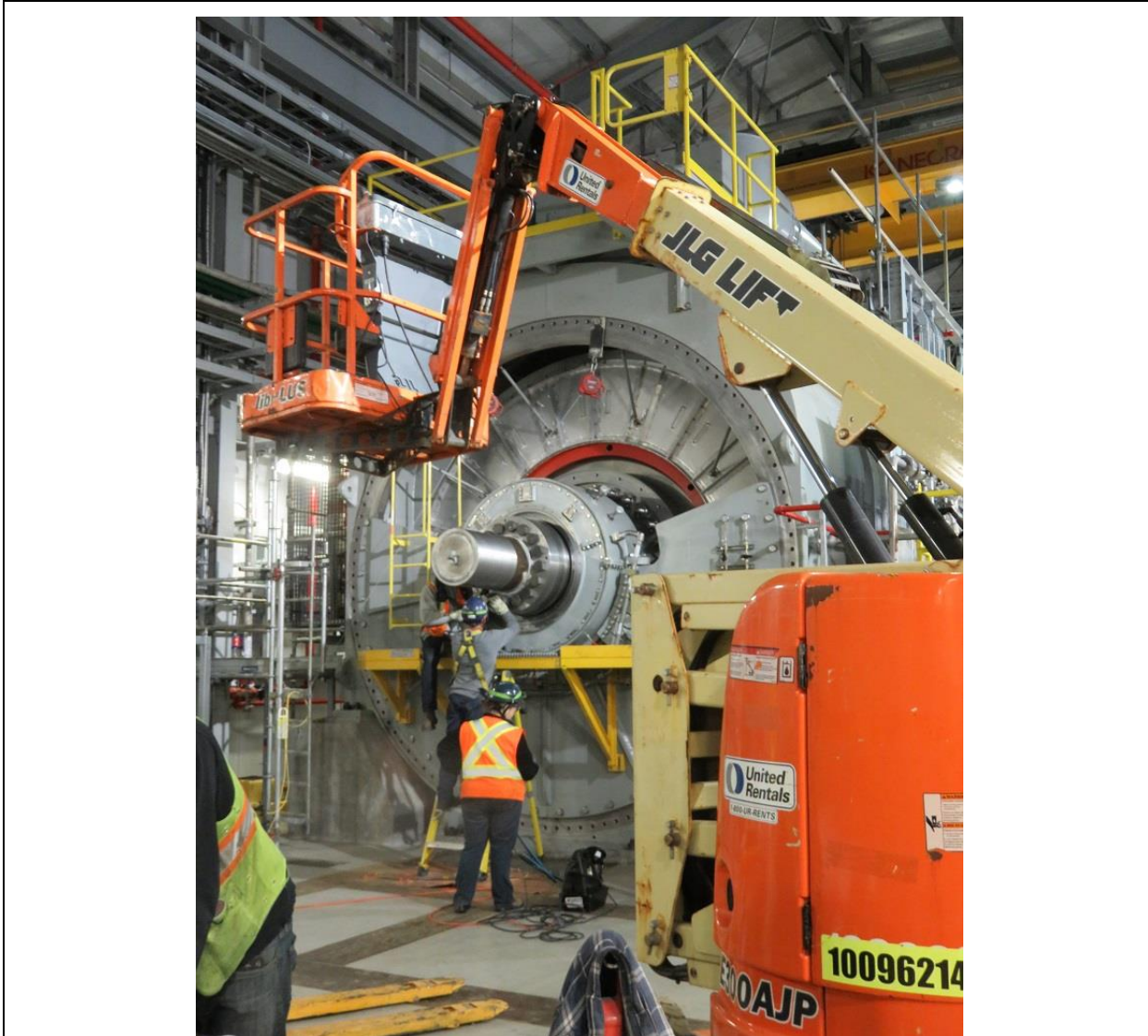


Photo 1: Soldiers Pond – synchronous condenser no. 2 with bearing housing removed.



Photo 2: Downstream side of RCC dam at time of site visit – winter conditions.

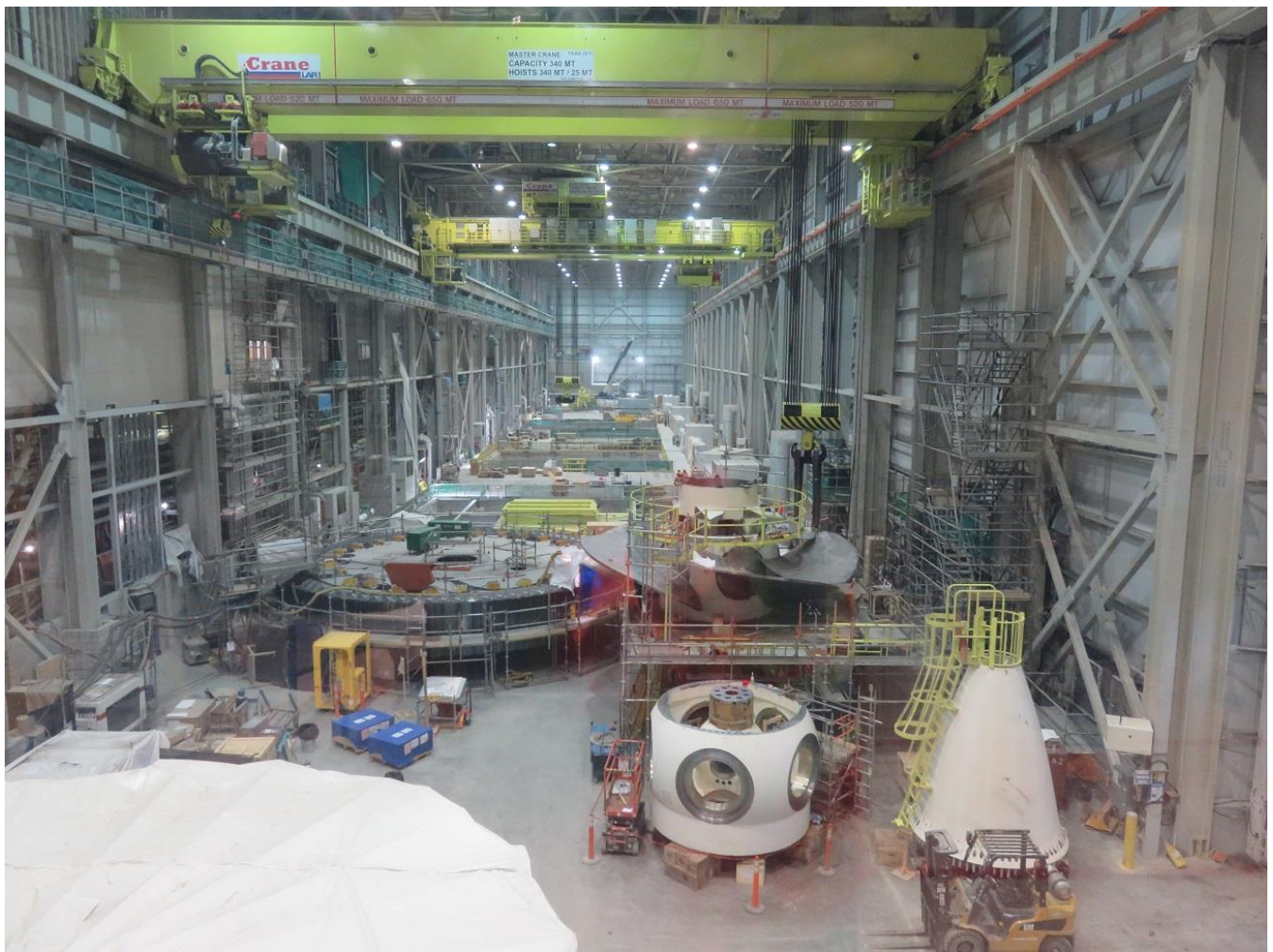


Photo 3: Northerly view of powerhouse interior with Unit #2 generator rotor (centre left); Unit #3 turbine runner (centre right); Unit #4 runner hub and cone (right foreground).



Photo 4: Unit #2 turbine runner viewed from below.



Photo 5: Control room equipment installation in progress.

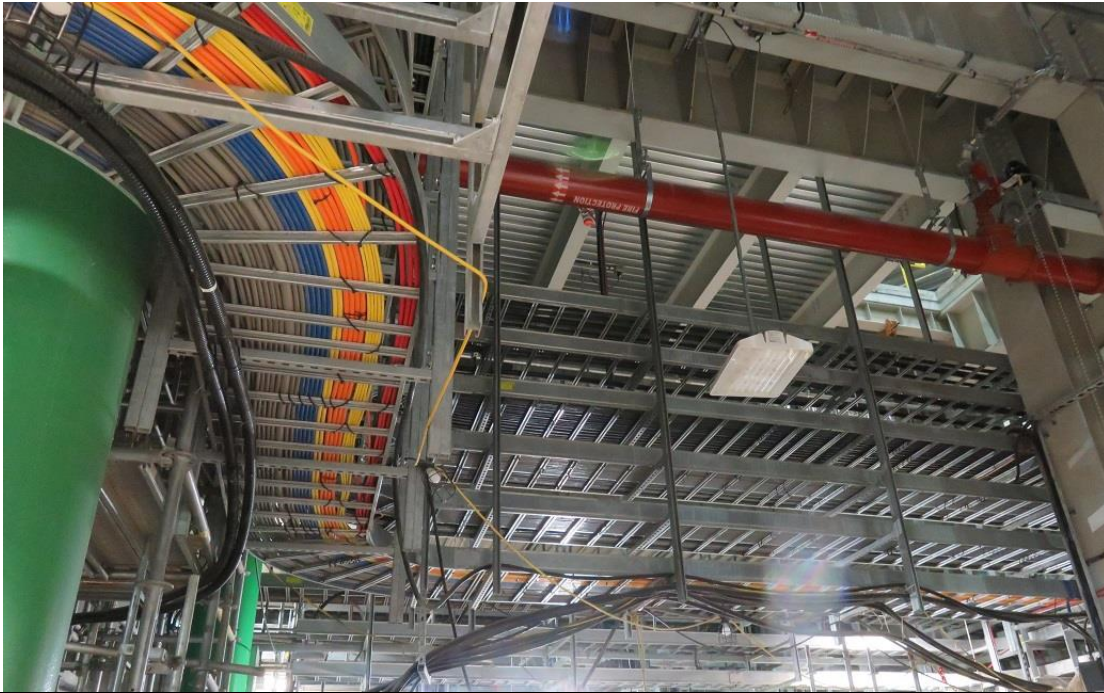


Photo 6: Typical view of balance of plant cabling installation; red pipe at upper right is fire protection water line.