Technical Specification for SAB2 DC Station Service Upgrade

NF28-SPEC-55000-0001 R00

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SAB2 Generating Station
Niagara Operations

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Revision Summary

The revision summary needs to detail only the current revision **if** the old revision(s) are available in an OPG approved information management system (AIMS).

Revision Number	Affected Section	Description of Revisions
R00	Sep 6, 2018	Initial issue.

1.0 INTRODUCTION

1.1 Purpose

Sir Adam Beck 2 (SAB2) Generating Station is a 16 unit hydroelectric generating station located on the Niagara River, 6 km north of Niagara Falls, Ontario. The facility was placed in service from 1954 to 1958. Major overhauls of each unit at SAB2 started in 1989 and were completed in 2005. SAB 2 is equipped with a 250VDC station service system. The DC station service system is used for PLC and SCADA equipment and protection & control system purposes. The 250VDC system consists of two 113-cell battery banks – Bank A and Bank B – their respective chargers, two partially-automated transfer panels, and a flexible distribution scheme; the current topology is shown as Figure 1 in Appendix A. Switching between source and loads is handled by two DC transfer panel ("A" & "B") assemblies which contain four disconnect switches, two breakers and is cable connected to a distribution system. The distribution system is based on two main DC panels ("1" & "2") that each supply a number of subsequent distribution panels. Each subsequent distribution panel, in turn, services loads located throughout the power house, head-works, and switchyard.

The DC station service system including battery rooms require upgrades in order to meet present standards, as well some equipment is near end of reliable service life and is due for replacement. OPG has established a project to upgrade the SAB2 DC station service equipment including two 250 Vdc battery banks, battery racks, chargers, two DC transfer panels, ground fault detection systems, cabling and battery rooms/area. A conceptual single line diagram for the new system is provided as Figure 2 in Appendix A.

The detailed design of the system, specification of components, installation of the new system, and compliance to this specification as well as related regulations and legislation shall be the sole responsibility of the Contractor.

It is not intended that this specification describes and specify the work in complete detail. Rather, it shall be the Contractor's responsibility to furnish the work that from the Contractor's experience and practice, shall in all respects, meet the requirements of OPG and the referenced and applicable industry standards.

2.0 LAWS, STANDARD, AND CODES

2.1 General

All work shall conform to:

- The laws and regulations of Canada, the Province of Ontario and/or local municipalities.
- Specific standards listed in the sections below, their latest issues, amendments and supplements of which shall apply unless otherwise indicated in the contract documents.
- Any other standards mentioned elsewhere in this document or that apply in general to this work.

The Contractor shall clearly state in writing any exceptions or deviations it intends to take to these standards and specifications. Unless accepted by OPG's Engineer, materials, installation and workmanship not conforming to the standards and codes listed herein and elsewhere in the contract may be rejected.

Should conflict occur between laws, standards or codes and this Specification, the most stringent requirements shall govern.

2.2 References

- **Occupational Health & Safety Act & Regulations.**
- **Ontario Electrical Safety Code, 25th Edition.**
- **Ontario Building Code.**
- **Ontario Fire Code.**
- **NFPA 70E Standard for Electrical Safety in the Workplace**
- **NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.**
- **Canadian Standards Association (CSA):**
  - C22.1 -Canadian Electrical Code Part 1.
  - C22.2 No. 0 - Canadian Electrical Code Part 2.
  - C22.2 No. 5 - Molded-case Circuit Breakers, Molded-Case.
  - C22.2 No. 14 - Industrial Control Equipment.
  - C22.2 No. 29 - Panelboards and enclosed Panelboards.
  - C22.2 No. 31 – Switchgear Assemblies.
  - C22.2 No. 38 - Thermoset Insulated Wires and Cables.
  - C22.2 No. 39 – Fuseholder Assemblies.
  - C22.2 No. 75 - Thermoplastic Insulated Wires and Cables.

- C22.2 No. 40 - Cut-out, Junction and Pull Boxes.
- C22.2 No. 41 - Grounding and Bonding Equipment.
- C22.2 No. 45 - Rigid Metal Conduit.
- C22.2 No. 56 - Rigid Metal Conduit and Liquid Tight Flexible Metal Conduit.
- C22.2 No. 65 - Wire Connectors.
- C22.2 No. 106 – HRC-Miscellaneous Fuses.
- C22.2 No. 107.2 – Battery Chargers.
- C22.2 No. 126.1 - Metal Cable Tray Systems.
- C22.2 No. 131 - Type TECK 90 Cable.
- C22.2 NO.211.2-06 - Rigid PVC Conduit.
- C22.2 No 239 - Control and Instrumentation Cables.
- G40.20-13/G40.21-13 General Requirement for Rolled or Welded Structural Quality Steel - 7th Edition.
- G164-M92 - Hot Dip Galvanizing of irregularly Shaped Articles.
- W59.2-M1991, Welded Aluminium Construction - First Edition, General Instruction No.1.
- W59-15 Welded Steel Construction (Metal Arc Welding) - Ninth Edition.
- Z460 - Control of Hazardous Energy - Lockout and Other Methods.
- CAN/ULC S801: Standard on Electric Utility Workplace Electrical Safety for Generation, Transmission and Distribution

- **Institute of Electric and Electronics Engineer (IEEE):**
  - IEEE Std. C37.20.1: Metal Enclosed Low Voltage Power Circuit Breaker Switchgear
  - IEEE Std. 484 – Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.
  - IEEE Std. 485 – Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications.
  - IEEE Std. 450 – Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
  - IEEE Std. 576: Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications.
  - IEEE Std. 946 – Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations.
  - IEEE Std. 1375- Guide for the Protection of Stationary Battery Systems.
  - IEEE Std. 1578- Recommended Practice for Stationary Battery Electrolyte Spill

Containment and Management.

- IEEE Std. 1635- Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications.
- IEEE Std. 1657- Recommended Practice for Personnel Qualifications for Installation and Maintenance of Stationary Batteries

- **ASTM:**
  - A325M Standard Specification for Structural Bolts, Steel, Heat Treated 830MPA Minimum Tensile Strength
- **OPG Standards, Procedure and Guidelines:**
  - ENG-MAN-002E - Station Grounding and Bonding Guide
  - ENG-STD-004 - Drafting Presentation Standard and Practices
  - ENG-MAN-015 - Drawing Requirements Manual - Instructions to Professional Services Providers re: OPG Hydro Drawings Creation and Revision
  - ENG-MAN-008 - Constructability, Operability, Maintainability and Safety (COMS) process
  - OPG-M-377 - Terminal Blocks
  - OPG-M-582 – Cable Control and Instrumentation, Multiple Conductor Shielded upto 60V
  - OPG-M-783 – DC Battery Charger
  - OPG-M-784 – Station Batteries
  - OPG-M-785 – Low Voltage DC Power Circuit Breaker Switchgear
  - OPG-M-772 – Temporary Ground Assemblies

2.3 Drawings, Documents and Models

The following drawing is for the existing system and for reference purposes. The Contractor shall assume there will be some existing drawings that may require Contractor updates. Reference drawing shall be assumed not to scale or accurate, until field verified by the Contractor:

Table 1: Reference Drawings

Drawing Number	Name
NF28-D1H-55300-0004	SAB2-Powerhouse 250 V DC Station Service Operating Diagram
NF28-D1H-66400-0311	Sab Gs 2 Terminal Room Misc. Plc Digital Status Inputs Rack 1f Slot 7 (10065-10096) Elementary Wiring Diagram
NF28-D1H-66400-0312	Sab Gs 2 Terminal Room Misc. Plc Digital Status Inputs Rack 1f Slot 8 (10097-10128) Elementary Wiring Diagram
NF28-D1H-08965-0004	Sab 2 Powerhouse Generator Floor (elev. 279' & 282') Emergency Fire Plan

3.0 OPG REPRESENTATIVES

The OPG project leader will be the single point of contact between the Contractor and OPG. All submissions, correspondence and requests for review shall be addressed to the OPG project leader.

The following people will be the key OPG members for this project:

John Urie - Project Leader
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4.0 SCOPE OF WORK

This section provides a general overview of work that is the sole responsibility of the Contractor. The following sections and subsections will provide further details on the individual scope items, specifically design specific requirements.

The following numbered items provide a summary of scope of work that shall be the Contractors responsibility:

1. Design, procure, install and test a new DC Station Service to replace the existing. Following provides a list of major equipment (to be confirmed by the Contractor Engineer) that shall make the new DC station service:

   (a) Two (2), 250Vdc Vented Lead Acid (VLA) battery banks including battery racks.

   (b) Two (2), Battery chargers, input voltage: 600Vac 3Ph, Output Voltage: 250Vdc.

   (c) Two (2), 250Vdc low voltage DC power circuit breaker switchgear.

   (d) Various sizes and lengths of Power and Control Cable to interconnect aforementioned equipment with existing.

OPG has prepared a conceptual design to determine the scope of work however, the final design shall be the Contractor's responsibility. A conceptual single line diagram for the new system is provided as Figure 2 in Appendix A and Section 7.0 provides detailed technical requirements. The main 250V DC panels installed and equipment downstream of these panels are not part of the scope.

2. Conduct the station batteries size calculation as per the IEEE 485 standard and engineering studies (load flow, short circuit and protection co-ordination) to review and finalize the equipment rating referenced in item 1. The results shall be summarized in a form of a report and submitted to OPG for review and acceptance as per Section 7.4.

3. Prepare supplementary specifications to procure equipment referenced in Item 1. Use OPG standard technical specifications where available, only OPG pre-determined vendors listed in applicable sections shall be used. All documentation (i.e. procurement specifications and vendor submitted drawings) shall be submitted to OPG for review and acceptance prior to the equipment procurement.

4. Replacement of existing DC transfer panels (A & B) with A and B DC switchgear for all loads to ensure a truly redundant system. Install a new DC switchgears with manual transfer. The switchgear shall have redundant battery banks operating with lockout provisions to prevent parallel operation of the chargers.

5. As physical space for DC equipment room in the powerhouse is limited, OPG has identified preferred potential locations for a new DC Switchgear as well as developed a simplified conceptual design for the upgraded DC distribution system, see Appendix A and Appendix B.

6. Replacement and installation of new ground detection system.

7. Replacement and installation of new DC system cables from battery banks to DC switchgears and from DC switchgears to existing main DC panels (1B & 2A).

8. Replacement and installation of new DC system cables from chargers to DC switchgears.

9. Remove the Station service panels (DC1A and DC2B) main breaker feed from Transfer panels (A & B) and re-install at the main DC panels (1B and 2A) with a new breakers.

10. Design and Install new pad to suit the new equipment layout.

11. Design and install details for modifications necessary to the existing battery room, including construction/modification of eyewash station including drainage for spill of electrolyte or water, fire extinguishers, HVAC, lighting, door, exit/hazardous signage etc. The Section 7.4.4 provides detailed technical requirements for battery room modification.

12. The battery room shall have an adequate heating and ventilation to ensure concentration of free hydrogen is limited to 2% and maintain 25˚ C as per IEEE standard 484.

13. The monitoring system shall be provided for eyewash station and battery room temperature.

14. Provide construction & integration design drawings including layout, elementary and connection wiring diagrams to install new equipment and integrate new with existing equipment.

15. Remove and demolish all unused equipment and components no longer required as per Section 8.0.

16. Repair any unused penetrations as per Section 7.1.

17. Supply procedure, equipment and labour to conduct tests summarized in Section 10.0.

18. Provide a consolidated maintenance binder at project completion.

19. Submit as-built drawings at project completion as per Section 11.0.

20. Design, procure, install and test any other equipment or system not explicitly mentioned in this section but required to meet the requirements of this specification.

5.0 MISCELLANEOUS RESPONSIBILITIES

This section only provides a list of additional responsibilities that do not fit anywhere else in this specification.

5.1 OPG's Responsibilities

- Provide access to the site and washroom.
- Provide electrical power to supply the Contractor’s office/lunchroom trailer.
- Provide electrical power to supply the required power tools from existing services only.
- Provide OPG reference standards and drawings (Table 1).

5.2 Contractor's Responsibilities

- Provide all labour, construction, equipment, materials and documents to execute the work as specified in this specification. All items which are not specifically mentioned in the contract but are necessary for the efficient and safe installation and operation shall be provided by the Contractor. This may include power cables, control/instrumentation cables, TECK connectors, cable clamps, cable trays, conduits, nuts, bolts, junction box, terminal block and other special tools/equipment required to complete the requirements of this contract.
- Supply communication equipment for phone, fax, printing and computer access, and supply office/lunch trailer and washroom facilities.
- Supply air compressor(s) for any outside work as required.
- Provide all sundries like cleaning agents, paint brushes and necessary hardware for all work.
- General site, project and safety management.

6.0 GENERAL REQUIREMENTS

6.1 Technical Qualifications

The Contractor shall have detailed technical knowledge and project experience in designing, replacing and testing DC switchgears, VLA batteries, DC chargers, power cables, communication cables, cable trays, conduits and associated controls.

The Contractor shall have an implemented Quality Assurance program conforming to ISO 9001 or equivalent.

The Contractor shall submit a detailed execution plan and an overview statement to summarize their execution strategy, understanding of scope of work, technical qualifications, and past project experience by listing similar projects.

6.2 Reliability and Maintainability

The equipment design and construction shall ensure the highest degree of reliability by utilizing the latest available proven technology. All equipment and components shall meet all referenced, applicable industry and OPG standards. For ease of maintenance and to reduce overall equipment cost equipment design shall utilize industrial grade and standard off-the-shelf components when possible.

6.3 Design

The design work shall be undertaken by professional engineer(s), licensed in the province of Ontario (P.Eng). All design documents including engineering studies, construction drawings and test procedures and reports shall bear the seal(s) and signature(s) of the Professional Engineers responsible for the design. The Contractors shall forward all design documents and drawings to the OPG Engineer for review and acceptance. This will also be a hold point as per Section 13.0. Prior to submitting any documentation to OPG, the Contractor shall carefully perform an internal review of all submittals. All submittals shall contain the Contractors internal review mark-ups, and a stamp confirming the document was internally reviewed by the Contractors engineer (internal or external). Submittals with errors and omissions shall be returned to the Contractor. Accompanying project management specification provides further detail on the submittal process. Acceptance of the design by OPG in no way alleviates the Contractor or their P.Eng of their legal or contractual responsibility for the design. The design submissions shall be provided for OPG review at 30%, 60% and 90% completion stage.

6.4 Material and Workmanship

- Equipment used shall be CSA Certified or ULC listed
- Final installation and design shall be met the requirements of the Ontario Electrical

Safety Code (OESC).

- Unless specified, all materials shall be new and in strict accordance to this and reference standards and specifications.
- No component shall contain PCB, lead, asbestos or any substances with toxic levels.
- There shall be no patching, plugging, shimming, or other such means used to overcome defects or discrepancies.

6.5 Service Condition

Unless more demanding requirements are detailed in subsections of this document, all equipment supplied by the Contractor shall be capable of satisfactory operation and performance under the following conditions:

Indoor Equipment	
Ambient Temperature:	0 ºC to +40 ºC.
Humidity:	95 %

All Equipment:

- Humidity, seismic and air quality conditions normally expected in Niagara-On-The-Lake, Ontario.
- Equipment supplied under this contract will not be operated above 1000 m elevation.

6.6 Identification

- Electrical equipment shall be identified with nameplates, operating nomenclature labels and CSA labels.
- Each wire and cable shall be tagged at each termination point with the wire numbers and cable numbers. The tags shall have printed 3 mm letters or numbers. The tags shall be fastened to the cable by non ferrous tapes, bands, wire, lacing twine or equivalent type (zip ties are not acceptable).
- Warning labels, nameplates and CSA labels shall be provided as per the OESC.
- As a minimum, panels and disconnects shall indicate the operating nomenclature, panel and enclosed equipment rating, and voltage level.
- As a minimum, nameplates for terminal cabinet and junction boxes shall indicate system voltage level.
- Warning labels shall be made of engraved Lamacoid, red face and white core, and

shall be mechanically attached to a location that is visible after equipment is installed.

- Nameplates and labels shall be made of engraved Lamacoid, black face, white core and mechanically attached to a location that is visible after equipment is installed.
- Wording on all nameplates and labels shall be proposed by the Contractor and approved by the OPG prior to manufacturing.

6.7 Rigging

The Contractor shall supply all hoisting and rigging equipment to execute the project.

All craning, jacking and rigging shall be performed using qualified personnel in accordance with all the applicable standards, rules and regulations.

For lifting, the lifting lugs, jacking steps, and pulling eyes identified on the equipment shall be used.

7.0 DETAIL TECHNICAL REQUIREMENTS

This section provides detail description on Contractor Scope of Work that is summarized in Section 4.0. The Contractor shall note that this section and subsequent sub-sections are not intended to provide a complete design, but rather, it provides the minimum requirements and some information (Conceptual ONLY) to assist the Contractor with the final design. It shall be the Contractor's responsibility to review the information presented in this specification and accordingly undertake a design, which in all respects, shall meet the requirement of all applicable standards, specifically the ones that are referenced in this specification.

The design shall be undertaken and approved by a P.Eng as per Section 6.3. The Contractor shall ensure the installation plan and design documentation, including drawings, are submitted to OPG for review and acceptance prior to procurement and start of any construction activities. If the Contractor does not follow the requirements and process laid out in this specification, then OPG has a full authority to reject the equipment procured and installed, and the Contractor shall bear all cost to design, re-purchase and re-install replacement equipment.

7.1 General

The following is the list of general requirements the Contractor shall be responsible for:

- The Contractor shall submit all design documents associated with this project the OPG Engineer for approval prior to equipment procurement or start of construction activities.
- Review existing structural installations and perform structural repairs and re-surface floors, walls, containment, vaults, ceilings, etc. that will be affected by the equipment removal or installation. This includes painting of any disturbed surfaces. All floor openings shall be repaired with concrete fill design approved by a P.Eng. All unused protrusions (bolts, studs, etc.) must be removed to the level of the floor, wall, ceiling, etc, and the surface around the protrusion must be resurfaced if it is damaged. All pipe openings shall be permanently sealed with watertight flanges.
- Ensure correct polarity and identification. Polarity shall be consistent throughout entire installation.
- Equipment shall be equipped with appropriately sized mounting pads to connect incoming and outgoing feeds.
- The cable entrance (top, bottom or side) shall be determined by the Contractor based on overall design. Bottom entry is preferred where possible.
- Torque values shall be in accordance with the manufacturer's requirements. Where there are no clear requirements from the manufacturer regarding the hardware, the information presented in an applicable industry standard, such as Table D6 and D7 of the Ontario Electrical Safety Code (OESC) shall be used.

7.2 Definition Phase Engineering

1. Gather information pertinent to execution of the scope as described in this specification. OPG will make available the drawings, manuals, and maintenance history files to assist the Contractor. The Contractor is responsible for performing field verifications (of drawing, nominal loading, equipment rating, etc.) through site visits, installing temporary online load monitors, discussions with site personnel, etc. The Contractor shall review all gathered information, determine nominal loading and design the new station service.

2. DC Station Service Load Study and Battery Bank/Battery Charger Sizing

   - Replacement battery bank sizing/capacity calculation and associated battery charger sizing to IEEE standards

3. DC System Single Line Diagram

   - Provide single line drawing with ratings for equipment, protective devices, and cable sizes.

4. Battery Room Area and DC Equipment Room Layout

   - Provide a layout drawing for existing battery rooms with the location of battery banks, egress, eyewash station, fire extinguishers, HVAC, lighting, exit/hazardous signage etc.

   - Provide preliminary design drawings (limited detail) for each battery room and equipment room. Drawings to include size/dimensions for battery room, battery bank and equipment layout including dimensions of equipment, and main cable tray routing. Indicate details for modifications necessary to the existing battery room, including construction of new egress and DC switchgear.

5. Preliminary Design Review

   - Provide preliminary report for the definition phase engineering. The report should include a summary of the design and a discussion of applicable codes and standards referenced. The report shall include the load study with battery bank/charger sizing, hydrogen concentration study, HVAC calculation and preliminary drawings.

   - Attend a meeting in person to review the preliminary design review package. Incorporate OPG's review comments into the final definition phase report.

6. Definition Phase Report

- Provide a finalized report to OPG for the definition phase engineering. Include report, final studies, preliminary drawings, cost estimates, and recommendations.

OPG stakeholders will review the Definition Phase Report in order to proceed with the next phases of the project.

7.2.1 Equipment Specifications and Procurement

Upon completion and OPG acceptance of the definition phase report, the major equipment can be specified. OPG must review and approve the specifications and the equipment must be purchased from one of OPG's approved vendors.

1. DC Chargers (Rectifier)

   Presently there are two (2) 250V DC charger (A & B) located outside of the battery room. Under this contract, the contractor shall remove existing chargers and install two (2) new DC chargers with same equipment tag name.

   The DC chargers shall meet the following minimum requirement:

   (1) Designed, built, and tested in accordance with OPG Standard Main (OPG-M-783) and the Contractor filled-in Supplementary Specification (OPG-M-783S) on Battery Chargers (125 Vdc and Above) and CSA standard C22.2 No. 107.2-01 Battery Chargers.

   (2) Replace and install new DC chargers into the existing location. DC charger pads are to be modified as required to suit the new equipment dimensions.

   (3) Electrically connected to the upstream (600Vac, MCCNB #13 and MCCSB #15) and downstream devices by appropriately rated cables and shall be equipped with appropriated sized lugs to integrate this cable.

   (4) The contractor to finalize the equipment ratings based on the engineering studies, in accordance with Section 7.4.

   (5) Alarm contacts shall be wired to terminal blocks for OPG connection to the SCADA system as specified in main specification OPG-M-783.

   Procurement

   - Review OPG standard technical specification OPGM-783 Battery Chargers

   - Prepare supplementary specification OPGM-783S for use to procure new chargers

- The Contractor shall only use one of the following OPG qualified vendors for the charger procurement:

  (a) Gentec

  (b) Primax Technologies

  (c) C-Can Power Systems

  (d) HindlePower

2. Station Batteries / Battery Bank

Presently there are two (2) 250Vdc Station Battery Banks (A & B) located in separate battery rooms. Under this contract, the contractor shall remove the existing battery banks and install (2) two new battery banks with same equipment tag names.

The battery banks shall meet the following minimum requirement:

(1) Designed, built, and tested in accordance with OPG Standard Main (OPG-M-784) and the Contractor filled-in Supplementary Specification (OPG-M-784S) on Station Batteries and IEEE standard 484, 485 and 450 for Vented Lead-Acid (VLA) batteries. (No recess terminals allowed)

(2) Replace and install new battery banks into the existing location. New battery racks shall be constructed to meet the National Building Code of Canada seismic condition for the site, and install as required to suit the new battery bank dimensions.

(3) Electrically connected to the associated equipment by appropriately rated cables and shall be equipped with appropriated sized lugs to integrate this cable.

(4) The contractor to finalize the equipment ratings based on the engineering studies, in accordance with Section 7.4.

Procurement

- Review OPG standard technical specification OPG-M-784 Station Batteries

- Prepare supplementary specification OPGM-784S for use to procure new battery banks

- The Contractor shall only use one of the following OPG qualified vendors (North-American made prefer) for the battery procurement:

  (a) C&D Technologies

  (b) Exide Technologies (GNB)

(c) EnerSys Canada

3. DC Switchgear

Presently there are two (2) DC Transfer Panels (A & B) located outside of the battery room. Under this contract, the contractor shall remove existing transfer panels and install two (2) new metal-enclosed DC switchgears with new equipment tag. The new switchgears shall distribute power to the equipment at station in accordance with the conceptual operating diagram Appendix A.

The switchgear shall meet the following minimum requirement:

(1) Designed, built, and tested in accordance with OPG Standard Main (OPG-M-785) and the Contractor filled-in Supplementary Specification (OPG-M-785S) on Low Voltage DC Power Circuit Breaker Switchgear and CSA standard C22.2 No. 31 for Switchgear Assemblies.

(2) Installed two (2) new DC switchgears (A & B) at the proposed location (or new) as per photos in Appendix B. Install maintenance pads as required to suit equipment dimensions.

(3) Each DC switchgear assembly shall be equipped with one (1) main, one (1) tie power circuit breaker, protection relays, control circuits, analog metering and a separate remote transfer control panel to perform the transfer operations away from the switchgear.

(4) Electrically connected to the upstream (battery banks and chargers) and downstream devices (DC panels) by appropriately rated cables and shall be equipped with appropriated sized lugs to integrate this cable.

(5) The contractor to finalize the equipment ratings based on the engineering studies, in accordance with Section 7.4.

(6) The switchgear shall be equipped with ION7330 series power meter's with MODBUS TCP or equal for local voltage and current display. All meter terminals shall be wired to local terminal blocks within the switchgear control compartment to connect with SCADA.

(7) An anti-condensation system (e.g., space heaters, thermostats, humidistats, etc.) is required in each vertical section and in other areas of the switchgear assembly as necessary.

(8) As per OPG-M-785 the switchgear shall be equipped with electrical and mechanical interlocks to prevent paralleling of two power supplies, and interlock to prevent transfer during a fault condition.

(9) The protection and control power shall be sourced from the incoming dc feeds from the station battery/charger, with the connection points occurring on the switchgear bus upstream of the main circuit breakers.

(10) Protection and Control power for the “A” and “B” side shall be tied together through electrically interlocked contactors. In the event of a loss of either source, the other source shall automatically supply control power for both sides. Interlocking must prevent a parallel connection of the supplies through the control circuits.

(11) Two wall-mounted remote control panels (switchgear control panels), one for each 250VDC switchgear assembly, shall be provided. Each panel shall be equipped with the following devices:

- Control switches, one for each DC power circuit breaker, to facilitate remote opening and closing operations.
- LED indicating lamps, green for closed, red for open, and amber for fault indication, to indicate power circuit breaker positions and status.
- A hand-reset Lock-Out-Relay (LOR), one for each switchgear assembly, for lockout of the main and tie power circuit breakers common to an assembly in the event of a trip cause by the operation of the associated overcurrent relay.
- Analog meters showing measured voltages and currents at all metered points.
- Annunciation of all other monitored conditions and quantities requested by this specification.

Procurement

- Review OPG standard technical specification OPG-M-785 for low voltage DC power circuit breaker switchgear.
- Prepare supplementary specification OPG-M-785S for use to procure new switchgear
- The Contractor shall only use one of the following OPG qualified vendors for the DC switchgear procurement:

  (a) Eaton

  (b) Dual-Ade

  (c) Schneider (Square D)

The Contractor shall use the applicable sections of this specification, and referenced applicable standards to create a specification for equipment procurement. It is the Contractors responsibility to make the manufacturer aware of any dimensional constraints. The completed specification and accompanying drawings to be used for the equipment procurement shall be submitted to OPG for review prior to issuing it for Contractors RFP.

The Contractor shall submit to OPG the manufacturer's concept drawings and documents prior to awarding the Contract.

In addition, the Contractor shall provide written documentation to OPG's owner engineer explaining why a particular supplier was chosen over the other – prior to awarding the Contract.

7.2.2 Detailed Design and Deliverables

1. Final Design / Construction Drawings for Battery Room / Equipment Area and Modifications to Existing Equipment Area

   - General Arrangement drawings showing final equipment layout including battery banks, fused disconnect switches, rectifiers, dc distribution switchgear, including dimensions of actual equipment from vendor equipment drawings.
   - Civil/Structural Design - construction details for new doors, ceilings, flooring, etc.
   - Mechanical Design - HVAC for battery room with calculation, including heating, cooling and ventilation ducting, modifications to any plumbing for eyewash station and door between battery rooms.
   - Electrical Design – Modification of battery room lighting and outlets to meet the requirement for Hazardous locations, cable trays for DC station service cables.

(a) 250Vdc Station Service Replacement

   - 250Vdc System One-Line Diagram
     - Include final conductor sizing (taking into account voltage drop calculations) for all main feeder cables to panels and cable schedules.
   - Equipment general arrangement drawings and installation/removal details
     - demolition details for existing equipment and cabling
     - location diagrams for all new/existing equipment
     - installation details for new equipment
     - installation details for new station service main feeder cables / cable tray / cable routing to main DC panels including floor/wall penetrations
   - Protection and Coordination Study (battery bank fuse / cable sizing)
   - Voltage Drop Study (battery banks to field DC panels and to end devices)

- Electrical Schematic and Wiring Diagrams
    - Provide elementary and connection wiring diagrams, including:
    - 250VDC system main connection wiring diagram (include cable numbers for main feeder and all DC branch circuit wiring)
    - DC Switchgear
    - DC Chargers
    - DC ground fault detection systems
    - Modified existing drawings
- Cable Schedule
    - Cable schedule with cable numbers for all new cables
    - Cable schedule for demolition of existing cables

7.3 Project Schedule

A current schedule for the project is as follows:

Milestone	Completion Date
PO Award	Dec 3, 2018
Engineering & Design Period	March 2019
Site Construction Period	2019
Final Completion	September 2019

7.4 Additional Details for Engineering Services

The sections provides further details on some of the required engineering services listed in Section 7.2.

7.4.1 DC Station Service Load Study

The DC system load study will be used to define capacity requirements for the DC system. The purpose of the study is to determine appropriate ratings for the new battery banks and chargers. The new equipment shall be adequately rated for the facility's DC load demands during normal conditions, future loads and capable of meeting the Ontario Energy Board's Transmission System Code requirements for a realistic, yet abnormal 8-hour duration event involving loss of AC station service and/or other events resulting in the loss of charging rectifier supply. The study must

incorporate the existing DC system loads, considerations for future expansion, and any design assumptions.

The study shall be performed in accordance with the recommendations and guidelines of IEEE 946 Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations and IEEE 485 Recommended Practice for the Sizing of Lead-Acid Batteries for Stationary Applications. The results of the loading study shall provide OPG with a clear understanding of the present DC system load profile, capacity ratings required for replacement equipment necessary to meet the required standards, as well as providing information on spare available capacity with the upgraded system.

7.4.2 Short Circuit Analysis and Protective Device Co-ordination Study

A short circuit analysis and protection coordination study is required to determine appropriate equipment ratings and setting of the protective devices. Protective device elements are expected to include overcurrent fuse protection close to the battery terminals, main DC breakers in the switchgear, and panel branch circuit overcurrent devices. A protection co-ordination study shall be completed in accordance with recommendations and guidelines of IEEE 1375 Guide for Protection of Stationary Batteries to confirm appropriate equipment withstand ratings and settings for overcurrent devices, to allow continuity of DC system under worst case operating conditions.

Perform short circuit and protective device coordination with the latest version of Easy Power, and provide OPG with a copy of the electronic file.

7.4.3 Voltage Drop Study

Once final equipment locations and cable routing are known, and cable lengths can be estimated. At this point, a voltage drop study to confirm appropriate sizing all of DC station service cables shall be performed. The study should clearly indicate the allowable and expected voltage drop at the switchgear, and main DC panels, under various system operating conditions, including worst case loading for the DC system.

7.4.4 DC Station Service System Design

The Contractor, using the information gathered from OPG drawings, site visits, preliminary design, as well as the studies above, shall produce the overall engineered design of the DC station service system.

The design is required, but not limited to consideration of the following:

1. Overall design, construction, and operation are consistent with good utility practice.

2. Reliability and service life of the system is maximized and life cycle cost is minimized.

3. No unexpected hazards are created and the battery system is safe for staff to operate.

4. Sizing and specification for battery banks, chargers, and switchgear based on results of DC system load study. Determine the existing main 250VDC panels (1B & 2A) is adequate based on results of DC system load study and short circuit analysis.

5. Overcurrent device ratings based on short circuit and protective device coordination study.

The specification of the design modifications to the existing battery room requires special consideration with regard to the capability to accommodate the ventilation, accessibility, and safety requirements. The renovation of the existing battery room shall be in accordance with applicable standards and regulations, including but not limited to the following considerations:

1. Battery room furnished with heating, cooling and ventilation to ensure consistently controlled ambient temperature of 25 degree C. (No ignition source are acceptable, forced air only)

2. Adequate ventilation to ensure concentration of free hydrogen is limited to 2% (especially during equalize charge). The hydrogen sensor shall be installed to monitor the hydrogen level in battery rooms.

3. Design battery room ventilation systems in accordance with IEEE Standard 450 and 1635/ASHRAE Guideline 21.

4. The complete electrical installation including equipment such as fans, heaters, lights, switches shall be of an intrinsically safe design and/or meet the requirements for Class 1, Zone 2, Hazardous Locations as defined by the Ontario Electrical Safety Code.

5. General lighting requirements shall be in accordance with applicable standards and regulations, including but not limited to the following considerations.

    - Light shall be LED with color temperature between 4000-5000K. Incandescent or fluorescent lighting is unacceptable.

    - Average lighting level at the battery terminals shall be 500 lux or more.

    - Lighting housings shall be corrosion free, high impact resistant.

    - Battery backup emergency lighting shall be installed in the rooms.

6. The ventilation system status (fan motor running and analog temperature indication) shall be wired to the existing station miscellaneous PLC to indicate the ventilation system is functioning properly.

7. Battery room smoke and/or heat detectors shall be connected to the facility fire alarm system.

8. Two points of egress (doors) located at least 75% of the diagonal distance of the room from each other, when the room is of sufficient size (refer to O.Reg 851. S122)

9. A shower and eyewash station, accessible within the battery room. (refer to O.Reg 851. S124/125). The drains associated with emergency eyewash/shower station may or may not require a dedicated containment tank, with preference to connect to station sump or drain directly to river if feasible.

10. Audible and visual alarm contacts shall be supplied and wired to the miscellaneous PLC to indicate the eyewash/shower station has been activated.

11. Battery room floor covered with slip-resistant and acid or alkali resistant material.

12. Contractor to determine the arrangement, spacing, and support for the rack design that will provide safe and ready access and working space for inspection, testing, maintenance, and replacement of cells.

13. Battery racks, enclosures, etc. shall be bonded to station ground with at least 4/0AWG.

14. Replace and install new blast and fire resistant double door with inserts into the existing location, which is between battery rooms.

15. Adequate hazardous and exit signage in accordance with OHSA regulation 67/93 and Canada Occupational Health and Safety Regulations SOR/86-304.

16. Repair any floor/wall/ceiling damage and paint where required.

The overall system design shall also consider the following:

1. Equipment layout

2. Location of loads and other equipment, including HVAC and ventilation systems

3. Existing floor/wall penetrations and penetrations required to be created.

The following assumptions shall be applied to the overall design:

1. The principle of Safety-By-Design shall be applied. For example, location selection for system and components shall take into consideration operating and maintenance personnel safety. The Safety-By-Design principles are outlined in the reference OPG document ENG-MAN-008 - Constructability, Operability, Maintainability and Safety (COMS) by design.

2. The new system shall adequately supply existing and foreseeable future load requirements without overloading or stress.

3. All systems shall be designed for minimal and user-friendly routine or emergency maintenance requirements.

4. System components shall be industrial grade varieties with reasonable replacement availability expectation over the system life span.

5. Breakers are required to have visible contacts.

6. All new breakers will have installed locking devices.

7. Where practical, all systems shall be designed such that any required maintenance to one part of the system has minimal or no impact on other parts of the system, station operations or requires production outages.

7.4.5 Material Specifications

The Contractor shall provide specifications for all other equipment and material necessary to complete the project. The material specifications could be incorporated as notes on the drawings. The equipment and material includes, but is not limited to:

1. HVAC equipment for battery room(s) – AC, heating, ventilation (forced air outside of the battery room), thermostats, etc.

2. Electrical equipment for battery room – lights, fire alarm system mods

3. Other equipment (door, eyewash stations, etc.)

4. Cables (power)

5. Conduits and conductors in conduits (if applicable)

6. Fused and non-fused disconnect switches (visible contacts to allow visual verification of the open blade position)

7. Overcurrent devices (both fuses and breakers)

8. Continuous cable tray systems including installation hardware

9. Grounding system components

7.5 Grounding

The grounding shall be in accordance with the OPG Station Grounding and Bonding Guide ENG-MAN-002E and shall conform to the requirements of the OESC. Some of the specific requirements out of this guide and code include but are not limited to the following:

Permanent Grounding:

1. All metallic parts at ground potential, including equipment bases, mounting brackets, conduits, piping, junction boxes, enclosure, cable tray, etc. shall be connected to the station's ground grid.

2. Paint shall be removed in all areas of the equipment that is connected to the station ground.

3. All ground connections between conductor to conductor and conductor to flat bar shall be compression style using Burndy CJC or YGHC.

4. All metal conduits terminating at sheet metal enclosure pull boxes, cable trays shall be fitted with ground bushings at both ends.

5. It is preferred the ground cable is run the entire length of the cable tray/conduit, or each section of the cable tray or conduit is bonded with a jumper cable to provide electrical continuity. The OPG Grounding Guide - Section 7, of ENG-MAN-002E provides examples of acceptable jumper design.

6. When TECK cable used, the cable armour and ground conductor shall be connected to the enclosure at each branch using appropriate TECK connectors and ground bushings.

7. Where a separate ground conductor run in tray, it shall be supported at no more than one bond per section. Use Burndy or Penn Union 1 or 2 bolt grounding clamps for support.

8. The main ground cable shall be 4/0, class B, medium hard temper (ASTM B2), uncoated as per ASTM B8-04. Secondary surface ground and connection to minor equipment shall be #2/0 manufactured to aforementioned class and standards.

9. Use oxide inhibiting compound, such as Burndy Penetrox 'E', for all copper connections between all mating surfaces.

10. All shielded type cables shall have the shield grounded at one end closer to the supply point as per Section 7.4.21 of the ENG-MAN-002E.

11. Cable terminations shall be grounded as per the manufacturers' instructions.

Temporary Grounding:

The new equipment shall have engineered locations to temporary ground the equipment with the OPG approved temporary ground assemblies (OPG-M-772). The electrical and physical locations of these points shall be at following location (exact location to be proposed by the manufacturer of equipment):

1. On both sides of DC power circuit breaker switchgear.

Each aforementioned location shall have a “bus end” and “ground end” ground attachment points installed (ball studs manufactured by MacLean power). Temporary grounding assemblies shall be supplied by Contractor as per OPG-M-772.

8.0 REMOVAL

1. The Contractor shall be responsible for the removal and disposal of equipment no longer required. This includes removal of the existing cables, terminal boxes, junction boxes, splitter boxes, panels, chargers, batteries, etc. The contractor shall completely remove cables no longer required.

2. The existing control and communication cables shall remain in service. If it appears that this may not be achievable, the Contractor must discuss options with OPG prior to any work that might compromise these cables.

3. The Contractor shall submit a removal plan for OPG approval eight weeks prior to work taking place.

4. Scrap metal will be placed in OPG provided scrap metal bins on site. Other debris shall be disposed of in Contractor provided garbage bins. Larger pieces of equipment will be disposed of by the Contractor with a credit provided to OPG for scrap metal.

5. The removals shall be performed in a manner that power to the station remains uninterrupted. OPG understands that during execution, some outages might be required. These outages are to be minimized and may require the Contractor to install a temporary power source.

9.0 CONSTRUCTION

The Contractor shall be responsible for the construction work and installation of all equipment and material, cable and cable trays, grounding, protection and control modifications, integration into the existing PLC systems, testing and commissioning/start-up procedures.

The contractor is responsible for demolition and to identify all equipment and cables to be removed from service. The Contractor shall clearly state the hazardous materials identified for removal from site related to the project. OPG will provide documentation for known hazardous materials and conduct the necessary tests on suspect equipment.

Where the installation requires civil or mechanical alterations to the powerhouse structure such as floor or wall penetrations, foundation alterations/extensions, or equipment relocation, a report by a qualified and licensed Professional Engineer of Ontario shall be provided to verify the alterations will not compromise the operation of the generating station.

10.0 TESTING

The Contractor shall perform testing as per the requirements outlined in this specification, accompanying main and supplementary specifications and the equipment manufacturer's operating and maintenance manuals. The applicable industry standards shall be followed to conduct the tests. Any deficiencies found shall be immediately brought to the attention of OPG's Project leader and shall be addressed by the Contractor. The equipment shall be re-tested after the deficiencies are addressed at no additional cost to OPG.

Test plans (factory and field testing) shall be submitted to OPG a minimum of four weeks prior to testing taking place. All factory and field tests shall be witnessed by the Contractors engineer. OPG may also choose to send OPG representative for witnessing of tests. The test results shall be recorded on standard recording sheets, to be provided by the Contractor. A test report approved by a P.Eng as per Section 6.3 shall be submitted for OPG's acceptance prior to the first energization of the equipment. The report shall include results of all tests conducted, including the completed recording sheets and the equipment calibration certificates.

Contractor will entail checking each delivery to ensure that the complete shipment of batteries and other equipment has arrived, safely and without damage. The pre-commissioning checks/test to be performed include but are not limited to the following:

Station Batteries:

- Visual inspection of battery cells, inter-cell bus links, bus connectors, and battery racks.
- Verify bolt joint torque values for inter-cell bus links and bus connectors in accordance with the manufacturer's published data. In absence of the manufacturer's published data, use OESC or other applicable industry standards.
- Verify the ground isolation of inter-cell bus links and power cables.
- Verify the battery cells specific gravity, voltage level, temperature, and discharge/capacity.
- On-site acceptance test of the capacity of each battery bank.

Chargers:

- Visual inspection of battery charger, breakers, cables, meters, etc.
- Functional checks of breakers, instruments, meters, relays, etc.
- Verify the charger equalizing charge, float charge, load balance and initial operation.

DC Switchgear:

- Insulation resistance on breaker and terminals.
- Auxiliary devices and breaker operational verification.

- Protective relay testing by secondary injection.

Power and Control Cable Test and all Wiring:

- Continuity test to ensure correct cable connection.
- Visual Inspection of cable supports, terminations, insulation from physical defects, bend radius within OESC or manufacturer's published data and cable identification against construction drawings.
- Insulation resistance test on each conductor with all other conductors and shields grounded. Apply voltage in accordance with OEM published data. In the absence of OEM data, use Table 2.
- Load verification of electrical connections between equipment that will be installed or modified as part of this project, and completing forms to state that these connections have been confirmed.
- Verify uniform resistance of parallel conductors.

Grounding System:

- Resistance measurement using low-resistance ohmmeter between the known working station ground and each ground point used for equipment grounding.

All Equipment:

- Verify bolt-torque values in accordance with the manufacturer's published data. In absence of the manufacturer's published data, use OESC or other applicable industry standards.
- Verify the battery room's area ventilation.
- Resistance measurements through all bolted connections using a low-resistance ohmmeter.
- Inspect physical and mechanical condition of connections to be free of corrosion.
- Inspect all equipment against physical damage, anchorage alignment, clearance and grounding.
- Inspection of all wiring and bus connections for correctness and tightness.

Table 2 - Insulation Resistance Test Voltage

Nominal Rating in V	Minimum Test Voltage DC
300	500
600	1,000
1,000	1,000
5,000	2,500
15,000	2,500

11.0 DRAWINGS

1. The Contractor shall be responsible to update via field mark-ups (red for 'add' and green for 'removal') all existing OPG drawings and create new drawings as required.

2. The drawings work includes but may not be limited to the following:

   - Revise existing Elementary Wiring Diagrams (EWD) and Connection Wiring Diagrams (CWD) for associated systems such as protections, controls, annunciation and their associated subsystems, civil plans, floor plans, and elevation drawings. These EWD & CWD drawings shall reflect the internal wiring of the modified equipment, and integration detail with connected equipment, and existing loads. It is OPG's experience that understanding the requirements of EWDs and CWDs is misunderstood by Contractors. Prior to drawing development, please ensure that the requirements and differences between the two types of drawings is clearly understood.

   - New EWDs and CWDs for new equipment or where the drawing for the existing system is not available.

   - New drawings detailing the cable routing and strapping plans.

   - New drawings detailing the equipment arrangements and layouts.

3. All drawings shall be produced in accordance with OPG drawing standards:

   - ENG-STD-004 - Drafting Presentation Standard and Practices.

   - ENG-MAN-015 - Drawing Requirements Manual - Instructions to Professional Services Providers re: OPG Hydro Drawings Creation and Revision

4. All drawings shall be produced in AutoCAD 2017. OPG will provide the Contractor with an electronic copy of the appropriate AutoCAD title block and borders.

5. All drawings and documents shall be sealed by a P.Eng. For revised OPG drawings, the approval is only applicable to the new revision number.

6. Prior to the fabrication of any equipment or purchasing of electrical equipment or cabling, an electronic copy of shop drawings and bill of materials, manufacturer's drawings, equipment data sheets and cable data sheets covering all items/or systems supplied or manufactured by the Contractor shall be submitted to OPG for review and acceptance.

7. No work shall start until the 'issued for construction or fabrication' drawings are issued by the Contractors P.Eng, and are reviewed and accepted by OPG. All

drawings must be carefully checked by the Contractor and bear the Contractor's identification review stamp or signature prior to submitting them for OPG review. Drawings will not be considered otherwise. The Contractor shall take responsibility and risks for all costs which result from ordering or installing any equipment prior to acceptance of the drawings by OPG.

8. All wiring shall strictly follow the accepted CWDs. OPG will conduct random audits to ensure this requirement is met.

9. The Contractor shall field mark-up 'issued for construction' drawings reflecting 'As-Builts'. A working set of these drawings shall be managed on-site by the Contractor's site supervisor. OPG will conduct random audits to ensure this requirement is met.

All designs and drawings submitted shall become intellectual property of OPG and may be used for any and all future maintenance, operation, and improvement work associated with this project.

12.0 CONSOLIDATED LIST OF TECHNICAL DELIVERABLES

The proponents shall sequentially fulfill the deliverables and associated required actions summarized in Table 3. Table 3 is in no way a complete summary of the technical requirements of this specification.

Table 3 - Consolidated List of Technical Deliverables and Action Required

Item	Deliverable	Action Required
1.	Mandatory Site Visit	Attend a **Mandatory Site Visit** at SAB2 before submittal.
2.	Evidence of the ability to meet technical qualification and experience requirements as outlined in Section 6.1 and accompanying main specifications.	Submit a **Description of Technical Qualification and experience, and Description of Project Strategy with Summary of execution plan** to OPG.
3.	A list of all technical exceptions.	Submit a **list of Technical Exceptions** to OPG. If there are no exceptions, a statement stating the same shall be provided.
4.	A list of all 3rd party Contractors that the Contractor intends to use during this project, including the firms to be used for engineering, drawings, equipment procurement, construction, testing, quality assurance and any other work that the Contractor will be contracting out.	Submit list of **3rd Party**.
5.	Detailed Project schedule level 3 in 2007 Microsoft Project.	Submit a detailed **Project Schedule**.
6.	Detailed engineering reports and Easy Power Model as outlined in Section 7.4	Submit **Engineering Studies** eight weeks prior to successful Contractor issuing Contractors RFP for purchase of the equipment.

Item	Deliverable	Action Required
7.	Technical specifications specifically "OPG-M-784S" for station batteries as outlined in Section 7.2.1	Submit **Technical Specification** 4 weeks prior to successful Contractor issuing Contractors RFP for purchase of the station battery banks.
8.	Proponent supplied documents/drawings in response to battery bank Contractors RFP	Submit **Design Document/Drawing** from the leading proponent prior to successful Contractor awarding the contract for supply of battery banks.
9.	Technical specifications specifically "OPG-M-785S" for DC switchgear procurement as outlined in Section 7.2.1	Submit **Technical Specification** 4 weeks prior to successful Contractor issuing Contractors RFP for purchase of the DC switchgears.
10.	Proponent supplied documents/drawings in response to DC switchgear Contractors RFP	Submit **Design Document/Drawing** from the leading proponent prior to successful Contractor awarding the contract for supply of DC switchgears.
11.	Technical specifications specifically "OPG-M-783S" for battery chargers procurement as outlined in Section 7.2.1	Submit **Technical Specification** 4 weeks prior to successful Contractor issuing Contractors RFP for purchase of the battery chargers.
12.	Proponent supplied documents/drawings in response to battery chargers Contractors RFP	Submit **Design Document/Drawing** from the leading proponent prior to successful Contractor awarding the contract for supply of battery chargers.
13.	Technical specifications including cable list for power cable procurement as outlined in Section 7.2.1	Submit **Technical Specification** 4 weeks prior to successful Contractor issuing Contractors RFP for purchase of the power cables.
14.	Proponent supplied documents/drawings in response to power cable Contractors RFP	Submit **Design Document/Drawing** from the leading proponent prior to successful Contractor awarding the contract for supply of power cable.
15.	Proponent supplied design documents/drawings/BOM in response to miscellaneous equipment	Submit **Design Document/Drawing** from the supplier prior to successful Contractor awarding the contract for supply of miscellaneous equipment.
16.	A letter stating why particular proponents were chosen over other.	Submit **Letter of Justification or Scorecard** used to select an equipment supplier prior to successful Contractor awarding the contract for supply of station batteries, chargers, DC switchgears, cables and other miscellaneous equipment.
17.	Final design drawings, bill of material list, documentation prior to manufacturing of DC switchgear, station batteries, chargers, power cable	Submit **final design documentation/drawings** 4 weeks prior to start of equipment manufacturing.
18.	Construction drawings including EWD/CWD/Layout plans/integration work plans prior to site construction.	Submit final **Construction Drawing/Documentation** 4 weeks prior to start of onsite construction.
19.	Detailed Removal and installation plan.	Submit **removal/installation plan** 4 weeks prior to work taking place.
20.	Final test plan as per Section 10.0	Submit **test plan** prior to conducting any test.

Item	Deliverable	Action Required
21.	Approved test reports including completed test forms and equipment calibration certificates as per Section 10.0	Submit **test report** prior to completion of work.
22.	Certificate of Warranty certifying all work for a minimum period of one year upon project completion date	Submit **certificate/statement of warranty** on completion of work date.
23.	Consolidate reference binder and maintenance binder containing at a minimum the following information: Close out report summarizing specifics on work performed and system description. Information required for troubleshooting. Completed new equipment form identifying new components and associated maintenance. Sequence of operation document Data sheets for all components utilized in the system including specific manufacturer product numbers and weight of the components. Warranty requirements and details. Final as-built drawings as per Section 11.0. Design calculations and assumptions. A detailed cable list. The list shall provide the cable number, location (to and from), length, cable info and conduit info for each cable. In-Service test plans, report and test recording sheets. Engineering/Assessment reports. Copy of all obtained permits, certifications, and approvals.	Submit **final maintenance binder** as part of the project completion.
24.	Easy Power model	Submit **easy power model** prior to completion of work.

13.0 HOLD AND WITNESS POINTS

As a minimum, the Contractor shall establish the following hold points where a delegate appointed by an OPG Representative either witnesses and signs off on the activity or provides its acceptance before work proceeds any further.

Category:

1. Witness Point - OPG must witness the entire activity and sign off.

2. Hold Point - OPG must review and provide its acceptance prior to proceeding further.

Activity Description	Category
Engineering Studies	2
Design submissions for OPG review at 30%, 60% and 90% completion stage	2
Technical Specifications for equipment procurement	2
Concept Design Documents from leading proponents submitted in response to Contractors RFP for equipment procurement	2
Design drawings and documents for equipment manufacturing	2
Onsite Removal and Install Work Plans/integration drawings/documents	2
Factory Acceptance Testing	1
Visual Inspection of equipment on Delivery	1
Termination of power supply into Existing OPG Equipment	1
Integration of new controls with existing	1
Upon completion of removal	2
Upon completion of installation	2
Testing	1

14.0 COMPLETION OF WORK

The Contractor shall advise OPG of construction completion and perform a final walk down with all OPG representatives and Contractor representatives. If any deficiencies exist or are uncovered during the walk down, the Contractor shall correct those deficiencies and request a final joint walk down with OPG representatives.

The Contract will be considered complete only when:

- All work as dictated by this specification is completed.
- All applicable information required for fulfilling the requirement of Procedure for

Transfer of Operating Control and Turnover of Equipment is submitted to OPG Project leader.

- Installations have been accepted by OPG.
- As-built drawings are handed over to OPG.

Acceptance of the installation by OPG in no way alleviates the Contractor or their P.Eng of their legal or contractual responsibility for the design & installation.

Appendix A 250Vdc Station Service Operating Diagram

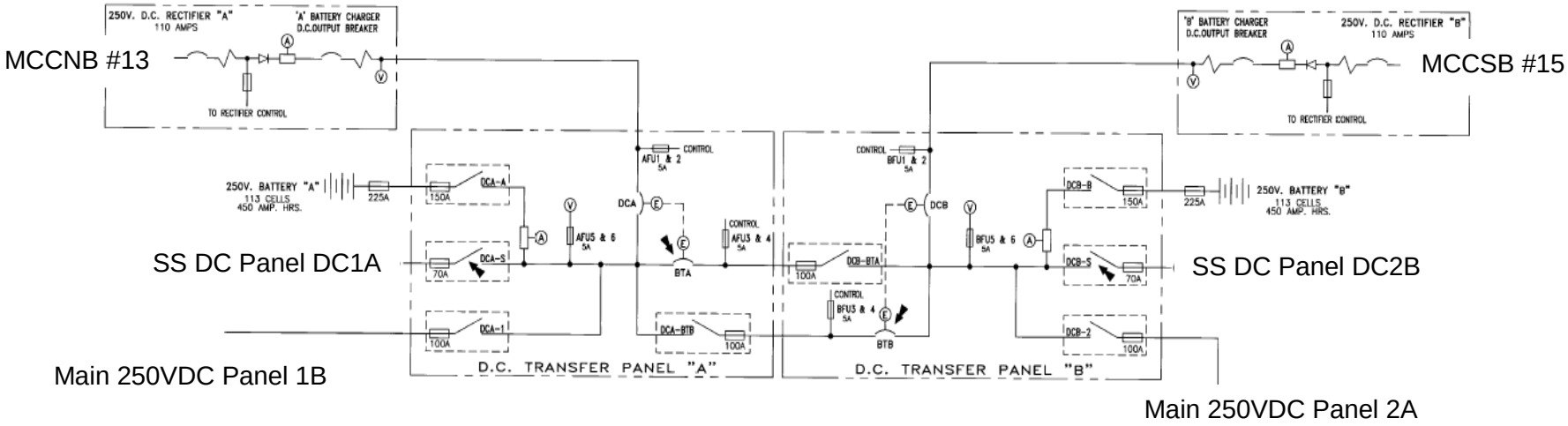


Figure 1 – Existing 250 VDC Station Service System Partial Diagram

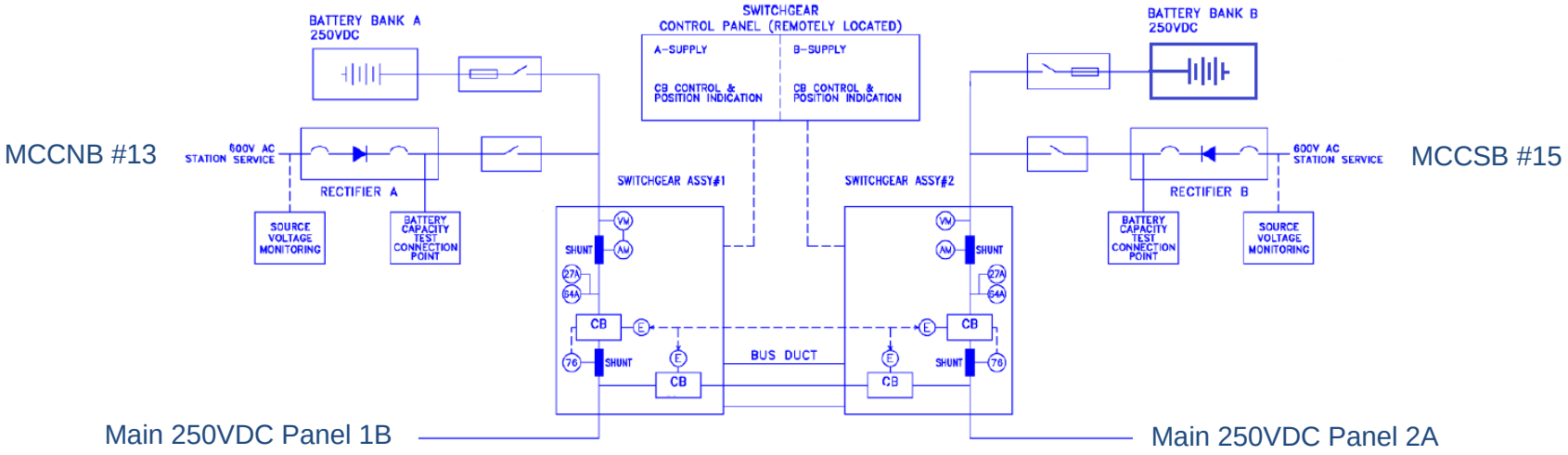


Figure 2 – Proposed 250 VDC Station Service System - Conceptual Design Partial Diagram

Appendix B Photos



Figure 3 – Charger A & B and Transfer Panel A & B



Figure 4 – Eye Wash and Shower Area



Figure 5 – Battery Bank-A Room and Door between Battery Rooms



Figure 6 – Battery Bank-B Room



Figure 7 – Proposed Area for DC Switchgear